ROUX

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Subject: Former Bishop Tube Site
Feasibility Study Addendum
Remedial Alternative #8 – Basis of Design Memorandum

1.0 Introduction

Roux Associates, Inc. ("Roux"), on behalf of the Bishop Tube Team ("BT Team"), has prepared this Feasibility Study Addendum ("FS Addendum") that describes the assumptions, scope, and cost for Remedial Alternative #8 ("RA #8") for groundwater. The BT Team submits this integrated RA #8 FS Addendum to assist Pennsylvania Department of Environmental Protection's ("DEP's") preparation of its Analysis of Alternatives under consideration for the former Bishop Tube Site ("Site")[1]. This FS Addendum incorporates, by reference, pertinent information presented in the Feasibility Study Report - Former Bishop Tube Property ("FS Report")[2].

The FS Report includes seven remedial alternatives ("RAs") designed to address groundwater impacts at the Site. All of these groundwater RAs anticipated there would be separate but complementary soil RAs developed for certain source areas within the Property[3,4]. As noted in the FS Report, it was anticipated that:

> "…. soil conditions for all constituents of concern ("COCs") may be addressed in the future by a remediator and/or a developer of the Property. In order to select remedial action(s) for the Site, any remedial action for soil on the Property needs to be considered in conjunction with the Bishop Tube Project Team's FS Report which focuses on groundwater (FS Report, pg. 2)."

A soil remedial alternatives evaluation had not been published in time to be considered in the groundwater FS Report.

In parallel with finalizing the groundwater FS Report, the DEP was preparing RAs for soil as described in the Groundwater & Environmental Services, Inc. ("GES") November 10, 2020 Technology Assessment Memorandum ("Technology Assessment Memo")[5]. The Technology Assessment Memo provides an analysis of RAs for unsaturated and saturated soil at the Property. Having now had the opportunity to consider DEP's soil RAs in the Technology Assessment Memo, the BT Team has prepared this FS

[1] The term "Site" as used herein is in accordance with Chapter 250, Section 1.
[2] The FS Report is dated June 17, 2019, has been revised through comment and response between DEP and the BT Team, and is near finalization with a final date to be determined. Similar to the FS Report, this FS Addendum conforms with the August 4, 2009 Amended Consent Order and Agreement ("2009 COA"), the National Contingency Plan ("NCP"), the Hazardous Sites Cleanup Act ("HSCA"), and the Land Recycling and Environmental Remediation Standards Act ("Act 2").
[3] The term "Property" as used herein specifically refers to the 13.7-acre former Bishop Tube property itself.
[4] The complementary soil source area RAs were outside the scope of the groundwater FS Report.
[5] A Remedial Alternatives Analysis ("RAA") that addresses unsaturated soil prepared by DEP's contractor was published on August 5, 2020, and certain information in the RAA for soil was supplemented (by DEP's contractor) in a Technology Assessment memorandum on November 10, 2020 to address remediation of both unsaturated and saturated soil.

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Addendum that identifies an integrated soil and groundwater remedy for the Site - RA #8 Basis of Design ("BOD") Memorandum ("RA #8 BOD Memo").

This RA #8 BOD Memo integrates RAs for soil and groundwater source area mitigation with FS Report RA #2. As described in more detail in the FS Report, RA #2 includes: 1) monitored natural attenuation ("MNA"), 2) Best Management Practices ["BMPs"] for the diffuse discharge of groundwater to surface water, 3) a Technical Impracticability ("TI") waiver for dense non-aqueous phase liquid ("DNAPL") present in the bedrock, 4) Institutional Controls ["ICs"] to mitigate potential direct contact exposure to groundwater, and 5) Engineering Controls ["ECs"] for the single domestic well within the Site. The soil and groundwater source area mitigation RA components considered in RA #8 are intended to enhance the natural attenuation processes currently active at the Site. The three RA components are as follows:

- A principal groundwater component which is essentially equivalent to RA #2, previously described in the FS Report (briefly summarized below);
- A soil source area mitigation component from the Technology Assessment Memo (briefly summarized below); and
- A groundwater source area mitigation component described below.

Although RA #8 is described in this FS Addendum as a stand-alone groundwater RA, the attachments to this RA #8 BOD Memo include a comparison of RA #8 to RAs #2 through #7 from the FS Report[6].

This RA #8 BOD Memo includes the following components:

- Section 2.0 - Summary of RAOs and BMPs;
- Section 3.0 - Conceptual Structure of an Integrated RA;
- Section 4.0 - Discussion of GES' Soil Source Area AOCs;
- Section 5.0 - Overall Scoping Assumptions for RA #8;
- Section 6.0 - RA #8 Basis of Design; and
- Section 7.0 - RA #8 Costs.

All necessary components for a complete groundwater RA that is protective of human health and the environment are incorporated into this RA #8 BOD Memo, and RA #8 is designed to be directly compatible with the soil source area mitigation RAs[7].

2.0 Summary of RAOs and BMPs

In consideration of the Act 2 statutory concepts and the actual and/or potential risk posed to public health and the environment from existing and anticipated future groundwater conditions, the FS Report presents Remedial Action Objectives ("RAOs") for groundwater (direct contact and potential vapor intrusion ["VI"]) and BMPs for diffuse discharge of Property-related COCs in groundwater to surface water. A description of the RAOs and BMPs taken directly from the FS Report is presented below.

<u>RAOs</u>

- Maintain current conditions at the Site which have been shown to be protective of human health via ingestion of, inhalation of, or dermal contact with groundwater containing Site-related chlorinated volatile organic compounds ("CVOCs") and inorganics in excess of preliminary remedial goals ("PRGs")[8].

[6] DEP and the BT Team agreed that provision of RA #8 in a stand-alone document would be timelier than attempting to modify the FS Report which was near finalization.
[7] Though as described in Section 4.0, there are aspects of the soil RAs which the BT Team views as unnecessary and unsupported by the data.
[8] See Section 7.0 of the FS Report for a complete discussion of PRGs for this Site.

- Ensure future conditions at the Site remain protective of human health via ingestion of, inhalation of, or dermal contact with groundwater containing Site-related CVOCs and inorganics in excess of PRGs.
- Monitor and/or establish conditions to ensure that the area of Site-related COCs in groundwater (i.e., the off-Property plume) remains in steady-state or decreasing over time (i.e., a continuing demonstration that the "Site" is not expanding).
- Identify remedial measures that a) do not produce undesirable side-effects, b) are compatible with observed natural attenuation mechanisms active at the Site, c) are reasonably expected to reduce the migration of COCs off of the Property, and d) are reasonably expected to hasten the retraction of the off-Property plume over time.

The RAOs above recognize that complete restoration of groundwater and removal of DNAPL beneath the Site a) is not a feasible goal given the overall Site conditions and the limitations of remedial technologies to address all observed conditions, and b) is not a requirement under Act 2 where pathway elimination measures may be employed to demonstrate the absence of current and future exposure pathways.

BMPs

- Identify reasonable and cost effective BMPs to be implemented on the Property to maintain current conditions which have shown the absence of unacceptable risks to human health or ecological receptors based on the diffuse groundwater discharge to surface water pathway.
- Identify reasonable and cost effective BMPs that ensure future conditions related to the diffuse discharge of groundwater to surface water do not pose unacceptable risks to human health or ecological receptors (i.e., BMPs do not increase the concentration or mass of COCs discharged to surface water).
- Identify reasonable and cost effective BMPs that may hasten the reduction of the concentration or mass of COCs discharged to surface water without negatively affecting base flow or the habitat in the stream.

3.0 Conceptual Structure of an Integrated RA

As described in the FS Report, it is the BT Team's opinion that RA #2 addresses the RAOs and BMPs as described in Section 2.0, above[9]. However, as noted in the introduction above, it was assumed in the FS Report that there would be separate but complementary soil RAs developed that would need to be considered in conjunction with the FS Report for groundwater. The conceptual structure of such an integrated RA was discussed with DEP and the following DEP-approved language was incorporated into the FS Report:

> "The additional information [in the Technical Assessment Memo] regarding [RAs for] unsaturated and saturated soil may need to be considered in conjunction with the FS Report. A new or modified remedial alternative for groundwater may be warranted to effectively integrate the supplemental soil approach [from the Technology Assessment Memo] with a complementary groundwater remedial alternative (FS Report, pg. 5)."

During discussions to finalize the FS Report, DEP expressed a view[10] that RA #2 as a stand-alone RA for groundwater may not sufficiently address two aspects of the RAOs: namely, that the remedial measure is "reasonably expected to reduce the migration of COCs off of the Property" and "reasonably expected to

[9] As also described in the FS Report and as discussed with DEP, protection of human health and the environment from contaminants in groundwater is principally achieved through MNA (i.e., RA #2) as a stand-alone RA.
[10] Any characterization by Roux of DEP's views herein is solely for the purpose of scoping this RA #8.

hasten the retraction of the off-Property plume over time (FS Report, pg. 68)"[11]. The BT Team submits this integrated RA #8 FS Addendum to assist DEP's preparation of its Analysis of Alternatives for the Site.

RA #8 integrates soil and groundwater source area mitigation RAs with the remedial elements of RA #2, as described below[12].

- Principal Groundwater Component – RA #2 from the FS Report. This component serves as the primary RA for demonstrating protection of human health and the environment with respect to potential groundwater-related exposure pathways.
- Soil Source Area Mitigation Component from the Technology Assessment Memo. This component, prepared by GES at the direction of DEP, is intended to address soil objectives[13] and FS Report groundwater RAOs[14]. Some form of soil source mass mitigation followed by groundwater performance monitoring (under RA #2) is anticipated, rather than adoption of numeric remediation/attainment standards for soil. Ultimately, the effects of soil source mass mitigation RAs on groundwater conditions would be expected to be observed via the groundwater sampling defined under RA #2.
- Groundwater Source Area Mitigation Component (i.e., the portion of RA #8 primarily described herein). This component would address groundwater RAOs in the FS Report and would complement the soil source mass mitigation. Some form of soil source mitigation RAs followed by groundwater performance monitoring is anticipated and will be followed by supplemental groundwater source mass mitigation measures, as warranted. Ultimately, the effectiveness of the integrated soil and groundwater source area mitigation RAs would be expected to be observed via the groundwater sampling defined under RA #2.

The first two components are further described below. The third component (i.e., the groundwater source area mitigation component of RA #8) is described in Sections 5.0 and 6.0 of this FS Addendum.

Principal Groundwater Component – RA #2 from the FS Report – As described in the FS Report, RA #2 ranks highly because it is protective of human health and the environment, complies with ARARs, complies with site-specific standards which would be employed in lieu of numeric PRGs (inclusive of pathway elimination through the use of ICs and engineering controls ECs)[15]. RA #2 would be readily implementable without the need for other active remedial measures and has minimal short-term effects on workers, surrounding businesses and the community. RA #2 is also the lowest cost RA that meets all evaluation criteria, including sustainability, with a high ranking in all but one category. The sole criterion with a 'low' ranking for RA #2 is short-term COC mass reduction.

Although described more thoroughly in the FS Report, the elements of RA #2, which are included in this integrated RA for the Site, are summarized below[16].

[11] The BT Team stands by its position outlined in the FS Report: that MNA (RA #2) adequately addresses the RAOs and BMPs established for the Site.
[12] The BT Team recognizes that although DEP has expressed certain views in the context of finalizing the FS Report, in part to assist Roux with the scoping of this RA #8, that DEP's final and independent decisions have not been made yet and are expected to be provided in a future "Analysis of Alternatives" document.
[13] The Technology Assessment Memo does not formally define soil RAOs, but does state an objective to "substantially reduce or remove COCs from source soil (unsaturated and saturated)" and also states that it is "anticipated that a site-specific standard via pathway elimination will be used…." [pgs. 1 and 3]
[14] More specifically, whether the remedial measure is "reasonably expected to reduce the migration of COCs off of the Property" and "reasonably expected to hasten the retraction of the off-Property plume over time (FS Report, pg. 68)".
[15] By contrast, other RAs considered in the FS Report (i.e., RAs #3 through #7) have lower rankings for some individual evaluation criteria primarily because of either implementation uncertainties or anticipated antagonistic effects that could adversely impact human health and/or ecological risks.
[16] While the collective elements remain the same as described in the FS Report, slight modifications were made to the scope of certain aspects of RA #2 to accommodate the conceptual structure of an integrated RA, inclusive of the soil and groundwater source area mitigation RAs.

- MNA components such as:
    - Sampling/monitoring;
    - Land use inspection;
    - Data trend assessment; and
    - Reporting with ongoing protectiveness determinations.
- BMPs such as:
    - Stormwater controls to reduce sediment loading and promote clean water infiltration proximate to a tributary of Little Valley Creek ("LVC");
    - Bioretention areas to serve similar functions related to discharge to a tributary of LVC;
    - Phytotechnology to reduce diffuse groundwater loading to a tributary of LVC; and
    - Impervious surfaces/stormwater controls to minimize new/future infiltration in residual source areas.
- ICs such as environmental covenants or well ordinances.
- TI waiver for DNAPL and related groundwater, including monitoring and periodic technology reviews.
- ECs such as a point-of-entry treatment ("POET") system (i.e., a carbon filtration system) or, if deemed appropriate by DEP, a public water supply line connection to address drinking water associated with one private supply well located within the Site.

Soil Source Area Mitigation Component from the Technology Assessment Memo – Soil source area mitigation alternatives were prepared by GES at the direction of DEP. Though described more thoroughly in GES' Technology Assessment Memo, the elements of a soil source area RA, which are included by reference in the conceptual structure of this integrated RA for the Site, are summarized below[17].

- Four potential RAs are discussed; the third alternative, in-situ chemical reduction/in-situ chemical oxidation ("ISCR/ISCO") via soil mixing, is the soil source area mitigation technology that presumably would be implemented in conjunction with RA #8.
- For RA #8 design purposes, it is assumed that ISCR via soil mixing will be employed as the remedial technology for both CVOCs and inorganics in soil (although the specific ISCR technique would likely be different for inorganics versus CVOCs).
- It is assumed that ISCO will not be employed as ISCO is expected to be largely incompatible with the existing and future natural attenuation processes occurring at the Site.
- Ten (10) preliminary soil areas of concern ("AOCs") were identified in the Technology Assessment Memo (see Figure 2 from that document). It is the BT Team's opinion that the depiction of most of those areas as potentially requiring soil source mitigation is overly conservative and can be focused through a thorough assessment of existing data or collection and review of additional data (i.e., pre-design data collection). Refer to Section 4.0 for a detailed discussion of empirical data associated with each of the ten AOCs identified by DEP.

4.0 Discussion of GES' Soil Source Area AOCs

Ten (10) preliminary soil AOCs were identified in the Technology Assessment Memo (see Figure 2 from that document). It is the BT Team's opinion that the depiction of most of those areas as potentially requiring soil source mitigation is overly conservative and can be focused through a thorough assessment of existing data or collection and review of additional data (i.e., pre-design data). DEP and GES

[17] Roux's characterization of the Technology Assessment Memo herein is for the purpose of scoping and preparing RA #8.

acknowledged that these preliminary soil AOCs are "conservative" and may not require active remediation upon assessment of future soil pre-design investigation data[18]. Thus, most of these identified soil AOCs, listed below, are not included as part of RA #8.

Soil AOC #	General Location	Primary COC Driver(s)
1	Building 8 VDA	CVOCs
2	Eastern Portion of Building 8	Inorganics
3	Beneath and East of Eastern Portion of Building 8	CVOCs & Inorganics
4	Northeast of Building 8	CVOCs
5	North of Building 5 (Alleged Railing Spill Area)	Inorganics
6	Building 5 VDA	CVOCs
7	South of Building 5 (Sanitary Cesspool Area)	Inorganics
8	East of Building 5 (Potential Vault Area)	Inorganics
9	DSA #3	CVOCs
10	Area East of Building 5 (Driveway to Building 8)	Inorganics

The soil and groundwater conditions associated with these 10 preliminary soil AOCs, as applicable, are discussed below to help define which of the AOCs, if any, should be addressed by the groundwater source area mitigation component of RA #8.

- **AOC-1 - Building 8 VDA[19] (CVOCs)** - This preliminary soil AOC has elevated CVOCs in unsaturated soil, saturated soil and in shallow overburden groundwater with anticipated CVOCs mass discharge from soil to groundwater. As described in the FS Report: "[t]his source area is characterized by the presence of trichloroethene ("TCE"), 1,1,1-trichloroethane ("TCA"), and related CVOC daughter products in soil and groundwater. The suspected presence of DNAPL, observed proximate to bedrock monitoring wells, is attributed to this source area (FS Report, pg.18)". Since this source area represents the most significant residual source of CVOCs at the Property, it was assumed in the FS Report there would be a complementary soil RA for this AOC. Although the horizontal and vertical extent of this soil AOC should be refined by future pre-design investigation (especially the areal extent at greater depth in the saturated overburden soil), both soil and groundwater source area (i.e., "hot spot") mitigation measures would be consistent with DEP's views regarding satisfying two aspects of the groundwater RAOs discussed above.

  For the reasons above, RA #8 includes groundwater source area mitigation measures, as warranted, for this AOC.

- **AOC-2 - Eastern Portion of Building 8 (Inorganics)** - This preliminary soil AOC was apparently established based on a single primary soil sample (PTA-01 [4-7]) and its duplicate (PTA-01 DUP [4-7]), with total chromium results of 84.9 milligrams per kilogram ("mg/kg") and 218 mg/kg, respectively. The samples were analyzed for total chromium which, in the absence of hexavalent chromium, would normally be compared to the trivalent chromium soil Medium Specific Concentrations ("MSCs") of 190,000 mg/kg, orders of magnitude higher than the sample results. Since the samples were not speciated for hexavalent chromium, GES conservatively compared

[18] November 17, 2020 teleconference with GES, DEP, and BT Team technical members to discuss the Technology Assessment Memorandum and potential scoping of the groundwater source area mitigation component of RA #8.
[19] The Building 8 Vapor Degreaser Area ("Building 8 VDA") refers to a general area within and adjacent to the north side of Building 8 including the following features: a vapor degreaser and solvent distillery indoors, subsurface piping, and a solvent above-ground storage tank ("AST") outside.

the total chromium analytical results to the hexavalent chromium MSCs, assuming all chromium present to be hexavalent chromium. This assumption is unfounded[20]. Based on this conservative and unsubstantiated assumption, the Technology Assessment Memo compared the total chromium results for the soil samples to the hexavalent chromium Residential Used Aquifer ("RUA")[21] Soil to Groundwater ("SGW") MSC of 190 mg/kg, the concentration used in the Technology Assessment Memo as a differentiator between a suspected release evaluated for remedial action and suspected naturally occurring chromium [22]. Even adopting this approach, the primary sample does not exceed 190 mg/kg. Furthermore, while the duplicate sample does exceed the hexavalent chromium RUA SGW MSC, the average of the primary sample and its duplicate is 152 mg/kg, below the 190 mg/kg hexavalent chromium standard referenced in the Technology Assessment Memo.

If this AOC was established based on chromium exceedances of RUA SGW MSCs (i.e., a threat to groundwater), review of groundwater data demonstrates that this is not appropriate. For example, overburden wells located to the north, northeast and east of PTA-01 [4-7] (e.g., MW-04, MW-05, MW-06, MW-8, and MW-12, see Figure 32 in the RIR)[23] do not show exceedances of 100 micrograms per liter ("ug/L") dissolved chromium, the RUA Groundwater ("GW") MSC, which is applicable to both total and hexavalent chromium results. As further noted in the FS Report, chromium has not been reported in off Property groundwater at a concentration that exceeds a groundwater MSC.

For the reasons stated above, preliminary soil AOC-2 does not warrant soil or groundwater source area mitigation measures for inorganics. This preliminary AOC should be eliminated from consideration for remediation. If concerns persist, pre-design soil sampling which speciates hexavalent chromium could be conducted.

RA #8 does not include groundwater source area mitigation measures for this AOC.

- **AOC-3 - Beneath and East of Eastern Portion of Building 8 (CVOCs and Inorganics)** - This preliminary soil AOC has reportedly been established based on the presence of both CVOCs and inorganics in soil.

  CVOCs - With respect to CVOCs, it is assumed that in the Technology Assessment Memo this preliminary soil AOC is proposed based on vinyl chloride ("VC") and cis-1,2-dichloroethene ("cis-1,2-DCE") analytical results that exceed the RUA SGW MSCs in one and three soil samples, respectively in this area (see RIR Figure 10). With one minor exception, there are no exceedances of "parent" CVOC criteria such as TCE or TCA[24]. The cis-1,2-DCE and VC are "daughter" or breakdown products of the parent CVOCs and the presence of these daughter products is direct

[20] In the Technology Assessment Memo GES points out that Roux, as a conservative measure in the absence of hexavalent chromium speciation data, also compares total chromium results to hexavalent chromium soil MSCs in the Remedial Investigation Report ("RIR"). The RIR is dated June 10, 2019, has been revised through comment and response between DEP and the BT Team, and is near finalization with a final date to be determined. On page 4 of the RIR Roux states: "As requested by DEP, the Bishop Tube Project Team has included an assessment of existing soil data (largely collected by DEP or others under contract to DEP) in this RIR. The soil data are compared to state-wide health standards ("SHSs") as benchmarks for DEP to assess the nature and extent of soil contamination on the Property." There is a substantial difference between employing hexavalent chromium SHSs as benchmarks for assessment of the distribution of total chromium results in an RIR and applying a similar approach to define AOCs subject to source area mitigation RAs.

[21] The residential or non-residential used aquifer MSCs cited in this document are based on presumed total dissolved solids ("TDS") <2,500 mg/L.

[22] As described in GES' Technology Assessment Memo, "[w]idespread total chromium observed on the Property may in part be attributable to suspected naturally occurring conditions in addition to discrete source areas containing elevated chromium concentrations which may not be naturally occurring (pg. 4)." Based on this, GES states that "[a]ll [total chromium] sample locations that exceed RUA SGW MSC for hexavalent chromium are included in the treatment areas (pg. 4)" while recognizing that "additional soil sampling may need to be conducted during pre-design activities to confirm hexavalent chromium concentration and distribution, if present (pg. 4)."

[23] MW-4 is actually a very shallow bedrock monitoring well with a screened interval of 7-20 ft bgs.

[24] Within the outline of AOC-3 from Figure 2 of the Technology Assessment Memo, there are 18 soil borings with soil samples analyzed for VOCs. From those 18 locations, one sample exceeded the TCE RUA SGW MSC of 0.5 mg/kg - a mobile laboratory sample (WDL-05[5-6]) from 2001 with a reported TCE result of 0.809 mg/kg.

evidence of ongoing natural attenuation processes in this area of the Property. In addition, while this preliminary soil AOC was established based on the most stringent RUA SGW MSCs for cis-1,2-DCE and VC, these two compounds are not found at meaningful concentrations in the most recent overburden groundwater data from the three closest monitoring wells (MW-4, MW-05, MW-6, see Figures 23 and 24 in the RIR)[25]. While some groundwater exceedances are acknowledged, in the overall context of CVOC conditions in groundwater beneath the Property, these conditions do not warrant an active soil or groundwater source area mitigation RA, especially given the proximity to the tributary of LVC (see the potential deleterious effects discussion in Section 5.0, below). Implementing a source area remedial action for soil or groundwater in this area would not advance the two RAOs for groundwater not already addressed by RA #2 since any remedial action would not affect the off Property CVOC plume or hasten its retraction. Collectively, these data indicate that this preliminary soil AOC is not expected to produce exceedances of applicable groundwater criteria and therefore does not warrant soil or groundwater source area mitigation measures to address CVOCs in groundwater.

Inorganics - With respect to inorganics, it is assumed that the Technology Assessment Memo based this preliminary soil AOC on nickel and chromium analytical results. Nickel exceeds the RUA SGW MSCs of 650 mg/kg (see Figure 15 from the RIR) in four soil samples. Total chromium exceeds the hexavalent chromium RUA SGW MSCs of 190 mg/kg (see Figure 12A from the RIR) in nine soil samples. While there are more total chromium exceedances of the 190 mg/kg MSC for hexavalent chromium in this AOC than in AOC-2 discussed above, the same observations apply as to why screening total chromium results against hexavalent chromium MSCs to establish soil source area mitigation areas is unfounded. Furthermore, if this AOC was established based on exceedances of RUA SGW MSCs (i.e., a threat to groundwater), review of the most recent overburden groundwater data in the area of this AOC demonstrates that this is inappropriate as there are no exceedances of RUA GW MSCs for nickel or chromium (total or hexavalent) in the three closest overburden monitoring wells (MW-04, MW-05, and MW-06, see Figures 32 and 33 in the RIR)[26]. Collectively, these data indicate that this preliminary soil AOC is not causing and is not expected to result in exceedances of applicable groundwater criteria and therefore does not warrant soil or groundwater source area mitigation measures for inorganics. As further noted in the FS Report, neither chromium nor nickel have been reported in off Property groundwater at a concentration that exceeds a groundwater MSC. Thus, no remedial action is required for soil or groundwater to address the groundwater RAOs in this RA #8.

For the reasons stated above, preliminary soil AOC-3 does not warrant soil or groundwater source area mitigation measures for CVOCs or inorganics. This preliminary AOC should be eliminated from consideration for remediation. If concerns persist, pre-design soil sampling which speciates hexavalent chromium could be conducted.

RA #8 does not include groundwater source area mitigation measures for this AOC.

- **AOC-4 - Northeast of Building 8 (CVOCs)** – This preliminary soil AOC has reportedly been established based on the presence of CVOCs, presumably in two soil samples collected from a single soil boring (MW-08-SB at depths of 11-11.5 and 13.5-14 feet below ground surface [“ft bgs”]). Based on the conceptual site model (“CSM”) for the Site, the BT Team attributed this localized contamination in the saturated zone near MW-08 to groundwater transport of CVOCs from AOC-1 (the Building 8 VDA). However, because of allegations of surface dumping in this area of the Property, the DEP required further investigation (see Subsection 7.1.1, the “Northeast Corner Soil Investigation”, as well as Table 1 and Figure 6 from the RIR). Collectively, 21 soil samples from 11 soil borings (NE-RX-1 to 6, LAG-02, S3, S5, SSA-05, and ARPSA01) were analyzed to characterize this area to DEP’s satisfaction (see Figure 8A from the RIR for the soil boring locations). None of the 21 soil samples exceeded soil MSCs for CVOCs. Given the

[25] MW-4 is actually a very shallow bedrock monitoring well with a screened interval of 7-20 ft bgs.
[26] MW-4 is actually a very shallow bedrock monitoring well with a screened interval of 7-20 ft bgs.

extensive investigation of the northeast corner of the Property, establishing this area as a soil AOC (subject to soil source area mitigation) from a single saturated soil boring is inappropriate. The extensive investigation in the northeast corner did not produce evidence of a shallow soil source area (i.e., no evidence to support the allegations of surface dumping in this area).

Overburden monitoring well MW-8 (collocated with soil boring MW-08-SB) does have RUA GW MSC exceedances for TCE (GW MSC = 5 ug/L), cis-1,2-DCE (GW MSC = 70 ug/L), and VC (GW MSC = 2 ug/L) of 27.1 ug/L, 135 ug/L, and 86.9 ug/L, respectively. As discussed under AOC-3 above, cis-1,2-DCE and VC are "daughter" or breakdown products of the parent CVOCs and the presence of these daughter products is direct evidence of ongoing natural attenuation processes in this area of the Property. While these groundwater exceedances are acknowledged, in the overall context of CVOC conditions in groundwater beneath the Property, these conditions do not indicate a source area that warrants an active soil or groundwater source area mitigation RA, especially given the proximity to the tributary of LVC (see the potential deleterious effects discussion in Section 5.0, below). Implementing a remedial action for soil or groundwater in this area would not advance the two RAOs for groundwater not already addressed by RA #2 since any remedial action would not affect the off Property CVOC plume or hasten its retraction.

For the reasons stated above, preliminary soil AOC-4 does not warrant soil or groundwater source area mitigation measures for CVOCs. This preliminary AOC should be eliminated from consideration for remediation.

RA #8 does not include groundwater source area mitigation measures for this AOC.

- **AOC-5 - North of Building 5 - Alleged Railing Spill Area (Inorganics)** – It is assumed that the Technology Assessment Memo based this preliminary soil AOC on two primary samples (from DEP's 2018 soil borings P5RSA01 and P5RSA02) and two duplicate samples analyzed for total chromium that exceeded the hexavalent chromium RUA SGW MSCs of 190 mg/kg (see Figure 12A from the RIR). The same observations apply for this AOC, as for AOC 2 above, as to why screening total chromium results against hexavalent chromium MSCs to establish soil source mitigation areas is unfounded. In addition, soil sampling was conducted in AOC-5 after the Technology Assessment Memo was prepared, as described below.

  On November 5-6, 2020, soil sampling was conducted by Roux on behalf of the BT Team to assess whether hexavalent chromium is actually present in this preliminary AOC. The soil investigation was conducted to the north of Building 5, collocated with DEP's soil borings P5RSA01 and P5RSA02 (which were previously analyzed for total chromium but not hexavalent chromium). The results of this additional soil investigation were submitted to the DEP in a technical memorandum dated December 16, 2020. The conclusions are summarized below.

  - Samples collected from soil borings collocated with DEP's 2018 soil borings P5RSA01 and P5RSA02 did not contain detectable concentrations of hexavalent chromium.
  - The total chromium data collected were therefore compared to the trivalent chromium soil MSCs and do not exceed the most stringent criteria. This is true for both the 2018 samples collected by DEP and the 2020 samples collected by Roux.
  - These data collected after the Technology Assessment Memo was prepared demonstrate that conditions suggestive of a hexavalent chromium source in this area of the Property do not exist.
  - AOC-5, presumptively depicted in the GES Technology Assessment Memo as an AOC without the benefit of hexavalent chromium speciation analysis, should be eliminated as an AOC since it is not supported by the speciation data.

  For the reasons stated above, preliminary soil AOC-5 does not warrant soil or groundwater source area mitigation measures for inorganics. As further noted in the FS Report, chromium has not

been reported in off Property groundwater at a concentration that exceeds a groundwater MSC. This preliminary AOC should be eliminated from consideration for remediation.

RA #8 does not include groundwater source area mitigation measures for this AOC.

- **AOC-6 - Building 5 VDA (CVOCs)** – This preliminary soil AOC has reportedly been established because of the presence of CVOCs in soil. The areal extent of this preliminary soil AOC appears, from review of the data, to encompass the combined extent of three individual areas, herein referred to as Area East, Area West and Area South.

  Area East - This portion of AOC-6 contains 6 soil borings with exceedances of soil RUA SGW MSCs for CVOCs (specifically, four soil borings for TCE and 2 soil borings for 1,1, 2-TCA). Two soil samples were collected from each of the four TCE soil borings: VD2-01/VDA5-4, VD2-02/VD2-03, VD2-05/VDA5-1, VD2-08/VDA5-2 with TCE results of 7.26/8.2 mg/kg (7 to 8 and 7 to 7.5 ft bgs), 3.7/0.6 mg/kg (3 to 4 and 3 to 4 ft bgs), 1.36/0.003J mg/kg (3 to 4 and 2.5 to 3 ft bgs), and 28.6/0.436 mg/kg (3 to 4 and 2.5 to 3 ft bgs), respectively.[27] The two samples were collected a decade apart and with one exception showed significant reductions in TCE concentrations over time. In three of the four soil boring locations the more recent and more reliable fixed laboratory analytical results are near or below the RUA SGW MSCs for TCE. In addition, based on the water level elevation in nearby MW-66, these soil samples were all in the unsaturated zone, sometimes with deeper soil samples also below the RUA SGW MSCs for TCE. The most recent 2014 overburden groundwater results for MW-66 show TCE at a concentration of 21.2 ug/L and the shallow bedrock groundwater results for MW-23 show TCE at a concentration of 1.4 ug/L. While the exceedance for TCE in overburden groundwater is acknowledged, in the overall context of CVOC conditions in groundwater beneath the Property (i.e., with AOC-1, the Building 8 VDA, immediately to the northeast and downgradient of this AOC), these conditions do not warrant a soil or groundwater source area mitigation RA. The two 1,1, 2-TCA soil samples were VD2-CB02 (8-12) and, VD2-CB03 (8-12) with 1,1, 2-TCA results of 1.7D and 0.56D, respectively. These two samples were collected in 2002 from depths of 8 to 12 ft bgs, respectively. Again, based on the water level elevation in MW-66, these soil samples were collected from the unsaturated zone. The most recent 2014 overburden groundwater results for MW-66 and shallow bedrock groundwater results for MW-23 show 1,1,2-TCA below its GW MSC (5 ug/L) at concentrations of 0.3J ug/L and 1.0U ug/L, respectively. Collectively, these soil and groundwater data indicate that this preliminary soil AOC is not causing and is not expected to produce exceedances of applicable groundwater criteria that warrant soil or groundwater source area mitigation measures. Implementing a remedial action for soil or groundwater in this area would not advance the two RAOs for groundwater not already addressed by RA #2 since any remedial action would not affect the off Property CVOC plume or hasten its retraction.

  Area West – This portion of AOC-6 was seemingly established based on 1 soil boring with an exceedance of the soil RUA SGW MSC for TCE. The soil sample, collected in 2018, was P5LDA02 with a TCE result of 21 mg/kg at a depth of 6 to 6.5 ft bgs. This sample was from the unsaturated zone, and for similar reasons as presented in the Area East discussion above, establishing this portion of AOC-6 as requiring soil source area mitigation measures based on this single soil sample is inappropriate. In addition, for this portion of AOC-6, soil sampling conducted after the Technology Assessment Memo was prepared is described below.

  On November 5-6, 2020, soil sampling was conducted to assess the horizontal and vertical extent of CVOCs in AOC-6. This soil investigation was conducted in a portion of Building 5 collocated with and proximate to DEP's 2018 soil boring P5LDA02, to determine whether TCE was present in shallow soil within this area at concentrations suggestive of an additional VOC source (i.e., an alleged "large degreaser").The results of this soil sampling conducted after the Technology

[27] The "VD2" results were 2001 analyses using a mobile laboratory. The "VDA" results were 2011 analyses using a fixed laboratory.

Assessment Memo was prepared were submitted to the DEP in a technical memorandum dated December 16, 2020. The conclusions are summarized below.

- Horizontal and vertical delineation of the prior TCE detection in sample P5LDA02 (6) was achieved.
- Vertical delineation was achieved entirely within the unsaturated zone and the deepest samples did not exceed the RUA/NRUA SGW MSCs, indicating that soil impact in this area is not reaching the water table.
- Only TCE was detected at concentrations above the default RUA/NRUA SGW MSC and, in all cases, the concentrations of TCE were below 38 mg/kg (the default soil RDC MSC). No soil borings had any notable photoionization detector ("PID") readings or other field indications of substantial impact. As a result, no evident source area has been identified.
- These new data demonstrate that conditions suggestive of an additional CVOC source (i.e., an alleged "large degreaser") in this area of the Property do not exist.
- This soil investigation demonstrates that both the horizontal and vertical extent of VOCs in this portion of AOC-6, as depicted in GES' Technology Assessment Memo, are significantly overestimated, overly conservative and not supported by the data.

Collectively, these soil and groundwater data indicate that this preliminary soil AOC is not causing and is not expected to produce exceedances of applicable groundwater criteria and therefore does not warrant soil or groundwater source area mitigation measures. Implementing a remedial action for soil or groundwater in this area would not advance the two RAOs for groundwater not already addressed by RA #2 since any remedial action would not affect the off Property CVOC plume or hasten its retraction.

Area South - This portion of AOC-6 appears to be established based on 1 soil boring with an exceedance of the soil RUA SGW MSCs for 1,1,2-TCA. The soil sample, collected in 2002, was VD2-CB01 (4-8) with a 1,1,2-TCA result of 5.5D mg/kg at a depth of 4 to 8 ft bgs. A sample collected from a deeper interval in this same soil boring (16 to 20 ft bgs) was below all soil MSCs for 1,1, 2-TCA. Based on the water level elevation in nearby MW-66, the shallower soil sample is from the unsaturated zone. The most recent 2014 overburden groundwater results for MW-66 and shallow bedrock groundwater results for MW-23 show 1,1,2-TCA below its GW MSC (5 ug/L) at concentrations of 0.3J ug/L and 1.0U ug/L, respectively. Collectively, these soil and groundwater data indicate that this preliminary soil AOC is not causing and is not expected to produce exceedances of applicable groundwater criteria and therefore does not warrant soil or groundwater source area mitigation measures.

For the reasons stated above, preliminary soil AOC-6 does not warrant soil or groundwater source area mitigation measures for CVOCs. This preliminary AOC should be eliminated from consideration for remediation. Implementing a remedial action for soil or groundwater in this area would not advance the two RAOs for groundwater not already addressed by RA #2 since any remedial action would not affect the off Property CVOC plume or hasten its retraction.

RA #8 does not include groundwater source area mitigation measures for this AOC.

- **AOC-7 - South of Building 5 (Sanitary Cesspool Area) (Inorganics)** – It is assumed that the Technology Assessment Memo based this preliminary soil AOC on chromium analytical results. Total chromium exceeds the hexavalent chromium RUA SGW MSCs of 190 mg/kg (see Figure 12A from the RIR) in six soil samples. While there are more total chromium exceedances of the 190 mg/kg MSC for hexavalent chromium in this AOC than in AOC-2 discussed above, the same observations apply as to why screening total chromium results against hexavalent chromium MSCs to establish soil source area mitigation areas is unfounded. If this AOC was established based on chromium exceedances of RUA SGW MSCs (i.e., a threat to groundwater), review of groundwater data demonstrates that this is not appropriate. Dissolved total chromium was not

detected (5U ug/L) in the most recent 2006 groundwater results from shallow bedrock monitoring well MW-21. MW-21 is in the center of this AOC and is below the RUA GW MSC (100 ug/L) for total or hexavalent chromium (see Figure 32 in the RIR)[28]. As further noted in the FS Report, chromium has not been reported in off Property groundwater at a concentration that exceeds a groundwater MSC.

For the reasons stated above, preliminary soil AOC-7 does not warrant soil or groundwater source area mitigation measures for inorganics. This preliminary AOC should be eliminated from consideration for remediation. If concerns persist, pre-design soil sampling which speciates hexavalent chromium could be conducted. Thus, no remedial action is required for soil or groundwater to address the groundwater RAOs in this RA #8.

RA #8 does not include groundwater source area mitigation measures for this AOC.

- **AOC-8 - East of Building 5 (Potential Vault Area) (Inorganics)** – It is assumed that the Technology Assessment Memo based this preliminary soil AOC on chromium analytical results. Total chromium exceeds the hexavalent chromium RUA SGW MSCs of 190 mg/kg (see Figure 12A from the RIR) in two soil samples. The same observations apply for this AOC, as for AOC 2 above, as to why screening total chromium results against hexavalent chromium MSCs to establish soil source mitigation areas is unfounded. If this AOC was established based on chromium exceedances of RUA SGW MSCs (i.e., a threat to groundwater), review of groundwater data demonstrates that this is not appropriate. While there are no monitoring wells located within this AOC to directly assess total or hexavalent chromium conditions in groundwater, the groundwater conditions do not support identification of this area of the Property as an AOC warranting soil source area mitigation measures. For example, the most recent groundwater data from overburden wells located to the north, northeast and east of this AOC – all down gradient of AOC-8 (e.g., MW-04, MW-05, MW-06, MW-8, and MW-12, see Figure 32 in the RIR)[29] do not show exceedances of 100 ug/L, the RUA GW MSC, which is applicable to both total and hexavalent chromium results. It is noted, however, that MW-65 (which is upgradient of the above noted wells) does exceed the RUA GW MSC for total and hexavalent chromium. As further noted in the FS Report, chromium has not been reported in off Property groundwater at a concentration that exceeds a groundwater MSC.

  For the reasons stated above, preliminary soil AOC-8 does not warrant soil or groundwater source area mitigation measures for inorganics. This preliminary AOC should be eliminated from consideration for remediation. If concerns persist, pre-design soil sampling which speciates hexavalent chromium could be conducted. Thus, no remedial action is required for soil or groundwater to address the groundwater RAOs in this RA #8.

  RA #8 does not include groundwater source area mitigation measures for this AOC.

- **AOC-9 - Drum Storage Area #3 ("DSA #3") (CVOCs)** – This preliminary soil AOC has fewer soil results for CVOCs than are available for AOC-1. There are five soil borings with TCE exceedances and one soil boring with an exceedance of 1,1,2-TCA. Shallow overburden groundwater has minimal CVOCs (see MW-65 with 7.8 ug/L of TCE and not detected for 1,1,2-TCA in 2014); more substantial, but variable, CVOCs are present in shallow bedrock (see MW-22 with 94,700 ug/L of TCE and not detected for 1,1,2-TCA in 2014). As described in the FS Report: "[t]his source area represents a less significant source [i.e., a secondary source as compared to the Building 8 VDA as the primary source] of CVOCs at the Property. This [secondary] source area is characterized by the presence of TCE (but no TCA exceedances) and related daughter products in soil and groundwater. With one possible exception, suspected

[28] A 2018 groundwater grab sample from this AOC (see Table 4 from the RIR) had primary and split sample results for total chromium of 115 ug/L and 135 ug/L. These results are based on one-time grab samples that were a) subject to uncertainty based on sample collection methods, b) not reproducible over time based on the absence of placement of a monitoring well, and c) were just slightly above the GW MSC.
[29] MW-4 is actually a very shallow bedrock monitoring well with a screened interval of 7-20 ft bgs.

DNAPL observed proximate to bedrock monitoring wells is not attributed to this source area (FS Report, pg.19)." Since this source area represents the second most significant residual source of CVOCs at the Property, it was assumed in the FS Report there would be a complementary soil RA for this AOC. Although the horizontal and vertical extent of this soil AOC should be refined by future pre-design investigation (especially the areal extent at greater depth in the saturated overburden soil), both soil and groundwater source area (i.e., "hot spot") mitigation measures are consistent with DEP's views regarding satisfying two aspects of the groundwater RAOs (discussed above).

For the reasons above, RA #8 includes groundwater source area mitigation measures for this AOC.

- **AOC-10 - Area East of Building 5 (Driveway to Building 8) (Inorganics)** – It is assumed that the Technology Assessment Memo based this preliminary soil AOC on chromium analytical results. Total chromium exceeds the hexavalent chromium RUA SGW MSCs of 190 mg/kg (see Figure 12A from the RIR) in one soil sample. If this AOC was established based on an exceedance of the RUA SGW MSC for chromium (i.e., a threat to groundwater), review of groundwater data demonstrates that this is not appropriate. While there are no monitoring wells located within this AOC to directly assess total or hexavalent chromium conditions in groundwater, the groundwater conditions in the vicinity of this AOC do not support identification of this area of the Property as an AOC warranting soil source area mitigation measures. It is acknowledged that there are total and hexavalent GW MSC exceedances to the east of the tributary of LVC, but there is no established link between the single soil sample that was used to establish AOC-10 and these groundwater conditions. As further noted in the FS Report, chromium has not been reported in off Property groundwater at a concentration that exceeds a groundwater MSC.

  For the reasons stated above, preliminary soil AOC-10 does not warrant soil or groundwater source area mitigation measures for inorganics. This preliminary AOC should be eliminated from consideration for remediation. If concerns persist, pre-design soil sampling which speciates hexavalent chromium could be conducted. Thus, no remedial action is required for soil or groundwater to address the groundwater RAOs in this RA #8.

  RA #8 does not include groundwater source area mitigation measures for this AOC.

5.0 Overall Scoping Assumptions for RA #8

Because ISCR has already been described and retained as a remedial technology in the FS Report for groundwater and in the Technology Assessment Memo for soil, further screening of the ISCR remedial technology for groundwater is not necessary herein. The screening, assumptions, and limitations for the ISCR remedial technology for groundwater presented in the FS Report are incorporated herein by reference and remain valid.

The overall scoping assumptions for the groundwater source area mitigation component of RA #8 are presented below.

- From discussions with DEP to finalize the FS Report, the Site is viewed by DEP as having three (3) media that warrant some remedial action: soil; groundwater; and drinking water. RA #8 addresses the groundwater and drinking water components (i.e., the one private well utilized within the Site).
- Of the ten (10) preliminary soil AOCs identified in the Technology Assessment Memo as potentially requiring soil source area mitigation, at most two of those AOCs may warrant complementary groundwater source area mitigation. RA #8 describes groundwater source mitigation measures that could be employed for AOC 1 (i.e., the Building 8 VDA) and AOC 9 (i.e., DSA #3). As discussed in the FS Report, "CVOCs in groundwater…..were sourced largely from

the Building 8 VDA and, to a lesser extent, from the Drum Storage Area #3 (FS Report, pg. 81)."[30] See Section 4.0 above for the BT Team's rationale why only AOCs 1 and 9 may warrant groundwater source mitigation measures as part of RA #8.

- The RA #8 groundwater source area mitigation measures would be expected to complement the soil source area mitigation RAs. Both the source soil and groundwater RAs address, in part, two aspects of the groundwater RAOs: that the remedial measure is "reasonably expected to reduce the migration of COCs off of the Property" and "reasonably expected to hasten the retraction of the off-Property plume over time (FS Report, pg. 68)."
- RA #8 employs ISCR injection as the remedial technology since it would be a) a preferred remedial technology for CVOCs in groundwater on a stand-alone basis and b) a complementary remedial technology to the ISCR soil mixing RA for CVOCs in soil described in the Technology Assessment Memorandum.
- To ensure the groundwater source area mitigation measures complement the soil source area mitigation measures and RA #2, an assumption for RA #8 is that ISCO will not be employed for soil treatment.
- RA #8 is designed to address all RAOs and BMPs since it fully incorporates the RA #2 components from the FS Report, modified as necessary to reflect the addition of ISCR injections described herein.
- For RA #8 the ISCR amendment would be delivered a) to AOCs 1 and 9: in addition to being soil source areas for historical groundwater contamination, they are located more interior to the Property and therefore less of a threat to the tributary of LVC; and b) to the overburden interval in these two CVOC source areas: so that the ISCR amendment further treats the saturated overburden, then percolates downward naturally into shallow bedrock via the same hydraulic regime and fracture pathway(s) that originally transmitted the CVOCs. If the soil source area mitigation effectively treats the entire horizontal and vertical extent of soil in these two AOCs (as described in the Technology Assessment Memo and summarized in Section 3.0, above), then the groundwater source area mitigation for the overburden portions of these two AOCs could theoretically be eliminated. In practice, guided by future pre-design data and after complete integration of the soil and/or groundwater source area mitigation RAs, the horizontal and vertical extent of soil or groundwater overburden ISCR treatment will likely be reduced for one or both components.
- Although RA #8 will be designed to reduce the risk of deleterious effects, potential deleterious effects will still exist[31]. In addition, as touched on above, there will need to be effective integration of the soil and groundwater source area mitigation RAs since they both apply ISCR technology

[30] Former Building 8 VDA – "This source area represents the most significant source of CVOCs at the Property. This source area is characterized by the presence of TCE, 1,1,1-trichloroethane ("TCA"), and related CVOC daughter products in soil and groundwater. The suspected presence of DNAPL, observed proximate to bedrock monitoring wells, is attributed to this source area (FS Report, pg.18)". Former DSA #3 – "This source area represents a less significant source of CVOCs at the Property. This source area is characterized by the presence of TCE (but no TCA exceedances) and related daughter products in soil and groundwater. With one possible exception, suspected DNAPL observed proximate to bedrock monitoring wells is not attributed to this source area (FS Report, pg.19)".

[31] Potential deleterious effects exist for RA #8 and were described more fully in the FS Report for RA #3. Injecting in-situ amendments in a manner designed to percolate into fractured bedrock is complex and injecting large quantities of amendments in reasonably close proximity to the LVC tributary also poses significant implementability concerns (e.g., human health and/or ecological risks that do not currently exist). Implementation concerns include a) dissolution of adsorbed-phase COCs and a consequent increase in the mass discharge rate of these COCs, b) discharge of the amendments themselves into the adjacent stream, c) injection measures could modify the groundwater flow and COC transport conditions which could cause undesirable conditions such as creation of VI exposure routes that do not currently exist, d) injection measures/amendments could be incompatible with observed natural attenuation mechanisms active at the Site (e.g., excessive methanogenesis due to over-application of ISCR amendments), e) injection measures could cause COCs or the amendments themselves to discharge at land surface (i.e., "day-lighting") and potentially produce adverse effects on human health and the environment, f) ineffective delivery of the amendment to the desired treatment intervals, g) loss of amendment to less-impacted but more transmissive bedrock fractures (i.e., not the desired fracture network where elevated CVOCs are located), h) loss of amendment to subsurface infrastructure (e.g., the abandoned AS/SVE piping network), and i) rebound effects after treatment including anticipated matrix back-diffusion.

to the same areas. More specifically, careful design, implementation and monitoring is required to prevent overdosing the source areas of AOCs 1 and 9 with ISCR amendment.

- A POET system (i.e., a carbon filtration system) is included in RA #8 to address drinking water associated with one private supply well located within the Site[32].

6.0 RA #8 Basis of Design

As described above, RA #8 is an integrated soil and groundwater remedy comprised of a principal groundwater component and soil/ground water source area mitigation measures. The principal groundwater component is FS Report RA #2 (described previously), which serves to protect human health and the environment (with respect to potential groundwater-related exposure pathways). As described in the FS Report, groundwater RA #2 anticipated the inclusion of complementary soil RAs for certain source areas within the Property, but evaluation of soil source area RAs was not included in the scope of the FS Report. Having now had the opportunity to consider DEP's soil RAs in the Technology Assessment Memo, the BT Team has prepared this FS Addendum that presents an integrated soil and groundwater remedy for the Site - RA #8 BOD Memo.

The BOD for the groundwater source area mitigation component of the integrated RA for the Site is discussed below, with additional detail contained in the following Attachments:

- Table 1 - Summary of Remedial Alternatives and Costs
- Table 2 - Miscellaneous Unit Costs for Remedial Process Options
- Table 3 - In-Situ Remedy Design, Unit Costs, and Assumptions
- Table 4 - Capital Cost Estimate for In-Situ Chemical Reduction in Building 8 Area (ISCR-1.4)
- Table 5 - OM&M Cost Estimate for Building 8 (ISCR-1.4)
- Table 6 - Capital Cost Estimate for In-Situ Chemical Reduction in DSA #3 (ISCR-1.5)
- Table 7 - OM&M Cost Estimate for DSA #3 (ISCR-1.5)
- Table 8 - Summary of Comparative Analysis of Remedial Alternatives
- Table 9 - Supplemental Summary of Comparative Analysis of Remedial Alternatives
- Figure 1 - RA #8 Conceptual In-Situ Groundwater Treatment Areas

The BOD for the groundwater component of RA #8 is described below.

- Target elevated CVOC concentrations in groundwater within overburden saturated soil and shallow bedrock in AOC 1 (Building 8 VDA) and shallow bedrock in AOC 9 (DSA #3).
- Employ ISCR injections within the Building 8 VDA and DSA #3 footprints as depicted on Figure 1 (with future adjustments based on applicable pre-design investigation and integration with soil source area mitigation designs).
- Employ a sequential/phased application of source area mitigation measures, as follows: 1) ISCR soil mixing as described in the Technology Assessment Memo; 2) groundwater quality monitoring to assess the effects of this ISCR soil mixing; and 3) focused ISCR injections in saturated soil to enhance CVOC source mass reduction in overburden and shallow bedrock groundwater. This approach for the supplemental groundwater component of RA #8 is necessary both to optimize the groundwater RA #8 design and to avoid over-application of the groundwater ISCR approach[33].

[32] In its "Analysis of Alternatives" it is anticipated that DEP will also consider a public water supply line connection as an alternative to a POET system to address the one private supply well within the Site.

[33] Over-applying ISCR amendments when implementing both soil and groundwater RAs could potentially cause: a) deleterious effects in the nearby tributary of LVC, b) generation of harmful vapors (e.g., methane), and c) negative effects on currently beneficial MNA (i.e., MNA inhibited by ISCR amendment conversion side-effects, such as excessive methanogenesis).

- Use direct-push injection ("DPI") amendment delivery to allow flexibility regarding injection area, flow rate, pressure, and depth interval for the purpose of optimizing amendment contact with residual CVOC mass and minimizing amendment daylighting/short-circuiting.
- DPI will be implemented in the saturated zone of the overburden aquifer, partially biased toward the base of the overburden interval (i.e., immediately above the top of weathered bedrock) so that ISCR amendments percolate downward into shallow bedrock via the same hydraulic regime and fracture pathway(s) that originally transmitted the CVOCs to the bedrock aquifer.
- Consistent with the FS Report, the DPI radius of influence ("ROI") is conservatively assumed to be 10 feet, the same ROI identified for in-situ approaches in the FS Report.
- Bench and pilot tests will be required for RA #8 to determine optimum amendment quantities and DPI application conditions, and a tracer may be used during the injection tests to assist in the assessment of ISCR amendment distribution.
- ISCR scopes of work and amendment applications for RA #8 are quantified using the implementation areas, depth intervals, and related groundwater treatment pore volumes below. As discussed in Section 4.0 above, groundwater source area mitigation RAs have been developed for AOC 1 (Building 8 VDA) and AOC 9 (DSA #3). For AOC 1 (Building 8 VDA) amendment quantities are estimated considering overburden and shallow bedrock treatment using the criteria in the embedded table below. For AOC 9 (DSA #3) amendment quantities are estimated considering only shallow bedrock treatment (because of the near absence of CVOCs in overburden groundwater) using the criteria in the embedded table below.

Area Considered for Amendment Calculation	Area (square feet)	Depth Interval (range in feet bgs)	Depth Interval Thickness (feet)	Total Volume (cubic feet)	Porosity (%)	Total GW Pore Volume (cubic feet)	Total GW Pore Volume (gallons)
Building 8 Overburden	4,325	6 – 16	10	43,250	30	12,975	97,053
Building 8 Shallow Bedrock	1,670	16 – 110	94	156,980	5	7,849	58,711
DSA #3 Shallow Bedrock	845	26 - 91	65	54,925	5	2,746	20,542

- ISCR amendment application rate criteria, as defined in the FS Report, was used for determining amendment quantities for RA #8, except for the following:
    - The ISCR amendment loading rate is increased from 0.066 pounds of amendment per gallon of treatment pore volume groundwater ("lbs/GW gal") to 0.086 lbs/GW gal to increase the amendment longevity in the aquifer; and
    - The ISCR amendment to water slurry ratio is decreased from 2.7 pounds of amendment mixed per gallon of water ("lbs/gal") to 1.35 lbs/gal to make the amendment slurry less viscous for improving amendment percolation into shallow bedrock.
- For evaluation and costing purposes, the groundwater ISCR approach for RA #8 utilizes the same amendment as in the FS Report (i.e., PeroxyChem EHC®), while acknowledging that other amendments (e.g., PeroxyChem Extended Release GeoForm with ELS Microemulsion organic carbon, TerraSystems SRS Emulsified Vegetable Oil with Zero Valent Iron) may be evaluated during pre-design testing. While subject to engineering design and presumptive pilot testing, the current amendment or any alternate amendment would be selected to be compatible with the amendment selected for the ISCR soil mixing RA.

The BOD assumptions described above for the groundwater source area mitigation component of an integrated RA #8 were incorporated into the detailed costing and screening tables revised from the FS Report and attached to this FS Addendum - RA #8 BOD Memo. The design conditions, associated costs, and comparative screenings for RA #8 (applicable to both the groundwater source area mitigation component and the RA #2 [MNA] component) are presented in greater detail on Tables 1 through 9, which consist of modified tables from the FS Report.

7.0 RA #8 Costs

RA #8 presents an integrated soil and groundwater remedy for the Site. The estimated total cost associated with the two groundwater components of this integrated Site remedy is approximately $4.7MM. Tables 1 through 7, attached, provide the backup for this estimated total cost. Since the selection and scope of the soil source mitigation component will be determined by the DEP and is subject to modification in the future (i.e., number, areal extent, and vertical extent of the AOCs, see discussion in Section 4.0), the estimated cost associated with the soil source area mitigation component of this integrated Site remedy is not included or discussed in this document. Certain data gaps, some of which might assist in refining the scope and cost of soil or groundwater RAs, have been identified in the RIR, FS Report, FS Addendum, and the Technology Assessment Memo[34]. Absent consensus with DEP as to the scope of soil or groundwater investigations, herein referred to as pre-design investigations, these pre-design costs are not included in the RA #8 cost estimate.

[34] Discussions with DEP would be required to develop a list of data gaps. This list could categorize investigative tasks into the following categories: general remedial investigation data gaps (see the RIR), data gaps related to effective scoping of the soil RAs, and data gaps related to effective scoping of groundwater RAs.

TABLES

Table 1. Summary of Remedial Alternatives and Costs. Former Bishop Tube Property; East Whiteland, Pennsylvania.

	Alternative 1 - No Action		Alternative 2 - MNA		Alternative 3 - ISCR		Alternative 4 - Single ISCO		Alternative 5 - ERD		Alternative 6 - Two-Part ISCO		Alternative 7 - Hydraulic Control		Alternative 8 - ISCR Supplement to ISCR Soil Mixing	
Active Period & Post-Remedial Years	Active Period	Post-Remedial	Active Period	Post-Remedial	Active Period[1]	Post-Remedial	Active Period[1]	Post-Remedial	Active Period[1]	Post-Remedial	Active Period[1]	Post-Remedial	Active Period	Post-Remedial	Active Period[1]	Post-Remedial
	NA	NA	0	30	7	23	11	19	7	23	12	18	30	0	7	23
Functional Areas	**Presumed Remedy**	**Estimated Cost**	**Presumed Remedy**	**Estimated Cost**	**Presumed Remedy**	**Estimated Cost**	**Presumed Remedy**	**Estimated Cost**	**Presumed Remedy**	**Estimated Cost**	**Presumed Remedy**	**Estimated Cost**	**Presumed Remedy**	**Estimated Cost**	**Presumed Remedy**	**Estimated Cost**
CVOCs IN ON-PROPERTY GROUNDWATER																
GW-1a-S/Building 8																
Capital[1]	No Action	$0	NA	NA	ISCR-1.1 Capital Cost	$5,642,480	ISCO-1.1 Capital Cost	$7,599,750	ERD-1.1 Capital Cost	$8,800,730	ISCO-1.3 Capital Cost	$8,022,690	HC-1.1 Capital Cost	$4,897,330	ISCR-1.4 Bldg. 8 Capital Cost	$808,560
O&M[2][3]	No Action	$0	MNA	See Common O&M Elements Below	ISCR-1.1 Active Period O&M Cost	$230,990	ISCO-1.1 Active Period O&M Cost	$292,890	ERD-1.1 Active Period O&M Cost	$230,060	ISCO-1.3 Active Period O&M Cost	$310,230	HC-1.1 Active Period O&M Cost	$17,084,810	ISCR-1.4 Bldg. 8 Active Period O&M Cost	$230,990
	NA	NA	NA	NA	Post-Remedial Care MNA	See Common O&M Elements Below	Post-Remedial Care MNA	See Common O&M Elements Below	Post-Remedial Care MNA	See Common O&M Elements Below	Post-Remedial Care MNA	See Common O&M Elements Below	NA	NA	Post-Remedial Care MNA	See Common O&M Elements Below
	NA	NA	Institutional Controls	See Common Capital & O&M Elements Below	Institutional Controls	See Common Capital & O&M Elements Below	Institutional Controls	See Common Capital & O&M Elements Below	Institutional Controls	See Common Capital & O&M Elements Below	Institutional Controls	See Common Capital & O&M Elements Below	Institutional Controls	See Common Capital & O&M Elements Below	Institutional Controls	See Common Capital & O&M Elements Below
GW-1a-S Total (Present Value)		$0		$0		$5,873,470		$7,892,640		$9,030,790		$8,332,920		$21,982,140		$1,139,550
GW-1a-D/Building 8	No Action	$0	MNA & Institutional Controls	See Common Capital & O&M Elements Below	MNA & Institutional Controls	See Common Capital & O&M Elements Below	MNA & Institutional Controls	See Common Capital & O&M Elements Below	MNA & Institutional Controls	See Common Capital & O&M Elements Below	MNA & Institutional Controls	See Common Capital & O&M Elements Below	MNA & Institutional Controls	See Common Capital & O&M Elements Below	MNA & Institutional Controls	See Common Capital & O&M Elements Below
GW-1a-D (Present Value)		$0		$0		$0		$0		$0		$0		$0		$0
GW-1b-S/DSA																
Capital[1]	No Action	$0	NA	NA	ISCR-1.2 Capital Cost	$958,380	ISCO-1.2 Capital Cost	$1,076,590	ERD-1.2 Capital Cost	$1,148,860	ISCO-1.4 Capital Cost	$1,233,330	HC-1.1 Capital Cost	Capital Cost incl. in GW-1a-S Above	ISCR-1.5 DSA Capital Cost	$766,560
O&M[2][3]	No Action	$0	MNA	See Common O&M Elements Below	ISCR-1.2 Active Period O&M Cost	$30,260	ISCO-1.2 Active Period O&M Cost	$37,360	ERD-1.2 Active Period O&M Cost	$30,260	ISCO-1.4 Active Period O&M Cost	$39,570	HC-1.1 Active Period O&M Cost	O&M Cost incl. in GW-1a-S Above	ISCR-1.5 DSA Active Period O&M Cost	$30,260
	NA	NA	NA	NA	Post-Remedial Care MNA	See Common O&M Elements Below	Post-Remedial Care MNA	See Common O&M Elements Below	Post-Remedial Care MNA	See Common O&M Elements Below	Post-Remedial Care MNA	See Common O&M Elements Below	NA	NA	Post-Remedial Care MNA	See Common O&M Elements Below
	NA	NA	Institutional Controls	See Common Capital & O&M Elements Below	Institutional Controls	See Common Capital & O&M Elements Below	Institutional Controls	See Common Capital & O&M Elements Below	Institutional Controls	See Common Capital & O&M Elements Below	Institutional Controls	See Common Capital & O&M Elements Below	Institutional Controls	See Common Capital & O&M Elements Below	Institutional Controls	See Common Capital & O&M Elements Below
GW-1b-S (Present Value)		$0		$0		$988,640		$1,113,950		$1,179,120		$1,272,900		$0		$796,820
GW-1b-D/DSA	No Action	$0	MNA & Institutional Controls	See Common Capital & O&M Elements Below	MNA & Institutional Controls	See Common Capital & O&M Elements Below	MNA & Institutional Controls	See Common Capital & O&M Elements Below	MNA & Institutional Controls	See Common Capital & O&M Elements Below	MNA & Institutional Controls	See Common Capital & O&M Elements Below	MNA & Institutional Controls	See Common Capital & O&M Elements Below	MNA & Institutional Controls	See Common Capital & O&M Elements Below
GW-1b-D (Present Value)		$0		$0		$0		$0		$0		$0		$0		$0
GW-1c-S/Building 5	No Action	$0	MNA & Institutional Controls	See Common Capital & O&M Elements Below	MNA & Institutional Controls	See Common Capital & O&M Elements Below	MNA & Institutional Controls	See Common Capital & O&M Elements Below	MNA & Institutional Controls	See Common Capital & O&M Elements Below	MNA & Institutional Controls	See Common Capital & O&M Elements Below	MNA & Institutional Controls	See Common Capital & O&M Elements Below	MNA & Institutional Controls	See Common Capital & O&M Elements Below
GW-1c-S (Present Value)		$0		$0		$0		$0		$0		$0		$0		$0
CVOCs IN OFF-PROPERTY GROUNDWATER																
GW-2a-S/Off-Property South																
Capital[1]	No Action	$0	NA	NA	ISCR-2.1 Capital Cost	$2,800,670	ISCO-2.1 Capital Cost	$3,759,490	ERD-2.1 Capital Cost	$3,697,590	ISCO-2.2 Capital Cost	$3,811,430	HC-2.1 Capital Cost	$1,987,990	NA	$0
O&M[2][3]	No Action	$0	MNA	See Common O&M Elements Below	ISCR-2.1 O&M Cost	$229,140	ISCO-2.1 O&M Cost	$286,750	ERD-2.1 O&M Cost	$228,210	ISCO-2.2 O&M Cost	$303,730	HC-2.1 O&M Cost	$4,758,260	ISCR-2.1 O&M Cost (for MNA & Downgradient ISCR Monitoring)	$229,140
	NA	NA	NA	NA	Post-Remedial Care MNA	See Common O&M Elements Below	Post-Remedial Care MNA	See Common O&M Elements Below	Post-Remedial Care MNA	See Common O&M Elements Below	Post-Remedial Care MNA	See Common O&M Elements Below	NA	NA	Post-Remedial Care MNA	See Common O&M Elements Below
	NA	NA	Institutional Controls	See Common Capital & O&M Elements Below	Institutional Controls	See Common Capital & O&M Elements Below	Institutional Controls	See Common Capital & O&M Elements Below	Institutional Controls	See Common Capital & O&M Elements Below	Institutional Controls	See Common Capital & O&M Elements Below	Institutional Controls	See Common Capital & O&M Elements Below	Institutional Controls	See Common Capital & O&M Elements Below
GW-2a-S (Present Value)		$0		$0		$3,029,810		$4,046,240		$3,925,800		$4,115,160		$6,746,270		$229,140
GW-2a-D/Off-Property South	No Action	$0	MNA & Institutional Controls	See Common Capital & O&M Elements Below	MNA & Institutional Controls	See Common Capital & O&M Elements Below	MNA & Institutional Controls	See Common Capital & O&M Elements Below	MNA & Institutional Controls	See Common Capital & O&M Elements Below	MNA & Institutional Controls	See Common Capital & O&M Elements Below	MNA & Institutional Controls	See Common Capital & O&M Elements Below	MNA & Institutional Controls	See Common Capital & O&M Elements Below
GW-2a-D (Present Value)		$0		$0		$0		$0		$0		$0		$0		$0
GW-2b-S/Off-Property North	No Action	$0	MNA & Institutional Controls	See Common Capital & O&M Elements Below	MNA & Institutional Controls	See Common Capital & O&M Elements Below	MNA & Institutional Controls	See Common Capital & O&M Elements Below	MNA & Institutional Controls	See Common Capital & O&M Elements Below	MNA & Institutional Controls	See Common Capital & O&M Elements Below	MNA & Institutional Controls	See Common Capital & O&M Elements Below	MNA & Institutional Controls	See Common Capital & O&M Elements Below
GW-2b-S (Present Value)		$0		$0		$0		$0		$0		$0		$0		$0
GW-2b-D/Off-Property North	No Action	$0	MNA & Institutional Controls	See Common Capital & O&M Elements Below	MNA & Institutional Controls	See Common Capital & O&M Elements Below	MNA & Institutional Controls	See Common Capital & O&M Elements Below	MNA & Institutional Controls	See Common Capital & O&M Elements Below	MNA & Institutional Controls	See Common Capital & O&M Elements Below	MNA & Institutional Controls	See Common Capital & O&M Elements Below	MNA & Institutional Controls	See Common Capital & O&M Elements Below
GW-2b-D (Present Value)		$0		$0		$0		$0		$0		$0		$0		$0
INORGANICS IN ON-PROPERTY GROUNDWATER																
GW-1d-S/Inorganics																
Capital[1]	No Action	$0	NA	NA	ISCR-1.3 Capital Cost	$3,659,480	ISCR-1.3 Capital Cost	$3,659,480	ISCR-1.3 Capital Cost	$3,659,480	ISCR-1.3 Capital Cost	$3,659,480	HC-1.2 Capital Cost	$1,511,690	NA	$0
O&M[2][3]	No Action	$0	MNA	See Common O&M Elements Below	ISCR-1.3 O&M Cost	$178,340	ISCR-1.3 O&M Cost	$248,140	ISCR-1.3 O&M Cost	$178,340	ISCR-1.3 O&M Cost	$262,830	HC-1.2 O&M Cost	$6,329,180	ISCR-1.3 O&M Cost (for MNA Monitoring)	$178,340
	NA	NA	NA	NA	Post-Remedial Care MNA	See Common O&M Elements Below	Post-Remedial Care MNA	See Common O&M Elements Below	Post-Remedial Care MNA	See Common O&M Elements Below	Post-Remedial Care MNA	See Common O&M Elements Below	NA	NA	Post-Remedial Care MNA	See Common O&M Elements Below
	NA	NA	Institutional Controls	See Common Capital & O&M Elements Below	Institutional Controls	See Common Capital & O&M Elements Below	Institutional Controls	See Common Capital & O&M Elements Below	Institutional Controls	See Common Capital & O&M Elements Below	Institutional Controls	See Common Capital & O&M Elements Below	Institutional Controls	See Common Capital & O&M Elements Below	Institutional Controls	See Common Capital & O&M Elements Below
GW-1d-S (Present Value)		$0		$0		$3,837,820		$3,907,620		$3,837,820		$3,922,310		$7,640,870		$178,340
DNAPL																
D-1	No Action	$0	Technical Impracticability	$50,000	Technical Impracticability	$50,000	Technical Impracticability	$50,000	Technical Impracticability	$50,000	Technical Impracticability	$50,000	Technical Impracticability	$50,000	Technical Impracticability	$50,000
D-1 (Present Value)		$0		$50,000		$50,000		$50,000		$50,000		$50,000		$50,000		$50,000
LITTLE VALLEY CREEK																
LVC-1 (On-Property)																
Capital[1]	No Action	$0	BMPs	$358,530	BMPs	$358,530	BMPs	$358,530	BMPs	$358,530	BMPs	$358,530	BMPs	$358,530	BMPs	$358,530
			LVC Institutional Controls	$15,000	LVC Institutional Controls	$15,000	LVC Institutional Controls	$15,000	LVC Institutional Controls	$15,000	LVC Institutional Controls	$15,000	LVC Institutional Controls	$15,000	LVC Institutional Controls	$15,000
O&M[2][3]			LVC BMP O&M[4][5][9]	$944,640	LVC BMP O&M[4][5][9]	$944,640	LVC BMP O&M[4][5][9]	$944,640	LVC BMP O&M[4][5][9]	$944,640	LVC BMP O&M[4][5][9]	$944,640	LVC BMP O&M[4][5][9]	$944,640	LVC BMP O&M[4][5][9]	$944,640
LVC-1 (On-Property: Present Value)		$0		$1,318,170		$1,318,170		$1,318,170		$1,318,170		$1,318,170		$1,318,170		$1,318,170
COMMON CAPITAL ELEMENTS																
Property-Wide Common Elements	No Action	$0	Groundwater Institutional Controls	$100,000	Groundwater Institutional Controls	$100,000	Groundwater Institutional Controls	$100,000	Groundwater Institutional Controls	$100,000	Groundwater Institutional Controls	$100,000	Groundwater Institutional Controls	$100,000	Groundwater Institutional Controls	$100,000
	POET O&M Plan	$0	POET O&M Plan	$3,000	POET O&M Plan	$3,000	POET O&M Plan	$3,000	POET O&M Plan	$3,000	POET O&M Plan	$3,000	POET O&M Plan	$3,000	POET O&M Plan	$3,000
Common Capital Cost Totals		$0		$103,000		$103,000		$103,000		$103,000		$103,000		$103,000		$103,000
COMMON O&M ELEMENTS (AFTER ACTIVE REMEDIATION IS COMPLETED)																
Elements/Cost Type	**Annual Cost**	**Present Value Total Cost**	**Annual Cost[6]**	**Present Value Total Cost[10]**	**Annual Cost[6]**	**Present Value Total Cost[10]**	**Annual Cost[6]**	**Present Value Total Cost[10]**	**Annual Cost[6]**	**Present Value Total Cost[10]**	**Annual Cost[6]**	**Present Value Total Cost[10]**	**Annual Cost[6]**	**Present Value Total Cost[10]**	**Annual Cost[6]**	**Present Value Total Cost[10]**
POET O&M&M		$0	$4,900	$34,420	$4,900	$34,420	$4,900	$34,420	$4,900	$34,420	$4,900	$34,420	$4,900	$34,420	$4,900	$34,420
Post-Remedial Care O&M Rerorine	No Action	$0	$50,000	$620,460	$31,140	$351,020	$23,750	$245,480	$31,140	$351,020	$22,200	$223,320	$6,570	$0	$31,140	$351,020
Post-Remedial Care MNA Sampling	No Action	$0	$64,520	$800,640	$40,180	$452,920	$30,650	$316,790	$40,180	$452,920	$28,650	$288,200	$8,480	$0	$40,180	$452,920
Post-Remedial Cost to Maintain Institutional Controls	No Action	$0	$5,000	$62,050	$3,110	$35,060	$2,380	$24,600	$3,110	$35,060	$2,220	$22,340	$660	$0	$3,110	$35,060
Common O&M Totals (Present Value)		$0		$1,517,570		$873,420		$621,290		$873,420		$568,280		$34,420		$873,420
Total Present Value per Alternative		**$0**		**$2,988,740**		**$16,074,130**		**$19,052,910**		**$20,318,120**		**$19,682,740**		**$38,874,870**		**$4,488,440**

Footnotes:

1. All supporting cost contained in the Appendix E cost tables are rounded up to the nearest $10 increment on this Summary of Remedial Alternatives and Costs Table.

Footnotes:

(1) Capital Costs for remedial process options include pre-design, design, and implementation of the remedial process options.

(2) Operation Maintenance and Monitoring (OM&M) Costs include performance monitoring and reporting associated with the remedial process option.

(3) Alternative #3 includes ISCR-1.1, ISCR-1.2, and ISCR-2.1 each requiring pre-design injection testing and design in year 1, three injection events (100%, 75% and 50% reductant injections) and performance monitoring performed over 2 years each for a total ISCR remediation period of 7 years. ISCR-1.3 can be completed subsequently to the other ISCR remedial process options so additional active remediation time is not required, making the active remediation period for Alternative #3 equate to 7 years.

(4) Alternative #4 includes ISCO-1.1, ISCO-1.2, and ISCO-2.1 each requiring pre-design injection testing and design in year 1, three injection events (100%, 75% and 50% oxidant injections) and performance monitoring performed over 1 year each for a total ISCO remediation period of 4 years. Because ISCR-1.3 must be completed subsequently to the ISCO remedial process options, an additional 7 years of active remediation is required, making the active remediation period for Alternative #4 equate to 11 years.

(5) Alternative #5 includes ERD-1.1, ERD-1.2, and ERD-2.1 each requiring pre-design injection testing and design in year 1, three injection events (100%, 75% and 50% ERD injections) and performance monitoring performed over 2 years each for a total ERD remediation period of 7 years. ISCR-1.3 can be completed subsequently to the ERD remedial process options so additional active remediation time is not required, making the active remediation period for Alternative #5 equate to 7 years.

(6) Alternative #6 includes ISCO-1.3, ISCO-1.4, and ISCO-2.2 each requiring pre-design injection testing and design in year 1, three permanganate injection events (100%, 75% and 50% oxidant injections), one ISAC injection event, and performance monitoring performed over 1 year each for a total ISCO remediation period of 5 years. Because ISCR-1.3 must be completed subsequently to the ISCO remedial process options, an additional 7 years of active remediation is required, making the active remediation period for Alternative #6 equate to 12 years.

(7) MNR for LVC-1 is considered to be required for the full 30-year FS evaluation timeframe regardless of any active remediation period considered in any particular remedial alternative. Therefore, common MNR sampling and reporting costs are only applied as an LVC-1 BMP O&M cost for the full 30 years of evaluation in each applicable remedial alternative.

(8) BMP O&M for LVC-1 is considered to be required for the full 30-year FS evaluation timeframe regardless of any active remediation period considered in any particular remedial alternative. Therefore, common BMP O&M costs are only applied as an LVC-1 BMP O&M cost for the full 30 years of evaluation in each applicable remedial alternative.

(9) Annual POET O&M&M is discounted for present value with a discount period equivalent to the total remedial period of 10 years and a 7% interest discount rate. Annual Post-Remedial Care Costs for Common O&M&M Elements are discounted for present value with a discount period equivalent to the end of the active remedial period and a 7% interest rate.

(10) POET O&M&M includes an allowance of $4,900 annually for one existing POET ($49,000 total over 10 years, see Table E-1 in Appendix E) and its Present Value Cost is calculated using the Active and Post-Remedial period 10-year duration and a 7% interest discount rate. The annual POET O&M&M cost is based on one carbon filter changeout every three years.

Table 2. Miscellaneous Unit Cost for Remedial Process Options. Former Bishop Tube Property; East Whiteland, PA.

Miscellaneous Unit Costs		
Drilling and Injection Subcontractor Costs		
$25,000	Design and Reporting Support	Vendor Quote
$25,000	Mobilization of Equipment	Vendor Quote
$25,000	Site Set-up	Vendor Quote
$4,500	Injection Crew and Equipment (per day)	Vendor Quote
$900	DPT Rig and Operator per Injection Point (Overburden)	Vendor Quote
$60	Sonic Drilling for Injection per linear foot (Bedrock)	Vendor Quote
$31	Sonic Drilling for Abandonment per linear foot (Bedrock)	Vendor Quote
$25,000	Demobilization	Vendor Quote
Remedial Action Add-ons		
$100,000	Site-Wide Groundwater Institutional Controls Capital Cost	Professional judgment based on similar projects
$15,000	BMP Institutional Controls Capital Cost	Professional judgment based on similar projects
$150,000	In-Situ Pre-Design & Injection Testing	Professional judgment based on similar projects
$50,000	Engineering Design	Professional judgment based on similar projects
$20,000	Site Preparation and Permitting	Professional judgment based on similar projects
75%	2nd Injection Event	Professional judgment based on similar projects
50%	3rd Injection Event	Professional judgment based on similar projects
75%	Plumestop Injection Event (chlorinated ethane polishing event)	Professional judgment based on similar projects
20%	Contingency Cost	Professional judgment based on similar projects
20%	Roux Oversight & Implementation PM (% of Total Capital Cost)	Professional judgment based on similar projects
$50,000	Technical Impracticability Establishment	Professional judgment based on similar projects
$5,000	Institutional Controls Annual Cost	Professional judgment based on similar projects
$25,000	Semi Annual Report Cost (per report)	Professional judgment based on similar projects
$3,000	POET OM&M Plan Development	Professional judgment based on similar projects
$49,000	Total 10-year POET OM&M of $49K comprised of: a) 8 annual POET inspection, sampling, and reporting events at $2.5K each; b) treatment component replacement/disposal – 3 total (every 3 years) at $3K each; and c) 8 quarterly compliance attainment sampling/reporting events at $2.5K each for years 9 and 10.	Professional judgment based on similar projects

Table 3. In-Situ Remedy Design, Unit Costs and Assumptions. Former Bishop Tube Property; East Whiteland, PA.

Injection Calcs	GW-1a-S (O)	GW-1a-S (BR)	GW-1b-S (BR)	GW-2a-S (O)	GW-2a-S (BR)	GW-1d-S (O)	GW-1d-S (BR)	RA #8 - Bldg.8 (OB)	RA #8 - Bldg.8 (BR)	RA #8 - DSA #3 (BR)	Unit Origin / Comments
Area of Injection (sq ft)	30,400	25,750	2,515	11,100	11,100	17,354	17,354	4,325	1,670	845	Based on conceptual remedial process option area
Injection ROI (ft)	10	10	10	10	10	10	10	10	10	10	Professional judgment per similar hydraulic injections (no pneumatic fracturing)
Min. Number of Injection Pts. (#)	97	82	8	35	35	55	55	14	5	3	Based on conceptual remedial process option design
Top of Treatment Interval (ft bgs)	6	16	26	5	21	6	16	6	16	26	Per RI information
Bottom of Treatment Interval (ft bgs)	16	120	120	21	120	16	100	16	110	91	Per RI information
Treatment Interval (ft)	10	104	94	16	99	10	84	10	94	65	Calculated
Total Treatment Volume (cu ft)	304,000	2,678,000	236,410	177,600	1,098,900	173,540	1,457,736	43,250	156,980	54,925	Calculated
Porosity (%)	0.30	0.05	0.05	0.30	0.05	0.30	0.05	0.30	0.05	0.05	Professional judgment based on Site-Specific Conceptual Site Model
Total GW Pore Volume (cu ft)	91,200	133,900	11,821	53,280	54,945	52,062	72,887	12,975	7,849	2,746	Calculated
Total GW Pore Volume (gallons)	682,176	1,001,572	88,417	398,534	410,989	389,424	545,193	97,053	58,711	20,542	Calculated
GW Pore Volume Per Injection Point (gallons)	7,033	12,214	11,052	11,387	11,743	7,080	9,913	6,932	11,742	6,847	Calculated
Cost of Water per Gallon ($)	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	$1,000 per 5,000 gallons of water - Vendor Quote
EHC Injections											
EHC Mass Required per Point (lbs)	465	807	730	752	776	468	655	597	1,010	589	Original FS loading rate of 0.066 lbs amendment/gal of GW Pore Vol. (50% of persulfate rate based on professional judgment) / Loading rate increased to 0.086 lbs amendment/gal of GW Pore Vol. for RA #8 approach because RA #8 relies on increased amendment distribution and greater amendment longevity
EHC Mass Required per FA (lbs)	45,105	66,174	5,840	26,320	27,160	25,740	36,025	8,358	5,050	1,767	Calculated
Cost/lb EHC (CVOCs) & EHC-M (Inorganics) ($)	2.25	2.25	2.25	2.25	2.25	3.50	3.50	2.25	2.25	2.25	Vendor Quote
Water Volume Required per Point (gallons)	172	299	270	279	287	173	243	442	748	436	Mix water ratio of 2.7 lbs amendment/gal of water for original FS applications per injection contractor recommendation & Engineering Experience / Mix water ratio of 1.35 lbs amendment/gal of water used for RA#8 because a less viscous amendment is needed to inject in overburden and percolate into shallow bedrock
Water Volume Required per FA (gallons)	16,706	24,509	2,163	9,748	10,059	9,533	13,343	6,191	3,741	1,309	Calculated
EHC Slurry Volume (gallons)	22,866	33,548	2,961	13,343	13,769	13,049	18,263	6,839	4,132	1,446	Based on 32.4% EHC slurry (by weight) per injection contractor recommendation for original FS approach (for greater "staying" power) and 16.2% EHC Slurry for RA#8 lower viscosity approach.
Approximate Percentage of Pore Space (%)	3.4%	3.3%	3.3%	3.3%	3.4%	3.4%	3.3%	7.0%	7.0%	7.0%	Lower pore volume injection % than other in-situ RAs because EHC viscosity is greater than other in-situ amendments evaluated and EHC provides greater treatment persistence.
EHC Slurry Volume per Point (gallons)	236	409	370	381	393	237	332	488	826	482	
EHC Slurry Volume Injected per Day	1014	982	999	991	984	996	996	1612	1570	1590	
Injection Points per Day	4.30	2.40	2.70	2.60	2.50	4.20	3.00	3.30	1.90	3.30	2,000 lbs/day per vendor input & similar project experience
Slurry Gallons Injected per Day	1,013.7	981.9	999.2	991.2	983.5	996.5	996.2	1,612.0	1,570.2	1,590.4	For RA#8 assumes 1600-gallons of slurry injection per day - between EHC & persulfate injection rate - accounts for tight overburden
Persulfate Injections											
Persulfate Mass Required per Point (lbs)	929	1,613	1,459	1,504	1,551	NA					Loading rate of 0.132 lbs amendment/gal of pore volume GW from vendor quote
Persulfate Mass Required per FA (lbs)	90,113	132,266	11,672	52,640	54,285						Calculated
Cost/lb Persulfate ($)	2.20	2.20	2.20	2.20	2.20						Vendor Quote
Water Volume Required per Point (gallons)	995	1,728	1,563	1,611	1,662						Percent by weight solution calculation - Vendor Quote
Water Volume Required per FA (gallons)	96,550	141,714	12,506	56,400	58,163						Calculated
Persulfate Slurry Volume (gallons)	101,205	148,547	13,109	59,119	60,967						Based on 10% persulfate solution (by weight) per amendment vendor recommendation
Approximate Percentage of Pore Space (%)	15%	15%	15%	15%	15%						Pore volume injection percentage based on stoichiometric loading rate and amendment vendor recommendation
Injection Points per Day	2.10	1.20	1.30	1.30	1.20						2,000 lbs/day per vendor input & similar project experience
Slurry Gallons Injected per Day	2,191.0	2,173.9	2,130.2	2,195.9	2,090.3						
Permanganate Injections											
Permanganate Mass Required per Point (lbs)	465	807	730	752	776	NA					Loading rate of 0.066 lbs amendment/gal of GW Pore Vol. (50% of persulfate rate based on professional judgment)
Permanganate Mass Required per FA (lbs)	45,105	66,174	5,840	26,320	27,160						Calculated
Cost/lb Permanganate ($)	3.00	3.00	3.00	3.00	3.00						Vendor Quote
Water Volume Required per Point (gallons)	735	1,276	1,155	1,189	1,227						Percent by weight solution calculation - Vendor Quote
Water Volume Required per FA (gallons)	71,340	104,663	9,237	41,629	42,957						Calculated
Permanganate Solution Volume (gallons)	103,713	152,158	13,428	60,519	62,451						NaMnO4 40% diluted to 5% Solution per amendment vendor recommendation and desired pore volume injection %
Approximate Percentage of Pore Space (%)	15%	15%	15%	15%	15%						Pore volume injection % similar to persulfate-based ISCO approach
Injection Points per Day	4.30	2.40	2.70	2.60	2.50						2,000 lbs/day per vendor input & similar project experience
Solution Gallons Injected per Day	4,597.6	4,453.4	4,532.0	4,495.7	4,460.8						

Table 3. In-Situ Remedy Design, Unit Costs and Assumptions. Former Bishop Tube Property; East Whiteland, PA.

Injection Calcs	GW-1a-S (O)	GW-1a-S (BR)	GW-1b-S (BR)	GW-2a-S (O)	GW-2a-S (BR)	GW-1d-S (O)	GW-1d-S (BR)	RA #8 - Bldg.8 (OB)	RA #8 - Bldg.8 (BR)	RA #8 - DSA #3 (BR)	Unit Origin / Comments
Molasses Injections											
Molasses Mass Required per Point (lbs)	2,110	3,665	3,316	3,417	3,523	NA					Loading rate = 0.3 lbs/gal of pore volume GW per Treatability Study (TS) + 50% factor of safety to account for limited TS success
Molasses Mass Required per FA (lbs)	204,670	300,530	26,528	119,595	123,305						Calculated
Cost/lb Molasses ($)	0.50	0.50	0.50	0.50	0.50						Vendor Quote
Water Volume Required per Point (gallons)	2,269	3,941	3,566	3,674	3,788						Mix water ratio of 0.93 lbs of Molasses/gallon of water - TS Experience
Water Volume Required per FA (gallons)	220,075	323,151	28,525	128,597	132,586						Calculated
Molasses Solution Volume (gallons)	237,568	348,837	30,792	138,819	143,125						Based on 0.93 lbs of Molasses/gallon of water solution mixture - TS Experience
Approximate Percentage of Pore Space (%)	35%	35%	35%	35%	35%						Greater pore volume injection % than other in-situ RAs because of the need to maintain more molasses solution in the targeted pore volume per TS experience
Injection Points per Day	1.10	0.60	0.70	0.70	0.70						2,500 lbs/day per vendor input & similar project experience
Solution Gallons Injected per Day	2,694.1	2,552.5	2,694.3	2,776.4	2,862.5						
Activated Carbon Injections											
ISAC Mass Required per Point (lbs)	774	1,344	1,216	1,253	1,292	NA					Loading rate of 0.11 lbs/gal of aquifer GW - Engineering Experience
ISAC Mass Required per FA (lbs)	75,078	110,208	9,728	43,855	45,220						Calculated
Cost/lb ISAC ($)	1.00	1.00	1.00	1.00	1.00						Vendor Quote
Water Volume Required per Point (gallons)	645	1,120	1,013	1,044	1,077						Mix water ratio of 1.2 lbs amendment/gallon of water - Vendor Quote
Water Volume Required per FA (gallons)	62,565	91,840	8,107	36,546	37,683						Calculated
ISAC Slurry Volume (gallons)	103,243	151,551	13,377	60,307	62,184						Based on mix water ratio of 1.2 lbs amendment/gallon of water - Vendor Quote
Approximate Percentage of Pore Space (%)	15%	15%	15%	15%	15%						Pore volume injection % similar to ISCO due to similar amendment viscosity and distribution approach
Injection Points per Day	4.30	2.40	2.70	2.60	2.50						3,350 lbs/day per vendor input & similar project experience
Slurry Gallons Injected per Day	4,576.7	4,435.6	4,514.9	4,479.9	4,441.7						

Notes:

1. A conservative 10-foot radius of influence was used for in-situ amendment injections. Based on DEP input, this assumption may be overly conservative, especially with regard to the shallow bedrock aquifer. However, since this assumption is uniformly applied to all of the applicable in-situ injection remedial alternatives, the assumption does not affect remedy selection. The assumed 10-foot radius of influence is predicted to be a minimum radius of influence for shallow bedrock and a more refined estimate of the injection radius of influence for both overburden and shallow bedrock may be determined, if this remedial alternative is selected by DEP, from pre-design testing.

Table 4. Capital Cost Estimate for In-situ Chemical Reduction in Building 8 Area (ISCR-1.4). Former Bishop Tube Property; East Whiteland, PA.

Task 1 - Baseline Groundwater Sampling					
Roux Associates, Inc.			*Subtotal Roux Associates Labor*	$	8,145
Roux Associates, Inc. - Expenses and Equipment			*Subtotal Roux Associates Expenses and Equipment*	$	2,640
Laboratory Subcontractor					
VOC+15	19	samples @	$72 /sample	$	1,359
TAL Metals	11	samples @	$127 /sample	$	1,392
Hardness	7	samples @	$44 /sample	$	308
Chloride	7	samples @	$31 /sample	$	216
Sulfate	7	samples @	$31 /sample	$	216
Nitrate/Nitrite	7	samples @	$50 /sample	$	347
Total Organic Carbon	7	samples @	$31 /sample	$	216
Dissolved Organic Carbon	7	samples @	$75 /sample	$	524
Alkalinity	7	samples @	$20 /sample	$	139
Volatile Fatty Acids	7	samples @	$220 /sample	$	1,540
Methane/Ethane/Ethene	7	samples @	$121 /sample	$	847
CO_2 Headspace	7	samples @	$132 /sample	$	924
			Subtotal Subcontractor	$	8,025
			Total Task 1	**$**	**18,810**
Task 2 - Engineering Design & Site Preparation					
Roux Associates, Inc.					
In-Situ Pre-Design & Injection Testing	1	l.s. @	$150,000 /l.s.	$	150,000
Engineering Design	1	l.s. @	$50,000 /l.s.	$	50,000
			Subtotal Roux Associates Labor	$	200,000
			Total Task 2	**$**	**200,000**

Task 3 - Remedial Implementation					
Task 3a - 100% Injection					
Drilling Subcontractor					
Design & Reporting Support to Roux	1	l.s. @	$25,000 /l.s.	$	25,000
Mobilization/Demobilization	1	l.s. @	$50,000 /l.s.	$	50,000
Site Set-up	1	l.s. @	$25,000 /l.s.	$	25,000
Injection Crew and Equipment	7	days @	$4,500 /day	$	31,500
DPT Rig and Operator (Overburden)	14	points @	$900 /point	$	12,600
Sonic Drilling for Injections (Bedrock)	0	lf @	$60 /lf	$	0
Sonic Drilling for Abandonment (Bedrock)	0	lf @	$31 /lf	$	0
EHC (includes delivery)	13,408	lbs @	$2.25 /lb	$	30,168
Water	9,932	gallons @	$0.20 /gallon	$	1,986
			Subtotal Driller	$	176,254
			Service Charge (10%)	$	17,625
			Subtotal incl. Service Charge	$	*193,880*
Roux Associates Oversight & Implementation PM				$	*38,776*
			Subtotal for 100% Injection	**$**	***232,656***
Task 3b - 75% Injection					
Subcontractor					
Driller incl. 10% Service Charge				$	*145,410*
Roux Associates Oversight & Implementation PM				$	*29,082*
			Subtotal for 75% Injection	**$**	***174,492***
Task 3c - 50% Injection					
Subcontractor					
Driller incl. 10% Service Charge				$	*96,940*
Roux Associates Oversight & Implementation PM				$	*19,388*
			Subtotal for 50% Injection	**$**	***116,328***
			Total Task 3	**$**	**523,475**

Task 4 - Project Management Support			
Roux Associates, Inc. (2% of Task 1 through 3c)	**Total Task 4**	**$**	**14,846**
	Subtotal ISCR-1.4	**$**	**757,131**
	20% Contingency ISCR-1.4	**$**	**151,426**
	Total ISCR-1.4	**$**	**908,560**

Table 5. OM&M Cost Estimate for Building 8 (ISCR-1.4). Former Bishop Tube Property; East Whiteland, PA.

Task 1 - Groundwater Sampling					
Roux Associates, Inc.			*Subtotal Roux Associates Labor*	$	8,145
Roux Associates, Inc. - Expenses and Equipment			*Subtotal Roux Associates Expenses and Equipment*	$	2,640
Laboratory Subcontractor					
VOC+15	18	samples @	$72 /sample	$	1,287
TAL Metals	10	samples @	$127 /sample	$	1,265
Hardness	6	samples @	$44 /sample	$	264
Chloride	6	samples @	$31 /sample	$	185
Sulfate	6	samples @	$31 /sample	$	185
Nitrate/Nitrite	6	samples @	$50 /sample	$	297
Total Organic Carbon	6	samples @	$31 /sample	$	185
Dissolved Organic Carbon	6	samples @	$75 /sample	$	449
Alkalinity	6	samples @	$20 /sample	$	119
Volatile Fatty Acids	6	samples @	$220 /sample	$	1,320
Methane/Ethane/Ethene	6	samples @	$121 /sample	$	726
CO_2 Headspace	6	samples @	$132 /sample	$	792
			Subtotal Subcontractor		7,073
			Subtotal Task 1	**$**	***17,858***
			Number of Events per Year	$	*2*
			Total Task 1 per Year	**$**	**35,716**
Task 2 - Project Management Support					
Roux Associates, Inc.			**Total Task 2**	**$**	**7,143**
			Total ISCR-1.4 Annual OM&M	**$**	**42,859**

Table 6. Capital Cost Estimate for In-situ Chemical Reduction in DSA #3 (ISCR-1.5). Former Bishop Tube Property; East Whiteland, PA.

Task 1 - Baseline Groundwater Sampling					
Roux Associates, Inc.			*Subtotal Roux Associates Labor*	$	750
Roux Associates, Inc. - Expenses and Equipment			*Subtotal Roux Associates Expenses and Equipment*	$	440
Laboratory Subcontractor					
VOC+15	2	samples @	$72 /sample	$	143
TAL Metals	2	samples @	$127 /sample	$	253
Hardness	1	sample @	$44 /sample	$	44
Chloride	1	sample @	$31 /sample	$	31
Sulfate	1	sample @	$31 /sample	$	31
Nitrate/Nitrite	1	sample @	$50 /sample	$	50
Total Organic Carbon	1	sample @	$31 /sample	$	31
Dissolved Organic Carbon	1	sample @	$75 /sample	$	75
Alkalinity	1	sample @	$20 /sample	$	20
Volatile Fatty Acids	1	sample @	$220 /sample	$	220
Methane/Ethane/Ethene	1	sample @	$121 /sample	$	121
CO_2 Headspace	1	sample @	$132 /sample	$	132
			Subtotal Subcontractor	$	1,150
			Total Task 1	**$**	**2,340**
Task 2 - Engineering Evaluation and Site Preparation					
Roux Associates, Inc.					
In-Situ Pre-Design & Injection Testing	1	l.s. @	$150,000 /l.s.	$	150,000
Engineering Design	1	l.s. @	$50,000 /l.s.	$	50,000
			Subtotal Roux Associates Labor	$	200,000
			Total Task 2	**$**	**200,000**

Task 3 - Remedial Implementation					
Task 3a - 100% Injection					
Drilling Subcontractor					
Design and Reporting Support	1	l.s. @	$25,000 /l.s.	$	25,000
Mobilization/Demobilization	1	l.s. @	$50,000 /l.s.	$	50,000
Site Set-up	1	l.s. @	$25,000 /l.s.	$	25,000
Injection Crew and Equipment	1	days @	$25,000 /day	$	25,000
DPT Rig and Operator (Overburden)	3	points @	$4,500 /point	$	13,500
Sonic Drilling for Injections (Bedrock)	0	lf @	$60 /lf	$	0
Sonic Drilling for Abandonment (Bedrock)	0	lf @	$31 /lf	$	0
EHC (includes delivery)	1,767	lbs @	$2.25 /lb	$	3,976
Water	1,309	gallons @	$0.20 /gallon	$	262
			Subtotal Driller	$	142,738
			Service Charge (10%)	$	14,274
			Subtotal incl. Service Charge	$	*157,011*
Roux Associates Oversight & Implementation PM				$	*31,402*
			Subtotal for 100% Injection	**$**	***188,414***
Task 3b - 75% Injection					
Subcontractor					
Driller incl. 10% Service Charge				$	*117,758*
Roux Associates Oversight & Implementation PM				$	*23,552*
			Subtotal for 75% Injection	**$**	***141,310***
Task 3c - 50% Injection					
Subcontractor					
Driller incl. 10% Service Charge				$	*78,506*
Roux Associates Oversight & Implementation PM				$	*15,701*
			Subtotal for 50% Injection	**$**	***94,207***
			Total Task 3	**$**	**423,930**

Task 4 - Project Management Support			
Roux Associates, Inc. (2% of Task 1 through 3c)	**Total Task 4**	**$**	**12,525**
	Subtotal ISCR-1.5	**$**	**638,795**
	20% Contingency ISCR-1.5	**$**	**127,759**
	Total ISCR-1.5	**$**	**766,554**

Table 7. OM&M Cost Estimate for DSA #3 (ISCR-1.5). Former Bishop Tube Property; East Whiteland, PA.

Task 1 - Groundwater Sampling					
Roux Associates, Inc.			*Subtotal Roux Associates Labor*	$	750
Roux Associates, Inc. - Expenses and Equipment			*Subtotal Roux Associates Expenses and Equipment*	$	440
Laboratory Subcontractor					
VOC+15	2	samples @	$72 /sample	$	143
TAL Metals	2	samples @	$127 /sample	$	253
Hardness	1	sample @	$44 /sample	$	44
Chloride	1	sample @	$31 /sample	$	31
Sulfate	1	sample @	$31 /sample	$	31
Nitrate/Nitrite	1	sample @	$50 /sample	$	50
Total Organic Carbon	1	sample @	$31 /sample	$	31
Dissolved Organic Carbon	1	sample @	$75 /sample	$	75
Alkalinity	1	sample @	$20 /sample	$	20
Volatile Fatty Acids	1	sample @	$220 /sample	$	220
Methane/Ethane/Ethene	1	sample @	$121 /sample	$	121
CO_2 Headspace	1	sample @	$132 /sample	$	132
			Subtotal Subcontractor		1,150
			Subtotal Task 1	**$**	***2,340***
			Number of Events per Year	$	*2*
			Total Task 1 per Year	**$**	**4,679**
Task 2 - Project Management Support					
Roux Associates, Inc.			**Total Task 2**	**$**	**936**
			Total ISCR-1.5 Annual OM&M	**$**	**5,615**

Table 8. Summary of Comparative Analysis of Remedial Alternatives. Former Bishop Tube Property; East Whiteland, Pennsylvania.

Assembled Integrated Remedial Alternatives - The remedial alternatives (RAs) represent a range of actions evaluated to achieve compliance with the groundwater beneficial use Remedial Action Objective (RAO).		Alternative # 1 - No Action	Alternative # 2 - Monitored Natural Attenuation	Alternative # 3 - In-Situ Chemical Reduction	Alternative # 4 - Single In-Situ Chemical Oxidation Remedy	Alternative # 5 - Enhanced Reductive Dechlorination	Alternative # 6 - Two-Part In-Situ Chemical Oxidation	Alternative # 7 - Hydraulic Control	Alternative # 8 - Building 8 and DSA #3 ISCR with MNA
Threshold Criteria	Overall Protection of Public Health and the Environment - *Ability to protect human health & the environment*	LOW	HIGH	HIGH	MEDIUM	HIGH	MEDIUM	MEDIUM	HIGH
	Compliance with Applicable or Relevant and Appropriate Requirements - *Ability to comply with regulatory drivers & achieve regulatory acceptance*	LOW	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH
Balancing Criteria	Long-Term Effectiveness and Permanence - *Ability to limit long-term risk / Use of Institutional/Engineering Controls also considered*	N/A	HIGH	HIGH	MEDIUM	HIGH	MEDIUM	MEDIUM	HIGH
	Reduction in Mobility, Toxicity or Volume through Treatment - *Ability to reduce and limit impact to make treatment irreversible & minimize the type and quantity of residual impacts*	N/A	HIGH	HIGH	MEDIUM	HIGH	MEDIUM	HIGH	HIGH
	Short-Term Effectiveness - *Protectiveness of public & workers during implementation, sustainability of remedy*	N/A	HIGH	MEDIUM	MEDIUM	MEDIUM	MEDIUM	LOW	MEDIUM
	Implementability - *Feasibility to construct, treat, & monitor the remedy and its reliability in providing desired treatment*	N/A	HIGH	MEDIUM	MEDIUM	LOW	MEDIUM	LOW	HIGH
	Cost - *Capital, O&M, Net Present Worth (HIGH = most attractive cost, LOW = least attractive cost)*	N/A	HIGH	MEDIUM	MEDIUM	MEDIUM	MEDIUM	LOW	HIGH
Summary Score		--	**21**	**18**	**15**	**17**	**15**	**13**	**20**

Notes:

1. Low rankings represent RAs that are the least desirable and least likely to satisfy the evaluation criteria, medium rankings represent the RAs that are more likely to satisfy the evaluation criteria than low rankings but with some limitations, and high rankings represent RAs that are the most desirable and most likely to satisfy the evaluation criteria.
2. Low rankings are given a numerical score of 1, medium rankings are given a numerical score of 2, and high rankings are given a numerical score of
3. N/A = Did not meet threshold criteria, therefore no evaluation of balancing criteria/was not completed.
4. All RAs are assumed to be completed over a 30-year time period.

Table 9. Supplemetal Summary of Comparative Analysis of Remedial Alternatives. Former Bishop Tube Property; East Whiteland, Pennsylvania.

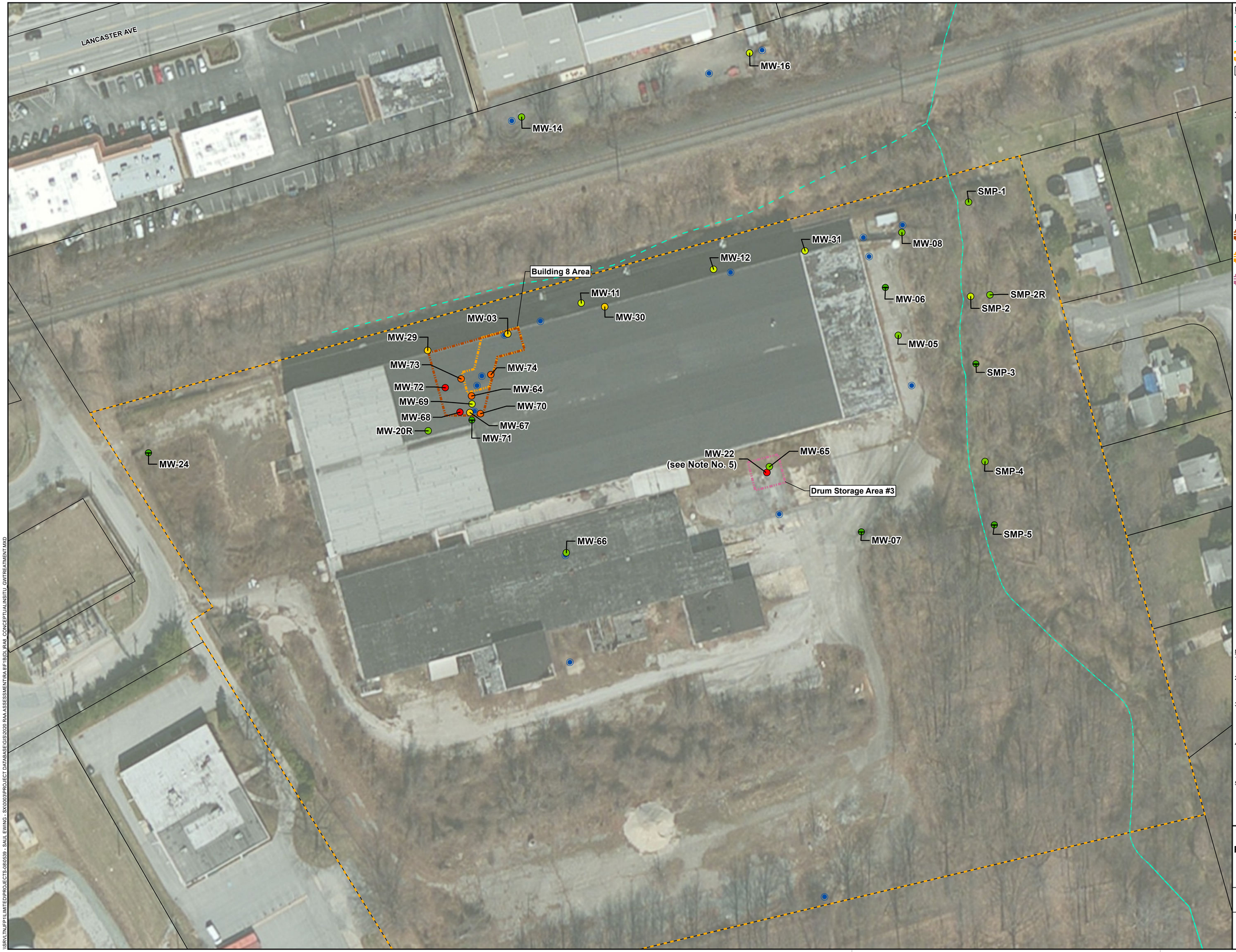
Assembled Integrated Remedial Alternatives - The remedial alternatives (RAs) represent a range of actions evaluated to achieve compliance with the groundwater beneficial use Remedial Action Objective (RAO).		Alternative # 1 - No Action	Alternative # 2 - Monitored Natural Attenuation	Alternative # 3 - In-Situ Chemical Reduction	Alternative # 4 - Single In-Situ Chemical Oxidation Remedy	Alternative # 5 - Enhanced Reductive Dechlorination	Alternative # 6 - Two-Part In-Situ Chemical Oxidation	Alternative # 7 - Hydraulic Control	Alternative # 8 - Building 8 and DSA #3 ISCR with MNA
Supplemental Criteria	Short-Term COC Mass Reduction - *Ability to demonstrate measurable COC mass reduction within the first 5 years of RA implementation*	N/A	LOW	MEDIUM	MEDIUM	MEDIUM	MEDIUM	LOW	MEDIUM
	Sustainability of RA - *Ability to minimize carbon footprint, natural resource use, & consequential detriment to the environment*	N/A	HIGH	MEDIUM	MEDIUM	MEDIUM	MEDIUM	LOW	MEDIUM
Summary Score		--	4	4	4	4	4	2	4

Notes:

1. Low rankings represent RAs that are the least desirable and least likely to satisfy the evaluation criteria, medium rankings represent the RAs that are more likely to satisfy the evaluation criteria than low rankings but with some limitations, and high rankings represent RAs that are the most desirable and most likely to satisfy the evaluation criteria.
2. Low rankings are given a numerical score of 1, medium rankings are given a numerical score of 2, and high rankings are given a numerical score of 3.
3. N/A = Did not meet threshold criteria, therefore no evaluation of balancing criteria/was not completed.
4. All RAs are assumed to be completed over a 30-year time period.

FIGURES

1. RA #8 Conceptual In-Situ Groundwater Treatment Areas



LEGEND

- Stream
- Drainage Swale
- Property Boundary
- Parcels
- Overburden Monitoring Well Location and Identification
- Bedrock Monitoring Well Location and Identification

Trichloroethene Concentration in Groundwater (µg/L)

- ND - 5 (MSC)
- 5 - 50 (10x MSC)
- 50 - 500 (100x MSC)
- 500 - 5,000 (1000x MSC)
- 5,000 - 50,000 (10000x MSC)
- 50,000+

RA #8 Conceptual In-Situ Groundwater Treatment Areas

- Building 8 Overburden Area Included in RA #8 Remedial Approach - See Note No. 2
- Building 8 Shallow Bedrock Area Included in RA #8 Remedial Approach - See Note No. 3
- Drum Storage Area #3 (DSA #3) Shallow Bedrock Area Included in RA #8 Remedial Approach - See Note No. 4

N

NOTES

1. Service Layer Credits: ESRI, DigitalGlobe, GeoEye, Earthstar Geopgraphics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP swisstopo, and the GIS User Community. Layer Access Date: 12/16/2020.
2. Chlorinated volatile organic compound (CVOC) concentrations in the Building 8 Overburden Area groundwater pore volume contribute to the ISCR design for RA #8. ISCR injections to treat saturated overburden CVOC concentrations in this area will be performed in the saturated overburden.
3. CVOC concentrations in the Building 8 Shallow Bedrock Area groundwater pore volume contribute to the ISCR design for RA #8. ISCR injections to treat shallow bedrock CVOC concentrations in this area will be performed in the saturated overburden to allow ISCR amendments to percolate downward into shallow bedrock via the same fracture pathway(s) that originally transmitted the CVOCs.
4. CVOC concentrations in the Drum Storage Area #3 (DSA #3) Shallow Bedrock Area groundwater pore volume contribute to the ISCR design for RA #8. ISCR injections to treat shallow bedrock CVOC concentrations in this area will be performed in the saturated overburden to allow ISCR amendments to percolate downward into shallow bedrock via the same fracture pathway(s) that originally transmitted the CVOCs.
5. MW-22, a shallow bedrock well, defines the DSA #3 Shallow Bedrock Area groundwater pore volume for RA #8 ISCR treatment.

40 0 40'

Title:

REMEDIAL ALTERNATIVE (RA) #8 CONCEPTUAL IN-SITU GROUNDWATER TREATMENT AREAS

FORMER BISHOP TUBE FACILITY
CHESTER COUNTY, PENNSYLVANIA

Prepared for:

BISHOP TUBE PROJECT TEAM

ROUX

Compiled by: T.P.	Date: 12/16/20
Prepared by: D.E.L.	Scale: AS SHOWN
Project Mgr: T.P.	Project: 0539.0003J000
File: 1019.F1(AD)	

FIGURE 1

I:\ROUX\TURF\LIMITED\PROJECTS-0910539 - SAUL EWING - SX0003\PROJECT DATABASE\GIS\2020 RAA ASSESSMENT\RA #8\1BDL\RA8 - CONCEPTUALINSITU_GWTREATMENT.MXD