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Remedial Alternatives Analysis and Remedial Action Selection Report

FORMER NEW METHOD CLEANERS/CUSTOM HELENIZING SITE

300-310 PROSPECT STREET

TRENTON, NEW JERSEY

PREPARED ON BEHALF OF:

City of Trenton

Department of Housing & Economic Development

PREPARED BY:

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GZA Project No. 12.0076579.00

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1.0 INTRODUCTION

GZA GeoEnvironmental, Inc. (GZA) has prepared this Remedial Alternatives Analysis, and Remedial Action Selection Report (RAA-RASR) on behalf of the City of Trenton Department of Housing & Economic Development (City of Trenton; the City) for the former New Method Cleaners/Custom Helenizing property located at 300-310 Prospect Street, Trenton, New Jersey (Site). This document pertains to New Jersey Department of Environmental Protection (NJDEP) Case No. 89-03-02-1610. The Program Interest (PI#) for the Site is 032917.

This RAA-RASR is subject to the Limitations described in **Appendix A**.

1.1 <u>OBJECTIVE</u>

The objective of this report is to evaluate remedial alternatives and select a remedial action to address contamination resulting from releases of chlorinated solvent contaminants (volatile organic compounds, or VOCs) to Site groundwater (AOC 19).

1.2 <u>SITE DESCRIPTION</u>

The approximately 1.65-acre Site is located in a mixed commercial and residential area of northwestern Trenton. The Mercer Tax Assessor's office identifies the Site as Block 4402, Lots 5, 6, and 6.01. The Site contains a vacant, 18,231 square foot single story building, a paved parking area to the west of the building and an unimproved area to the east of the building.

1.3 <u>SITE HISTORY</u>

The Site has a history of industrial and commercial activities dating back more than 120 years, including a pottery (from late 1800's to approximately the 1940s), a gasoline filling and service station (from approximately the 1940s to approximately the 1960s), and a coal and lumber storage and distribution facility (beginning sometime in the 1890s). Between the 1970s and approximately 1985, a leather cleaning ("Helenizing") business also operated on the property. Most recently, a wet and dry-cleaning business operated at the Site from the 1950s until approximately 2016 when the tenant was evicted and the Site came under the ownership of the City of Trenton. The Site has been vacant since 2016. **Figure 1** depicts the Site's location and **Figure 2** depicts the general Site layout and relevant features.

With regard to the historical usage and release of chlorinated solvents in the wet, dry-cleaning, and Helenzing (leather cleaning) businesses, GZA gathered the following information from previous reports:

The leather cleaning business operated in the northeastern portion of the building and the dry-cleaning business operated in the western portion of the building. Both businesses utilized transfer dry cleaning machines, dry-dry cleaning machines, transfer machines, tetrachloroethene (PCE) dryers/reclaimers, and a PCE still. Use and reclamation of PCE was an element of both businesses. The leather cleaning operation included the use of oils and softeners, which were also reclaimed.

Within the leather cleaning side of the building, there were two transfer machines, several dryer/reclaimers, and a PCE still. Within the dry-cleaning side of the building, there was 1 dry-dry machine, several dryers/reclaimers, and two transfer machines. The transfer machines were located in the utility room.

The PCE still had a capacity of up to 50 gallons. Secondary containment was not added beneath the PCE still until 1995. The PCE still is likely a major source area of contamination. Each transfer machine should also be considered significant source areas for contamination. Secondary containment was added to the transfer machines in the leather cleaning business in approximately 1980s, but not in the drying business until 1991.

2.0 SITE GEOLOGY AND HYDROGEOLOGY

Geology at the Site generally consists of up to 15 feet of granular urban fill, underlain by an additional five to 17.5 feet of natural silts, silty clays, and gravels with lesser amounts of sand (the Pennsauken Formation), underlain by up to 49 feet of saprolitic weathered bedrock. Bedrock has been encountered at depths ranging from 40 to 64 feet below ground surface (bgs). The bedrock is mapped in the Trenton Prong group of metamorphic/igneous rocks which contains gneiss and migmatite bedrock. No borings have been advanced into competent bedrock as of the date of this report.

Groundwater at the Site is typically measured 3 to 12 feet below existing grade. Measured vertical gradients in well couplets GZA- 6S/D and -7S/D were 00.0050 upward and 0.0004 upward ft/ft, respectively. Vertical gradients could not be reliably measured in other monitoring wells due to their relatively long screen intervals. Overburden groundwater generally flows towards the northeast and discharges to the unnamed tributary to Petty's run. Bedrock groundwater flow direction is not known but will be evaluated in the future.

3.0 REMEDIAL ACTION GOALS AND OBJECTIVES

Groundwater VOC contamination (AOC 19) is the subject of this analysis. Although source area soil has not been recently investigated, it is assumed to contain VOCs that exceed the NJDEP Impact to Ground Water Soil Remediation Standards (IGWSRS), particularly behind and beneath the building. For this report, we assume that soil containing VOCs that exceed the IGWSRS will either be removed prior to groundwater remediation or will be addressed by the selected groundwater remedy (*e.g.*, in-situ mixing as described in **Section 6.0** of this report).

The Site is located within an area of the State where groundwater is designated for potable use, otherwise known as a Class II-A aquifer area. As such, groundwater within this area is required to meet the Class II-A Groundwater Quality Standards (GWQS), which were derived to protect potential potable use of groundwater. If groundwater in this area of the State does not meet the applicable Class II-A GWQS, a Classification Exception Area (CEA) must be established to prevent potable use of the affected groundwater within the aquifer.

3.1 REMEDIAL ACTION OBJECTIVES

The remedial action objectives for a future remedial action for groundwater at this Site are as follows:

- Remediate Site soil to the applicable IGWSRS to the extent feasible;
- Remediate Site groundwater to the applicable Class II-A GWQS to the extent feasible;
- Control VOC plume migration; and
- Limit further impact to receptors.

3.2 DATA GAPS

Based on investigations performed at the Site to date, GZA has identified the following data gaps:

- Shallow groundwater VOC impacts to surface water and sediments, *i.e.*, the unnamed tributary to Petty's Run;
- Location(s) of residual source material;
- Extent of VOC impacts in soil and groundwater beneath the building;
- Extent of VOCs in deep overburden soil and groundwater southwest of the building;
- Extent of VOCs in deep overburden soil and groundwater downgradient of GZA-MW-5D; and
- Extent of VOCs in bedrock.

Groundwater investigations performed at the Site to date have identified PCE concentrations of up to 110,000 µg/L (GZA-MW-4D, May 2018), well above the 1,500 µg/L (1% of PCE's water solubility) threshold generally considered to be a conservative predicter of a residual NAPL. The data gaps identified are unlikely to prevent selection of an appropriate remedy for residual NAPL; however, supplemental investigation will be necessary to specify the horizontal and vertical extent of remediation.

4.0 CONCEPTUAL SITE MODEL

The conceptual site model (CSM) presented herein is the current understanding of the physical, chemical, and biological aspects of known discharges or other contamination and the processes that control the transport, migration, fate and potential impacts of VOCs in Site groundwater to human and/or ecological receptors. The CSM is an evolving model that is developed in an iterative manner during the course of an investigation and is subject to change with the collection of new data and information.

Historic VOC releases (primarily tetrachloroethene, PCE) appear to have occurred in the northeastern portion of the building near the PCE still and in the southeastern portion of the building near the transfer machines. These releases may have occurred via discharge from subsurface drainage features or via direct surficial discharges to the east of the building. VOCs may also have entered shallow groundwater and/or surface water via roof leaders. PCE non-aqueous phase liquid (NAPL) likely migrated downward through the fill, Pennsauken formation, saprolite, and potentially into fractures in the competent bedrock. Dissolved VOCs from the site generally migrated easterly in shallow overburden groundwater and southeasterly in deeper overburden groundwater.

In 2013, VOCs were detected in soil gas at concentrations that were greater than current NJDEP Soil Gas Screening Levels (SGSLs); however, because the NJDEP SGSLs are intended to be compared to sub-slab soil gas sampling results, these results did not trigger indoor air sampling of nearby buildings. Vapor intrusion risk is likely low because Site-related VOCs are predominantly located in the deeper overburden. GZA evaluated the 2018 groundwater data for potential vapor intrusion investigation triggers. The only wells that contained constituents of concern at concentrations greater than the NJDEP Groundwater Screening Levels were deep monitoring wells or shallow wells that were not located within 100 feet of a building. To date, there has not been a trigger for a vapor intrusion investigation.

Potential receptors under current conditions include trespassers and ecological receptors which may be impacted if VOCs are found in sediment and surface water.

Previous attempts at source control, including SVE and shallow groundwater extraction, have not proven successful, likely because the majority of VOC mass is located in the deep overburden.

A summary of the recent remedial investigations is provided in the *Groundwater Remedial Investigation Status Report* (RISR) dated November 8, 2019. A PCE source area exists immediately beneath and east (downgradient) of the building, with a plume extending east and into the saprolite overburden (weathered bedrock) to as deep as 50 feet below ground surface (ft bgs) in the vicinity of GZA-MW-2D. The building architecture did not permit investigation of deeper soil and groundwater beneath the building. Although the source area lateral extent was identified in historical investigations, the vertical VOC plume has not been fully delineated to date and may extend into underlying fractured bedrock. Vertical gradients could not be measured reliably in most monitoring wells due to their relatively long screen intervals; however, measured vertical gradients in well couplet GZA-MW-6S/D, upgradient of the source area, and GZA-MW-7S/D, downgradient of the source area, were 0.0050 upward and 0.0004 upward ft/ft, respectively, suggesting that impacts to underlying bedrock from groundwater transport may be minimal[1]. Evidence of natural attenuation (NA) via biological reductive dechlorination in all monitoring wells is described in the RISR. The CSM will continue to evolve as informed by supplemental investigation, source area remediation, and natural attenuation of Site VOCs. Additional investigations are needed to address data gaps outlined in **Section 3.2**.

5.0 REMEDIAL ALTERNATIVES CRITERIA

The purpose of a remedial action is to implement a remedy that removes, treats, or isolates contaminants of concern, and that is protective of the public health, safety, and the environment. A RASR is used to identify potential alternatives and describe and document to what extent the proposed remedial alternatives do or do not attain the criteria specified in N.J.S.A. 58:10B-12 and 13. A qualitative ranking system has also been developed to aid in the remedial selection process using levels defined as good, fair, and poor. The rankings, summarized in **Tables 1 and 2**, reflect the relative effectiveness of each remedial alternative to meet the conditions of a particular criterion. The following criteria are considered as part of the evaluation of remedial alternatives in this RASR:

- Compliance with applicable laws and regulations;
- Effectiveness and reliability of attaining the applicable remediation standards;
- Reduction of toxicity, mobility, and mass;
- Risk minimization;
- Implementability;
- Potential impacts on the local community; and
- Sustainability.

[1] The vertical gradient of GZA-MW-5S/D could not be accurately measured because the wells are approximately 60 feet apart horizontally.

5.1 EFFECTIVENESS AND RELIABILITY OF ATTAINING THE APPLICABLE REMEDIATION STANDARDS

This criterion considers the technical performance of each remedial alternative relative to its ability to effectively attain compliance with the applicable remediation standard for the Site and provide sufficient long-term control to be protective of receptors. The more effective and reliable a remedial alternative, the higher the ranking.

5.2 REDUCTION OF TOXICITY, MOBILITY AND VOLUME

This criterion considers the extent to which each remedial alternative reduces the toxicity, mobility, or volume of VOCs through treatment, reuse, or recycling. The greater the reduction in toxicity, mobility, or volume, the higher the ranking.

5.3 RISK MINIMIZATION

The risk minimization criterion refers to the degree to which the proposed remedial action minimizes risk associated with the Site. Of specific importance is the minimization of any short-term risk associated with implementation of the remedy and possible VOCs left on-site, while still providing long-term risk protection with regard to any future use of the Site. Short- and long-term risks include potential impacts of remedial activities on receptors as well as remedial timeframes. The greater the risk minimized by a remedial action, the higher the ranking.

5.4 IMPLEMENTABILITY

Implementability of each remedial alternative is defined as the engineering and scientific feasibility of the alternative, availability of services and resources for implementation, timeliness of the alternative, and uncertainties associated with implementation and performance. The more feasible, available, and timely a remedial action, the higher the ranking.

5.5 COMPLIANCE WITH APPLICABLE LAWS AND REGULATIONS

This criterion considers each remedial alternative's compliance with applicable laws and regulations, specifically NJDEP's Administrative Requirements for the Remediation of Contaminated Sites (ARRCS, NJAC 7:26C) and Technical Requirements for Site Remediation (NJAC 7:26E). If a remedial alternative is not in compliance with applicable laws and regulations, it receives a low ranking.

5.6 POTENTIAL IMPACTS ON LOCAL COMMUNITY

This criterion considers each remedial alternative's impact on the local community during implementation, such as disturbances to community services and generation of emissions, odors, or noise. The more impact on the local community, the lower the ranking.

5.7 REMEDIATION SUSTAINABILITY

Remediation sustainability is an assessment of the overall environmental impacts associated with implementing a remedial action, including evaluation of greenhouse gas emissions, resource consumption (*i.e.*, water, energy), and waste generation.

6.0 POTENTIAL REMEDIAL ALTERNATIVES

6.1 ALTERNATIVE #1: MONITORED NATURAL ATTENUATION (MNA)

MNA is a passive remedial technology that relies on naturally occurring processes such as volatilization, adsorption, dilution, oxidation, reduction, and biotic and abiotic degradation to reduce the mass, concentration, and/or toxicity of VOCs. Biodegradation, the transformation of organic compounds by microorganisms, is commonly the dominant natural attenuation process for organic pollutants in groundwater. The rate and progress of natural attenuation is assessed by routine groundwater monitoring. The MNA alternative assumes no additional efforts are made to remediate Site groundwater, and it is left in its current condition, to attenuate naturally. MNA may be combined with other remediation strategies, particularly source area groundwater remediation. Under this alternative, groundwater monitoring would proceed as described in NJDEP's MNA Technical Guidance[2].

Site-specific considerations: Site conditions do not preclude MNA as a remedial option, though the potential presence of residual NAPL in the source area would make it ineffective in terms of achieving remedial standards in a reasonable timeframe in the source area.

Conclusion: MNA is retained for potential downgradient remediation, as well as for source area remediation following more active remedies.

6.2 ALTERNATIVE #2: ENHANCED NATURAL ATTENUATION (ENA)

Natural attenuation (NA) of chlorinated VOCs can be accelerated by strategic in-situ application of degradation additives such as organic carbon and zero-valent iron (ZVI). NA can also be enhanced by concentrating VOCs in-situ on an activated carbon (AC) barrier, which can retard VOC migration and improve contact between VOCs and dechlorinating bacteria growing in biofilms on the AC surfaces. Electron door additives and AC can be delivered to the subsurface by direct push injection, injection wells, trenching, or in-situ mixing (ISM).

Site-specific considerations: The silt, silty clay, and saprolite (weathered rock) where the source area VOCs are located limits delivery via direct push or injection wells; however, ISM would be feasible as a source area treatment. ENA may also be employed downgradient by placing AC and/or electron donors in trenches to create biologically reactive barriers (*i.e.* "biobarriers") that can minimize offsite migration of VOCs.

Conclusion: ENA is retained for potential use at the Site.

6.3 ALTERNATIVE #3: AIR SPARGING/SOIL VAPOR EXTRACTION (AS/SVE)

AS/SVE is an in-situ physical treatment technology that is fully developed and widely utilized. Properly designed and under the right conditions, air sparging effectively removes volatile compounds from groundwater and soil located in the saturated zone, while soil vapor extraction is implemented to capture vapors from air sparging activities. Air sparging includes the use of air injection wells extending below the water table, while soil vapor extraction includes the use of air extraction wells extending through the vadose zone. Exhaust air from the SVE wells is typically treated using activated carbon, catalytic oxidation, or thermal oxidation. AS/SVE is considered effective for the remediation of volatile compounds that have vapor pressures exceeding approximately one millimeter of mercury (mmHg) at ambient

[2] NJDEP Monitored Natural Attenuation Technical Guidance, dated March 1, 2012 and available at http://www.nj.gov/dep/srp/guidance/srra/mna_guidance_v_1_0.pdf

temperature that also have low water solubility, including chlorinated ethenes at the Site. AS/SVE is best suited for use in permeable, unconsolidated soils.

Site-specific considerations: The Site overburden is predominately silty clays and saprolite, limiting the efficacy of AS/SVE. Due to the likely low permeability of Site soil and the limited effectiveness of the previous SVE system, AS/SVE is not retained as an alternative for Site remediation.

Conclusion: AS/SVE is not retained for potential use at the Site.

6.4 ALTERNATIVE #4: IN-SITU CHEMICAL OXIDATION (ISCO)

Oxidants generated by catalyzed persulfate, sodium or potassium permanganate, or peroxides can degrade Site VOCs.

Site-specific considerations: The assumed low permeability of Site silt, silty clay, and saprolite, and the difficulty associated with achieving additive contact with VOCs in low permeability soils make ISCO remedial methods impractical for direct treatment of Site VOCs. ISM of ISCO additives could be feasible as a source area treatment; however, ISCO additives are short-lived and often require multiple applications for VOC degradation. ISCO is unlikely to be a cost-effective or sustainable remedy for Site VOCs.

Conclusion: ISCO is not retained for potential use at the Site.

6.5 ALTERNATIVE #5: HYDRAULIC CONTAINMENT AND EX-SITU TREATMENT

Hydraulic Containment and Ex-Situ Treatment, also known as Pump and Treat (P&T), is a common method for containing groundwater contaminated with dissolved chemicals. P&T involves installing one or more wells to extract the groundwater and pump it to an above-ground treatment system that removes the VOCs.

Site-specific considerations: The assumed low permeability of Site silty clay and saprolite would minimize the efficacy of P&T at the Site.

Conclusion: P&T is not retained for potential use at the Site.

6.6 ALTERNATIVE #6: STRATEGIC EXCAVATION (SX)

Excavation is based on the mechanical process of physically removing contaminated soil and transporting it off-Site. Excavation is typically used to accelerate groundwater remediation via physical removal of contaminated media that can continue to provide a source of downgradient pollution.

Site-specific considerations: although VOCs have impacted deep overburden, SX could be useful in removing shallow mass.

Conclusion: SX of VOC-contaminated unconsolidated soil in the source area is retained for further evaluation.

7.0 SELECTION OF REMEDIAL ALTERNATIVE

A critical component of the remedial action selection is a comparative analysis of each alternative among the specified remedial action criteria (**Section 6.0**). This section compares the strengths and weaknesses of the retained remedial alternatives relative to one another with respect to the specified criteria, and how reasonable variations of key uncertainties could change the expectations of their relative performance. The following subsections present the evaluation of the proposed remedial alternatives against each evaluation criterion. A summary of this evaluation is provided in **Table 1**.

7.1 EFFECTIVENESS AND RELIABILITY OF ATTAINING THE APPLICABLE REMEDIATION STANDARDS

Historical and recent groundwater monitoring suggests that Site VOCs are being degraded by natural processes, supporting Alternative #1, MNA. Alternative #2, ENA, is designed to accelerate natural degradation processes by providing electron acceptors to increase the rate of biological or abiotic degradation. Alternative #6, SX, could be used strategically to meet this criterion for shallower impacts.

Conclusion: Alternative #1, MNA, Alternative #2, ENA, and Alternative #6, SX, can be combined to meet this criterion in overburden soils.

7.2 REDUCTION OF TOXICITY, MOBILITY, OR VOLUME

Alternatives #2 (ENA) and #6 (SX), offer the most rapid reduction in toxicity, mobility, or volume by actively promoting VOC degradation (ENA) or removing VOCs from the source area (SX). MNA relies on natural attenuation processes to reduce toxicity, mobility, or volume. MNA, however, will be slower than more active remedies.

Conclusion: Alternative #1, MNA, Alternative #2, ENA, and Alternative #6, SX, can all be suited for meeting this criterion.

7.3 RISK MINIMIZATION

We anticipate that long-term risk will be managed using institutional controls (*i.e.*, a CEA). Short-term risks associated with implementation of Alternative #2, ENA and Alternative #6, SX, include general heavy equipment operation and work zone safety as well as specific hazards associated with trenches and excavations. Sloping and benching for excavations greater than 20 feet in depth will be designed by a registered professional engineer. Short-term risks will be managed via a Health and Safety Plan and an on-Site Safety Officer. It is possible that in-situ treatment of shallow soils may be more suited for minimizing risk related to Alternative #6, SX. This is discussed in **Section 8.1**.

Conclusion: Alternative #1, MNA, Alternative #2, ENA, and Alternative #6, SX, are all suited for meeting this criterion.

7.4 IMPLEMENTABILITY

The main uncertainty associated with MNA is the length of monitoring time required. If residual NAPL exists as a secondary source downgradient of the primary source area, monitoring time would likely be several decades. Due to data gaps described in **Section 3.2**, a time estimate for this alternative is currently unknown; however, monitoring frequency would follow NJDEP's MNA Technical Guidance.

Although injection wells for application of Alternative #2, ENA, may be technically feasible, they are not likely to be practical in the silt and silty clay soils that dominate the deeper overburden; however, ENA additives can be mixed directly into VOC source area soil without removing soil for off-Site disposal. For example, Alternative #2, ENA, could involve mechanically mixing emulsified ZVI into the soil at one to two percent (by weight).

Conclusion: Alternative #1, MNA, and Alternative #6, SX, are the most readily implementable alternatives for remediation of downgradient and shallow source area VOCs, respectively, at the Site.

7.5 COMPLIANCE WITH APPLICABLE LAWS AND REGULATIONS

The source area/groundwater remedial alternatives being evaluated are consistent with all applicable laws and regulations prescribed by the NJDEP. ENA and SX can be equally compliant. MNA can be compliant as a follow-on remedy in combination with a CEA, as long as more active remedies are employed to mitigate source mass and control the plume from impacting receptors. Alternative #1, MNA, will follow monitoring schedules prescribed in NJDEP's MNA Technical Guidance. Prior to application of additives for Alterative #2, ENA, a Permit-by-Rule will be filed for approval by NJDEP. If the additives chosen for ENA are able to address residual NAPL as well as dissolved-phase VOCs, for example, products that contain ZVI, ENA of the downgradient plume can be designed to protect off-Site receptors. The Site is located within an area of the State where groundwater is designated for potable use, otherwise known as a Class II-A aquifer area. As such, groundwater within this area is required to meet the Class II-A GWQS, which were derived to protect potable uses of groundwater. That being said, it is unlikely that groundwater will meet the applicable Class II-A GWQS within a limited time frame (*e.g.*, five to 10 years), even with Site remediation. We anticipate establishing a CEA, which will serve as an institutional control to prevent future potable use of the affected groundwater within the aquifer until natural attenuation processes attain groundwater standards.

7.6 POTENTIAL IMPACTS ON THE LOCAL COMMUNITY

The alternatives being evaluated are anticipated to have minimal (Alternative #1, MNA) or moderate impact on the surrounding community. None of the alternatives evaluated are anticipated to generate emissions or odors. Alternative #1, MNA, is not anticipated to generate significant noise. For Alternative #2, ENA, hydraulic press equipment used to install sheet piles and dewatering pumps, as well as excavator operations will likely result in noise and vibration that impacts the surrounding neighborhood. Alternative #6, SX, may have a much greater potential impact on the community due to noise, dust, and truck traffic. Perimeter air monitoring will be required to assess if dust or VOCs from the excavation could pose a risk to the local community.

7.7 REMEDIATION SUSTAINABILITY

Alternative #1, MNA, is anticipated to be the most sustainable remedial alternative in regard to greenhouse gas emissions, resource consumption, and waste generation, followed by Alternative #2, ENA. Alternative #6, SX, is anticipated to consume the most energy and generate the most greenhouse gas emissions. Each alternative offers opportunities to improve sustainability with a detailed evaluation of the processes and materials used in the implementation of the remedy. Additionally, remedial alternatives can incorporate best management practices for operations during implementation.

8.0 EVALUATION OF REMEDIAL ALTERNATIVES

Biological degradation, the dominant natural attenuation mechanism in groundwater, is evident across the Site, as demonstrated by decreasing PCE and trichloroethene (TCE) concentrations accompanied by increases in concentrations of degradation products dichloroethene (DCE) and vinyl chloride (VC). Groundwater conditions support continued biological reductive dechlorination, with near-neutral pH[3] and low DO and ORP. The low permeability of silt, silty clay,

[3] Site pH is generally above 6.0 standard units, with the exception of groundwater in the vicinity of GZ-MW-2D, where the pH measured in May 2018 was 4.9 standard units. Dechlorinating bacteria prefer a pH that is closer to neutral for robust growth; however, since PCE degradation has not slowed substantially at this location, it is possible that the measurement may not be representative of pH at this location.

and saprolite in Site soils restricts utilization of some remedial alternatives to manage Site VOCs (*e.g.*, AS/SVE, ISCO, and P&T, as discussed in **Section 6.0**).

Therefore, the selected remedial alternative for VOCs in Site groundwater is a combined remedy that includes application of Alternative #2, ENA, as well as a Site-wide application of Alternative #1, MNA. Groundwater MNA is frequently used in conjunction with other remedial measures or as a follow-up to an active remedial action. Alternative #6, SX, may also be employed to address shallow source area soil if it is deemed appropriate following further evaluation (**Section 3.2**, Data Gaps).

The following sections evaluate the selected remedies and discuss how they might be combined to optimize remediation of the Site source area and groundwater plume.

8.1 SOURCE AREA

Biological degradation appears to be robust in the PCE source areas identified by groundwater monitoring wells MW-5, GZA-MW-1D, and GZA-MW-4D located on the east-southeast side of the building; however, groundwater PCE concentrations are up to 110,000 µg/L (GZA-MW-4D, May 2018), well above the 1,500 µg/L (1% of PCE's water solubility) threshold generally considered to be predictive of a residual NAPL source. Natural attenuation alone is likely insufficient to remediate source area PCE within a limited time frame (*e.g.*, five to 10 years).

GZA understands that the City plans to demolish the Site building in conjunction with the future full-scale Site remediation. Although we have been unable to fully assess the extent of VOC contamination beneath the building, we anticipate that some of the soil and groundwater beneath the building will be part of the VOC source area. ENA additive addition via ISM is the selected source area remedy. SX of shallow VOC hot spots following building demolition may also be utilized; however, ISM of shallow soil impacts is preferred because it ranks higher in terms of implementability and sustainability (**Table 2**).

Source area VOC contamination extends into deeper overburden groundwater, for example, 110,000 µg/L at 30 to 40 ft bgs (GZA-MW-4D). ENA additives like emulsified ZVI (EZVI) and emulsified vegetable oil (EVO) can be successfully applied by in-situ mixing (ISM) where low permeability soils preclude treatment via in-situ injection. Excavator-mounted augers can facilitate ISM to depths of 20 to 50 feet, depending on the excavator mast height. If necessary, deeper soil mixing (50 to 100 ft bgs) can be achieved using crane-mounted auger platforms.

After source mass is attenuated by ENA, GZA recommends MNA as the remedial strategy for Site groundwater, as outlined in the NJDEP *Monitored Natural Attenuation Technical Guidance*.

8.2 DOWNGRADIENT PLUME

The selected remedies for the downgradient VOC plume are ENA and MNA. Prior to source area treatment, we recommend installing an in-situ biobarrier from approximately 35 to 50 feet below ground surface at the downgradient property boundary to minimize off-Site plume migration while enhancing natural attenuation in the source area. Creation of the biobarrier could involve injection of AC and electron donor additives using a continuous-trenching machine which allows simultaneous excavation and backfilling without an open trench. The biobarrier would enhance natural attenuation by concentrating VOCs in-situ, retarding VOC migration and improving contact between VOCs and dechlorinating bacteria growing in biofilms on the AC surfaces. ZVI can be also be incorporated into the biobarrier to enhance abiotic reductive dechlorination. MNA would be used to manage portions of the VOC plume that are less impacted by the source area. This alternative in combination with downgradient sentinel well monitoring could be more cost-effective than more active remediation of the downgradient plume.

In addition to PCE, TCE, and their degradation products, three VOCs are present at low concentrations downgradient of the source area: benzene, 1,4-dioxane, and 1,2-dichloroethane (1,2-DCA, also known as ethylene dichloride or EDC). 1,2-DCA degrades biologically by reductive dechlorination and can be managed by a combination of MNA and the downgradient biobarrier. Benzene and 1,4-dioxane can also be managed by a combination of MNA and the downgradient biobarrier. Although their degradation mechanisms are dissimilar to the chlorinated VOCs, their concentrations are likely low enough that sorption to the AC barrier would be sufficient to enhance natural attenuation.

TABLES

Table 1 Summary Evaluation of Remedial Alternatives - Groundwater
Remedial Action Selection Report
Former Modern Cleaners/Helenizing Property
300-310 Prospect Street, Trenton, New Jersey

Remedial Alternative	Effectiveness and Reliability of Attaining the Applicable Remediation Standards	Reduction of Toxicity, Mobility, or Volume (TMV)	Risk Minimization	Implementability	Compliance with Applicable Laws and Regulations	Potential Impacts on the Local Community	Sustainability	Ranking
(1) Monitored Natural Attenuation (MNA)	Effective for Site cVOCs as evidenced by existing data.	Moderate reduction in TMV via natural processes.	Minor short-term risks. Significant long-term risks because the time required to meet the applicable standards is longer	Readily implementable (common, well-established approach).	Consistent with TRSR.	Minor disturbance to the community. May be perceived as unprotective.	Minor emissions, resource consumption, and waste generation	Good
(2) Enhanced Natural Attenuation (ENA)	Effective and reliable at attaining remediation standards (accelerates the natural degradation process). Effective for Site cVOCs as evidenced by existing data.	Accelerated reduction in TMV through natural degradation enhanced by additive application.	Moderate short-term risk during additive application activities. Minor long-term risk.	Practical for overburden in-situ mixing. Additive injection feasible but may not be practical for weathered or fractured bedrock.	Consistent with TRSR. Requires NJDEP approval (Permit-by-Rule) prior to additive application.	Moderate disturbance to the community (noise, exhaust, and other operational activities).	Minor emissions, resource consumption, and waste generation.	Good
(3) Air Sparging /Soil Vapor Extraction (AS/SVE)	Effective and reliable for attaining compliance for VOCs only in more permeable soils.	Reduction of MV of cVOCs. Aerobic biodegradation of DCE and VC; however, PCE and TCE are not known to biodegrade under aerobic conditions.	Significant short-term risk during installation of the system and long-term risks due to the complexity of the system.	Poor performance likely in overburden due to anticipated low permeability of Site soils. Not practical for fractured bedrock because water bearing fractures likely have limited interconnectivity.	Consistent with TRSR.	Moderate disturbance to the community during system installation (noise, exhaust, and other operational activities).	Moderate emissions, resource consumption, and waste generation.	Poor
(4) In-Situ Chemical Oxidation (ISCO)	Can be effective in attaining remediation standards by destroying cVOCs through chemical reaction, but only where permeable soils facilitate rapid contact between additive and cVOCs.	Accelerated reduction in TMV by active contaminant degradation through injection of an additive.	Moderate short-term risk during additive application activities. Minor long-term risk.	Additive injective impractical for fractured bedrock due to potential of limited interconnectivity of water transmitting fractures. May be practical for overburden in-situ mixing or additive application to an open excavation on top of shallow bedrock allowing for gravity infiltration.	Consistent with TRSR. Requires NJDEP approval (Permit-by-Rule) prior to additive application.	Moderate disturbance to the community during system installation (noise, exhaust, and other operational activities).	Moderate emissions, resource consumption, and waste generation.	Fair
(5) Hydraulic Containment and Ex-Situ Treatment (P&T)	May not be effective or reliable for treating entire dissolved phase plume due to its extent.	Reduction in TM Moderate reduction in V because of hydraulic properties of soil and fractured bedrock, and the physical extent of cVOCs.	Significant short-term risk during installation of the system and long-term risks due to the complexity of the system.	Poor performance likely in overburden due to anticipated low permeability of Site soils. Not practical for fractured bedrock because water bearing fractures likely have limited interconnectivity.	Consistent with TRSR.	Moderate disturbance to the community during system installation (noise, exhaust, and other operational activities).	Moderate emissions, resource consumption, and waste generation.	Poor
(6) Strategic Excavation (SX)	Effective and reliable for accessable source area.	Reduction in TMV in shallow groundwater. Removal of accessable "hot spot" soils reduces ongoing contribution to downgradient plume.	Moderate short- and long-term risk.	Only implementable for shallow overburden; does not address deep overburden or bedrock cVOCs.	Consistent with TRSR.	Moderate disturbance to the community (noise, exhaust, and other operational activities).	Moderate emissions. High resource consumption and waste generation.	Fair

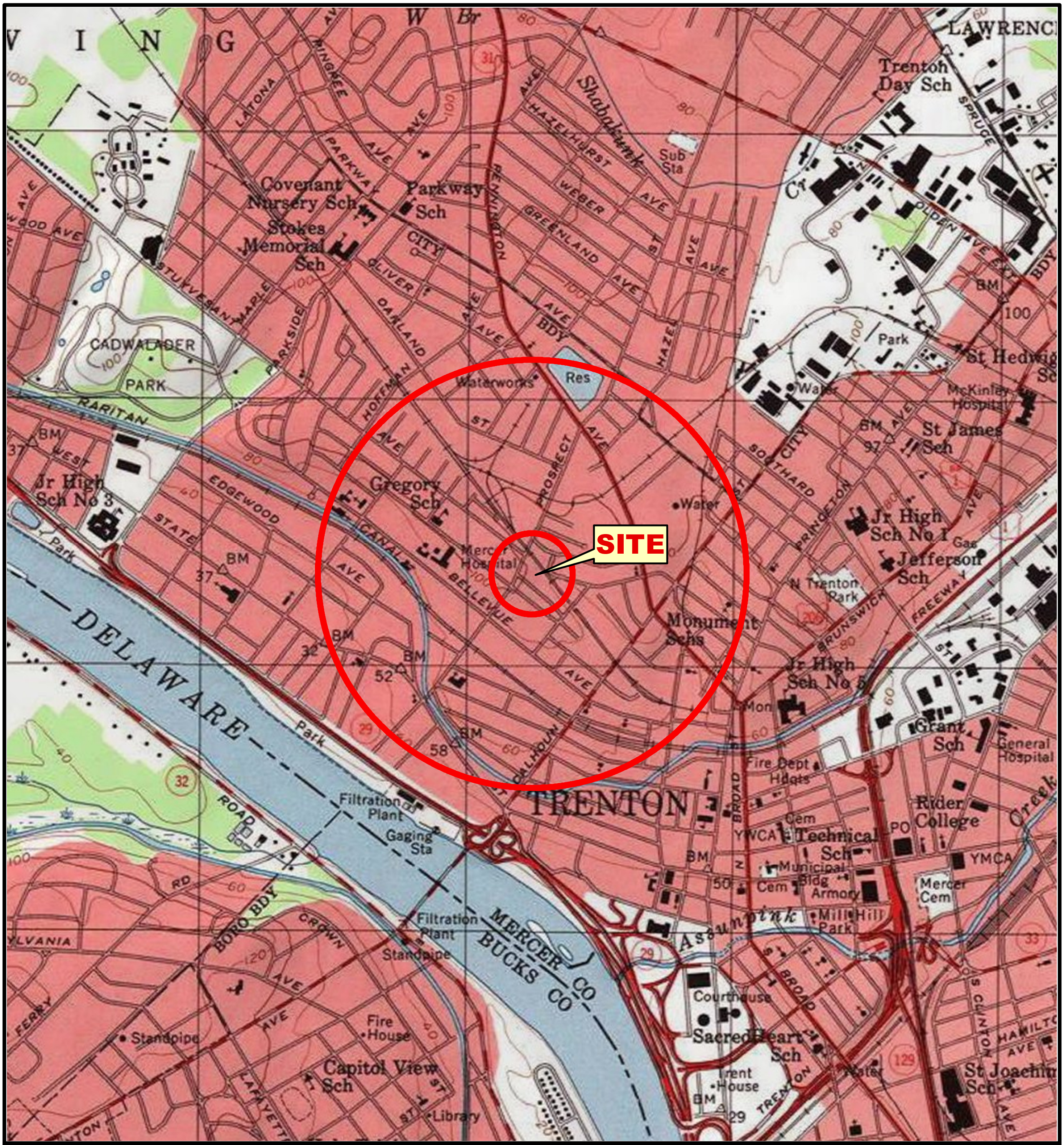
Table 2 Comparative Evaluation of Remedial Alternatives - Groundwater
Remedial Action Selection Report
Former Modern Cleaners/Helenizing Property
300-310 Prospect Street, Trenton, New Jersey

Remedial Alternative	Effectiveness and Reliability of Attaining the Applicable Remediation Standards	Reduction of Toxicity, Mobility, or Volume	Risk Minimization	Implementability	Compliance with Applicable Laws and Regulations	Potential Impacts on the Local Community	Sustainability	TOTAL SCORE
Monitored Natural Attenuation (MNA)	✓	—	—	✓	✓	✓	✓	12
Enhanced Natural Attenuation (ENA)	✓	✓	—	✓	✓	—	✓	12
Air Sparging /Soil Vapor Extraction (AS/SVE)	—	—	⊘	⊘	✓	—	—	6
In-Situ Chemical Oxidation (ISCO)	—	✓	—	—	✓	—	—	9
Hydraulic Containment and Ex-Situ Treatment (P&T)	⊘	—	—	⊘	✓	—	—	6
Strategic Excavation (SX)	✓	✓	—	✓	✓	—	⊘	10

The legend below refers to the ability of the remedial alternative to effectively meet the indicated criteria relative to the other options presented in the table.

✓	**Good** (2 points)	—	**Fair** (1 point)	⊘	**Poor** (0 points)

FIGURES



SOURCE : THIS MAP CONTAINS THE ESRI ARCGIS ONLINE USA TOPOGRAPHIC MAP SERVICE, PUBLISHED DECEMBER 12, 2009 BY ESRI ARCIMS SERVICES AND UPDATED AS NEEDED. THIS SERVICE USES UNIFORM NATIONALLY RECOGNIZED DATUM AND CARTOGRAPHY STANDARDS AND A VARIETY OF AVAILABLE SOURCES FROM SEVERAL DATA PROVIDERS.

Data Supplied by : esri

0 1,000 2,000 4,000 6,000

SCALE IN FEET

N W E S

GZA

PROJ. MGR.: MH
DESIGNED BY: JJR
REVIEWED BY: MH
OPERATOR: SMW

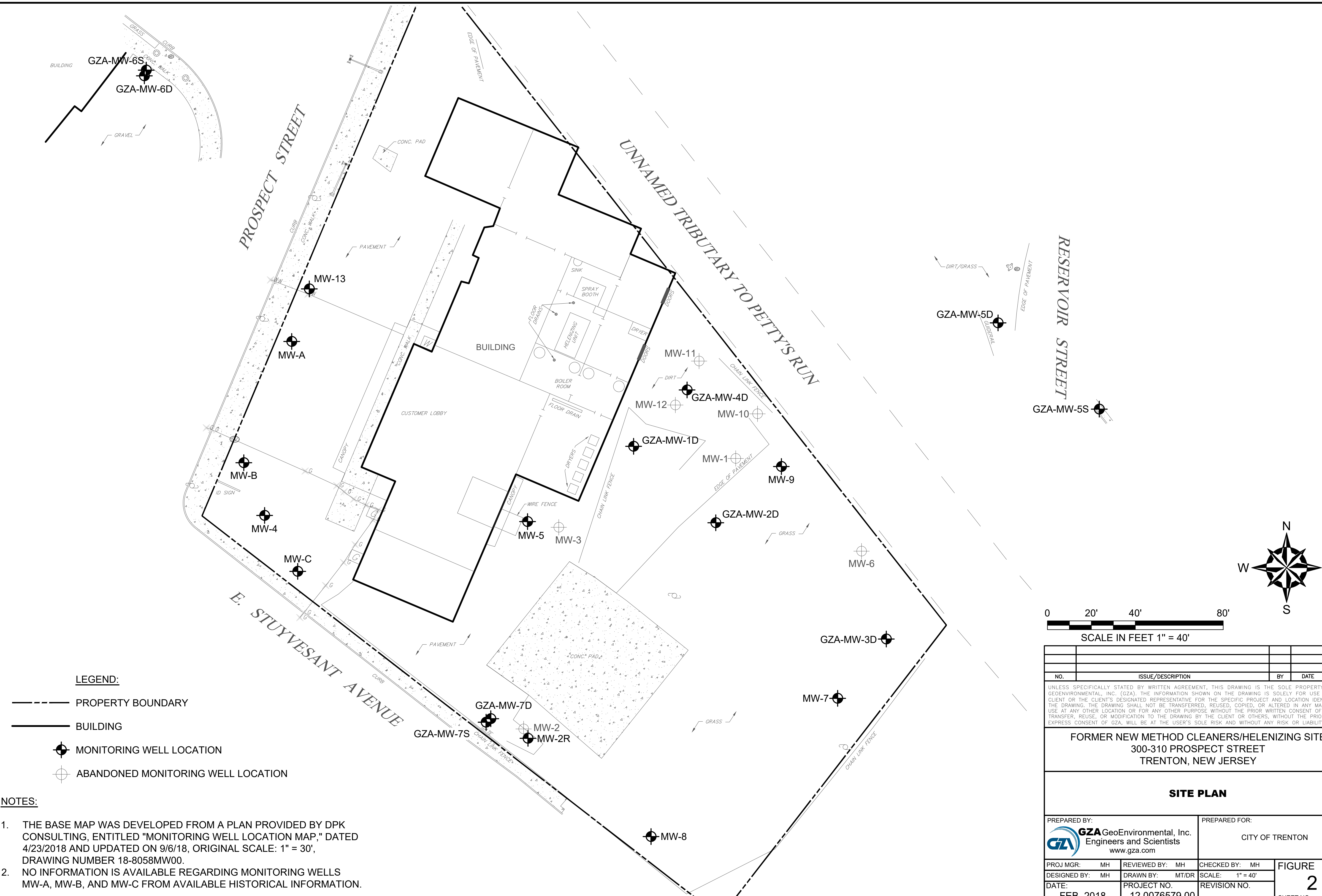
DATE: 11-14-2017

LOCUS PLAN
SHOWING 500 FOOT & 1/2 MILE RADII

REMEDIAL INVESTIGATION WORK PLAN
FORMER NEW METHOD CLEANERS/HELENIZING SITE
300-310 PROSPECT STREET, TRENTON, NEW JERSEY

JOB NO.
12.0076579.00

FIGURE NO.
1



LEGEND:

PROPERTY BOUNDARY

BUILDING

MONITORING WELL LOCATION

ABANDONED MONITORING WELL LOCATION

NOTES:

1. THE BASE MAP WAS DEVELOPED FROM A PLAN PROVIDED BY DPK CONSULTING, ENTITLED "MONITORING WELL LOCATION MAP," DATED 4/23/2018 AND UPDATED ON 9/6/18, ORIGINAL SCALE: 1" = 30', DRAWING NUMBER 18-8058MW00.
2. NO INFORMATION IS AVAILABLE REGARDING MONITORING WELLS MW-A, MW-B, AND MW-C FROM AVAILABLE HISTORICAL INFORMATION.

NO.	ISSUE/DESCRIPTION	BY	DATE

FORMER NEW METHOD CLEANERS/HELENIZING SITE
300-310 PROSPECT STREET
TRENTON, NEW JERSEY

SITE PLAN

PREPARED BY:
GZA GeoEnvironmental, Inc.
Engineers and Scientists
www.gza.com

PREPARED FOR:
CITY OF TRENTON

PROJ MGR: MH	REVIEWED BY: MH	CHECKED BY: MH	FIGURE
DESIGNED BY: MH	DRAWN BY: MT/DR	SCALE: 1" = 40'	2
DATE: FEB. 2018	PROJECT NO. 12.0076579.00	REVISION NO.	SHEET NO.

APPENDIX A

LIMITATIONS

USE OF REPORT

1. GZA GeoEnvironmental, Inc. (GZA) prepared this report on behalf of, and for the exclusive use of our Client for the stated purpose(s) and location(s) identified in the Proposal for Services and/or Report. Use of this report, in whole or in part, at other locations, or for other purposes, may lead to inappropriate conclusions; and we do not accept any responsibility for the consequences of such use(s). Further, reliance by any party not expressly identified in the agreement, for any use, without our prior written permission, shall be at that party's sole risk, and without any liability to GZA.

STANDARD OF CARE

2. GZA's findings and conclusions are based on the work conducted as part of the Scope of Services set forth in the Proposal for Services and/or Report and reflect our professional judgment. These findings and conclusions must be considered not as scientific or engineering certainties, but rather as our professional opinions concerning the limited data gathered during the course of our work. Conditions other than described in this report may be found at the subject location(s).

3. GZA's services were performed using the degree of skill and care ordinarily exercised by qualified professionals performing the same type of services, at the same time, under similar conditions, at the same or a similar property. No warranty, expressed or implied, is made. Specifically, GZA does not and cannot represent that the Site contains no hazardous material, oil, or other latent condition beyond that observed by GZA during its study. Additionally, GZA makes no warranty that any response action or recommended action will achieve all of its objectives or that the findings of this study will be upheld by a local, state or federal agency.

4. In conducting our work, GZA relied upon certain information made available by public agencies, Client and/or others. GZA did not attempt to independently verify the accuracy or completeness of that information. Inconsistencies in this information which we have noted, if any, are discussed in the Report.

SUBSURFACE CONDITIONS

5. The generalized soil profile(s) provided in our Report are based on widely-spaced subsurface explorations and are intended only to convey trends in subsurface conditions. The boundaries between strata are approximate and idealized, and were based on our assessment of subsurface conditions. The composition of strata, and the transitions between strata, may be more variable and more complex than indicated. For more specific information on soil conditions at a specific location refer to the exploration logs. The nature and extent of variations between these explorations may not become evident until further exploration or construction. If variations or other latent conditions then become evident, it will be necessary to reevaluate the conclusions and recommendations of this report.

6. Water level readings have been made, as described in this Report, in and monitoring wells at the specified times and under the stated conditions. These data have been reviewed and interpretations have been made in this report. Fluctuations in the level of the groundwater however occur due to temporal or spatial variations in areal recharge rates, soil heterogeneities, the presence of subsurface utilities, and/or natural or artificially induced perturbations. The observed water table may be other than indicated in the Report.

COMPLIANCE WITH CODES AND REGULATIONS

7. We used reasonable care in identifying and interpreting applicable codes and regulations necessary to execute our scope of work. These codes and regulations are subject to various, and possibly contradictory, interpretations. Interpretations and compliance with codes and regulations by other parties is beyond our control.

SCREENING AND ANALYTICAL TESTING

8. GZA collected environmental samples at the locations identified in the Report. These samples were analyzed for the specific parameters identified in the report. Additional constituents, for which analyses were not conducted, may be present in soil, groundwater, surface water, sediment and/or air. Future Site activities and uses may result in a requirement for additional testing.

9. Our interpretation of field screening and laboratory data is presented in the Report. Unless otherwise noted, we relied upon the laboratory's QA/QC program to validate these data.

10. Variations in the types and concentrations of contaminants observed at a given location or time may occur due to release mechanisms, disposal practices, changes in flow paths, and/or the influence of various physical, chemical, biological or radiological processes. Subsequently observed concentrations may be other than indicated in the Report.

INTERPRETATION OF DATA

11. Our opinions are based on available information as described in the Report, and on our professional judgment. Additional observations made over time, and/or space, may not support the opinions provided in the Report.

ADDITIONAL INFORMATION

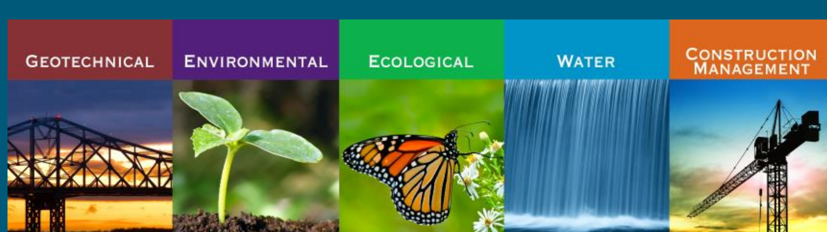
12. In the event that the Client or others authorized to use this report obtain additional information on environmental or hazardous waste issues at the Site not contained in this report, such information shall be brought to GZA's attention forthwith. GZA will evaluate such information and, on the basis of this evaluation, may modify the conclusions stated in this report.

ADDITIONAL SERVICES

13. GZA recommends that we be retained to provide services during any future investigations, design, implementation activities, construction, and/or property development/ redevelopment at the Site. This will allow us the opportunity to: i) observe conditions and compliance with our design concepts and opinions; ii) allow for changes in the event that conditions are other than anticipated; iii) provide modifications to our design; and iv) assess the consequences of changes in technologies and/or regulations.

CONCEPTUAL SITE MODEL

14. Our opinions were developed, in part, based upon a comparison of site data to conditions anticipated within our Conceptual Site Model (CSM). The CSM is based on available information, and professional judgment. There are rarely sufficient data to develop a unique CSM. Therefore observations over time, and/or space, may vary from those depicted in the CSM provided in this report. In addition, the CSM should be evaluated and refined (as appropriate) whenever significant new information and/or data is obtained.



GZA GeoEnvironmental, Inc.