June 13, 2012

Mr. Colin Wade
Pennsylvania Department of Environmental Protection
Southeast Regional Office
2 East Main Street
Norristown, PA 19401

RE: Hoff VC Site
New Hanover Township, Montgomery County, Pennsylvania
Requisition Number GTAC5-1-263
Remedial Alternative Analysis

1.0 SCOPE

Science Applications International Corporation (SAIC) has prepared this Remedial Alternative Analysis to evaluate potential treatment technologies for the removal of site-related contaminants found in residential potable well water under the PADEP General Technical Assistance Contract (GTAC) requisition 1-263. This analysis is limited to review of technology and its potential applicability to the detected contaminants. Evaluation of capital expenditures and annual operation and maintenance costs have not been performed due to the level of design consideration that are required. Though this analysis is focused on individual technologies, the ultimate design for each residence may consist of a combination of these and other water treatment technologies to balance total system costs with operational constraints and achieving compliance with overall protection of human health.

2.0 BACKGROUND

The area of the site is characterized by chlorinated organic impacts to groundwater at a limited group of residential properties along Layfield Road (Route 663) to the north of the intersection of Hoffmansville Road and Layfield Road in New Hanover Township, PA (Figure 1). Affected properties consist of four single family residences (314, 318, 322, and 325 Layfield Road) and a multi-tenant residential apartment building (324, 326, 328, 330, and 332 Layfield Road). All homes and businesses in the area obtain potable water from private wells and are served by on-lot septic systems. Future public water supply in the area of the site is not likely due to the distance from existing supply systems.

Table 1 is a compilation of the maximum detections of water sample results of samples collected from the drinking water wells of onsite homes. These values are also compared to the respective contaminant EPA Drinking Water Maximum Contaminant Levels (MCLs) or PADEP Medium Specific Concentrations (MSCs). This table presents only those compounds that were detected by laboratory analysis.

3.0 POTABLE WATER TREATMENT ALTERNATIVES

Potable water systems have utilized existing technologies such as air stripping, granular activated carbon (GAC), and advanced oxidation technologies to remove volatile organic compound (VOC) contamination. The effectiveness of said technologies is influenced by other water contaminants or properties, such as the presence of metals and/or suspended solids. These technologies are usually combined with other systems to reduce the impact of metals and suspended solids or alter the water to improve the performance of the main technologies, such as increasing the water temperature and/or making pH adjustments.

Below are descriptions of select technologies directed towards application to the known contaminants of concern as described in Section 2.0 above.

Granular Activated Carbon (GAC)

Granular activated carbon (GAC) remediates water by physical adsorption of the contaminant. Most organic compounds will adsorb onto activated carbon to some degree. In general, effectiveness is greater with volatile compounds with higher molecular weight and low solubility. The pH of the water has a moderate impact on absorption with lower pH values resulting in improved adsorption capabilities of the carbon. GAC adsorption efficiency also increases with higher contaminant concentrations.

1,4 Dioxane and MTBE have low molecular weight and high miscible solubility. 1, 4 Dioxane has minimal absorption at very low flow rate and high contact time with GAC. At concentrations of 100 ug/liter, MTBE absorption capability is approximately 1 pound of MTBE for every 1,000 pounds of carbon. Vinyl Chloride and cis-1,2- Dichloroethylene have a moderate adsorption potential with GAC. This adsorption potential is further reduced by the presence of other contaminants and non-uniform flow of water through the carbon vessel. The other contaminants of concern have a high or very high absorption rate by GAC.

The activated carbon within each tank has a limited treatment capacity and carbon change-out intervals will be dependent on the total water usage, total contaminant loading of the water treated, and the concentration of the controlling contaminant. Total contaminants consist not only of the target compounds of the environmental investigation listed in Table 1, but other potential contaminants including radon and select metals and sediment.

The advantage of GAC units is that they are passive systems that require little or no electrical usage. They are able to treat water instantaneously at minimal usage rates. Activated carbon efficiency can be impacted by metals or sediment precipitation, metal-related biological growth on the top surface of the carbon, or suspended particles that can clog the carbon pores. The development of one or more of these conditions would require carbon replacement prior to normal contaminant breakthrough or a backwash capability may be utilized if backwash material disposal is possible. There are optional water treatment methods to control the fouling or remove metals prior to the carbon units that would require additional components to the system.

The generic modifications to the existing residential water systems would include the installation of a GAC system after the existing well pump bladder tank where the carbon design flow would be less than the pumping rate of the submersible well pump. At 314 Layfield Road, where low concentrations of 1,4 Dioxane and MTBE exists, GAC system may be viable. The GAC system would consist of three pressure tanks, connected in a series, to induce a lead-lag flowthrough and insurance lag arrangement to provide continuing water treatment after contaminant breakthrough of the leading tank(s). Sampling ports would be installed before, after, and between these tanks for the periodic collection of samples for laboratory analysis to determine if contaminant breakthrough is occurring and facilitate planning for carbon replacement.

The nominal floor space required for the installation of the GAC units would be 3 feet by 12 feet, depending on the size of GAC vessels installed. The size of each tank will depend on the maximum water flow rate needed at a particular residence and projected carbon change-out intervals. The cross sectional area of the tank should be less than 5 gpm per square foot of carbon area. The carbon capacity of any size tank should meet the annual carbon demand for each residence. A tank could be partially filled, but should have a minimum carbon depth to provide the required contact time between the water and the carbon particles for adequate absorption.

Air Stripping

Air stripping is a remedial method where contaminants are transferred from the water to a passing air stream. This transfer occurs when the contaminant partitions between the aqueous phase and the vapor phase. The equilibrium phase transfer effectiveness is related to the vapor pressure of the pure contaminant compound and its water solubility. This equilibrium partitioning relationship is known as Henry’s constant for each compound. Typically, the higher the Henry’s constant for a contaminant, the more effective air stripping will be for that contaminant.

MTBE has a relatively low Henry’s constant and corresponding low partitioning potential. Therefore, MTBE requires a higher air/water ratio in air strippers compared to the normal air/water ratio for compounds such as benzene or TCE. The Henry’s constant for 1,4-Dioxane is two orders of magnitude lower than MTBE and virtually impossible to air strip. Without the remedial consideration of 1,4 Dioxane, MTBE is the contaminant that controls the sizing of the air stripper due to its percentage of total VOCs in the water samples and its 95% removal requirement to meet the MCLs.

The basic principle of an air stripper is the flow of air in the opposite direction of the water, through different methods where the water and air contact or interface area is greatly increased. There are three styles of air stripper technology. They include a vertical tower, a tank with aeration diffusers, and a shallow tray unit. Vertical towers are generally utilized for extreme high water flow rates and are an outdoor installation. Aeration diffusers have moderate water flow capabilities, but have limited contaminant removal potential and are limited to very high strippable compounds such as Radon or contaminants with low concentration levels. Shallow tray units are very common and consist of multiple levels of pans with tiny holes in which air is force through upward as the water flows downward.

The design of the air stripper is based upon maximum water flow rate and contaminant concentration for each contaminant. The air stripper has a moderate electrical usage, where main consumption is with the air blower and the discharge pressure pump. The presence of high concentrations of suspended solids or metals increases the potential for material precipitation within the stripper trays and could affect VOC removal effectiveness, thus requiring cleaning. Suspended solids and metals could be either removed from the water or conditioned to reduce the potential of material precipitation. Heating of the water will increase a contaminant's partitioning coefficient and thus improve its stripping potential.

The retrofitting of homes would consist of installation of a shallow tray air stripper, a water pressure pump, and probably a larger pressure tank. The submersible well pump may need to be replaced with a smaller pump to reduce the flow rate of impacted groundwater in order to minimize the air stripper requirements. A pressure pump would be used to recover the treated water from the air stripper sump and supply the home distribution system under pressure. A pressure or bladder tank would be sized to provide sufficient water storage for periods of water usage greater than the air stripper system capacity.

A typical shallow tray air stripper would occupy approximately 6 feet by 8 feet of floor space and nominally 8 feet of height. Additional space would be required for a larger pressure tank and pressure pump. In addition, intake and exhaust vent lines would need to be installed to provide and vent the blower air with the outside environment. The exhaust air should not require treatment since total VOC loading will be less than 0.1 pounds per hour at worst concentration.

Ultraviolet Light/Peroxide (UVP)

The combination of ultraviolet light and peroxide addition systems have been successfully applied to water treatment systems. These systems require large capital expenditures and are not easily scalable to smaller flow rates and mass loading. Therefore, these types of systems would not be cost-effective at individual residential sites. These UVP systems are usually installed for the removal of 1,4 Dioxane and/or MTBE in water. A UVP system will reduce the contaminants with concentrations presently exceeding the MCLs. Usually a UVP system is generally installed after an air stripper which will remove the majority of the strippable VOCs in the water prior to UVP treatment to minimize the large operating costs associated with the UVP systems.

A system utilizing UVP would require an air stripper unit with pretreatment and activated carbon treatment as a polishing function in addition to peroxide treatment, chemical feed, and bulk storage and control system. To improve the efficiency of the UVP system, optimum water pH is 3.8, thus requiring the addition of acids and then bases after treatment. High concentrations of iron, manganese and total organic carbon, also reduces the efficiency of UVP system. Sodium bisulfate is general required to remove any un-reacted hydrogen peroxide residual.

A separate building would be required for an UVP system. These systems require frequent operation and maintenance procedures and have large energy usage. They also require chemical storage and injection systems. The operation of a UVP system would also require the oversight of a Pennsylvania licensed water system operator. An additional concern is that the improper breakdown of MTBE can yield tert-butyl formate (TBF), tert-butyl alcohol (TBA), acetone, acetaldehyde, or formaldehyde.

Ultraviolet Light/Ozone (UVO)

UV light is not an effective treatment methodology for most organic chemicals. UV radiation is not suitable for water with high levels of suspended solids, turbidity, color, or soluble organic matter. These materials can react with UV radiation and reduce disinfection performance. Turbidity makes it difficult for radiation to penetrate water. Therefore a filtering pretreatment stage maybe required to reduce/eliminate the presence of these parameters in the water.

The benefit of a UVO system is that it reduces the need and volume of treatment chemicals as compared to the UVP systems. In addition, the overall maintenance and operational costs of the UVO is less than a UVP system. The UVO systems have significantly higher initial capital costs associated with system installation.

As with the UVP systems, a UVO system is generally a pretreatment part of an overall treatment train of air strippers to remove the higher concentration strippable VOCs and GAC is used as a final polishing measure prior to water consumption.

4.0 SUMMARY AND LIMITATIONS

This assessment of available technologies for treatment of VOCs in drinking water was focused on individual technology application. The effectiveness of individual technologies is different for different compounds and concentration levels. Effectiveness was focused on a combination of contaminant concentration, percentage of removal required, and difficulty of treatment. The most effective technology for one contaminant may not be the more effective technology for other contaminants. In addition, the presence of a contaminant may impact the effectiveness of the treatment of another contaminant.

A parameter for evaluating the effectiveness of a technology is the percentage that a contaminant actually needs to be reduced. The goal is to reduce each contaminant below the contaminant's MCL and not necessarily totally eliminate it from the water.

Design or selection of technologies that need to be incorporated into the residential treatment systems will depend on the space available to house the combination of water treatment equipment and store treated water. Water storage requirements will be a balance between the maximum total daily water demand and the amount of instantaneous water use above the average flow rate of the total daily water demand and the duration and frequency of this use. Instantaneous water demand of individual or small systems has a bigger impact on small system water storage requirements than with a larger community system since there is no averaging of instantaneous water demand of households served by a larger system. Additional water storage would be required for active treatment systems which require either equipment startup time, such as developing air flow through an air stripper or water treatment time as with oxidation technologies.

This analysis was based upon the range of concentrations of detected contaminants in the affected individual potable water wells. Contaminant levels may decline or increase over time. Also, the reduction of well pumping rates to an average over a 24 hour period may impact the contaminant concentrations seen in the well water. This evaluation did not include a review of the existing residential water supply systems including pump size, bladder tank size, water treatment equipment such as water softeners, and available areas within the homes for installation of treatment systems.

5.0 CONCLUSIONS

Due to the presence of 1,4 Dioxane at elevated concentrations, only the UVP and UVO systems are capable of treating the groundwater from the identified potable wells. The space requirements and high capital and operational costs for these types of systems hinder the feasibility of the installation of individual treatment units in each residence.

An air stripper is effective at removing many of the VOCs detected, but its inability to effectively remove 1,4 Dioxane and MTBE eliminates its viability as the sole treatment method. Vapor emission treatment is not expected to be required. Air strippers have higher initial capital cost than carbon units, but net operation costs generally are lower than carbon exchange. Air strippers require larger spaces for installation and maintenance. The blower on the air stripper requires a startup period to develop full air flow. This results in a delay in the supply of treated water as the raw water can only pass through the stripper until once the blower has already started functioning.

Granular activated carbon is effective at removing the majority of the contaminants detected in home well water at the site. However, MTBE and 1,4 Dioxane are limiting contaminants. GAC treatment at 314 Layfield Road may provide effective treatment if the well is pumped at a low flow rate, which would require a large treated water storage pressure tank. A pilot test would need to be performed to confirm that GAC alone could sufficiently reduce the 1,4 Dioxane concentration. This assumes that MTBE and 1,4 Dioxane concentrations do not increase. The advantages of carbon are the minimal amount of space required for installation, simple and quiet operation, instantaneous treatment, and reliability in the lead-lag arrangement of the multiple carbon vessels. Disadvantages include limits to the carbon’s useful treatment life, replacement costs, and the requirement to properly dispose and/or treat the spent carbon.

A final selection of technologies for home well water treatment will depend on their overall protection of human health, reliability, effectiveness, ability for implementation, and total present worth cost of the design, capital procurement, and annual operation (including energy, consumables, and associated labor for operation and maintenance). Other design considerations include available space, loss of space, noise levels, and operator or technician access.

The apartment building well water supply has a high contaminant mass to be treated based upon the larger water demand of the five apartments combined. The apartment building and the single residence at 325 Layfield Road have significantly lower concentrations of MTBE that require removal. Carbon alone should be adequate to treat the well water at these locations as well as

314 Layfield Road where the well water only has low concentrations of TCE and 1,1-dichloroethylene above the MCLs.

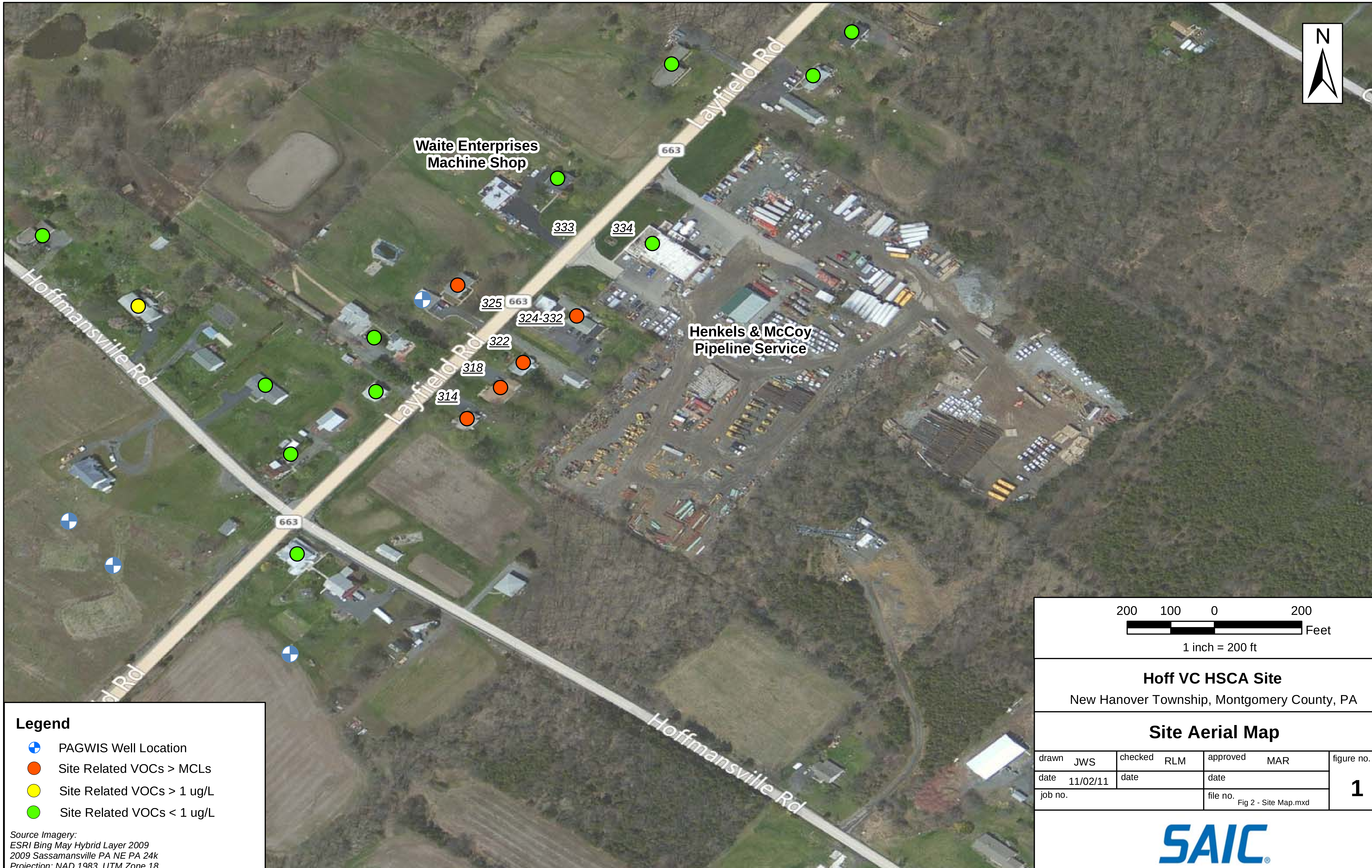
The most viable option is to provide a common water system for the 5 affected buildings and other nearby residences, if desired. This type of system would be considered a "Public Water System" under Pennsylvania's Safe Drinking Water Act and 25 Pa. Code Chapter 109 because it would serve more than 25 individuals. This can be achieved by extending existing public water supply mains to this area and connection of each affect property, or the installation of a common water system that would consist of a supply well or multiple supply wells and a single treatment system. Wellhead protection may require restricted land use surrounding the connected wells through land purchase or deed restriction. If using the existing home supply wells is not an option, a new, higher capacity/yielding supply well would be required. If a new source well is required due to zone 1 wellhead protection requirements, the well could be located outside the impact area of the contaminant plume.

Advantages of a common system would include centralizing the treatment components and equipment in a single location/building, reduction in capital and operation costs and reduction in water storage requirements due to the averaging of peak water demands over longer durations. Additionally, nearby residences that are currently unaffected could easily be connected to ensure continued and future protection of human health. Disadvantages would include the costs associated with the installation of a new supply well (if required), land purchase, installation of a water distribution system, and the requirement for a licensed operator to routinely maintain the system.

SAIC recommends that a conceptual design evaluation be conducted next to assess or compare the installation of a common water supply system and single home well systems to evaluate potential water sources, assess existing buildings/residences for available system installation space, determine preliminary equipment sizing and water demands, review Pennsylvania Safe Drinking Water Act and 25 Pa. Code Chapter 109 regulations for community system design standards, determine system components and costs, and evaluate other factors related to the installation of these types of systems.

Sincerely
Scientific Application International Corporation

Steven D. Glazier, P.E.
Sr. Remediation Engineer



Hoff VC HSCA Site

New Hanover Township, Montgomery County, PA

Site Aerial Map

drawn JWS	checked RLM	approved MAR	figure no.
date 11/02/11	date	date	1
job no.		file no. Fig 2 - Site Map.mxd	

SAIC

Path: G:\GTAC\Hoff_VC\Projects\Fig 2 - Site Map.mxd

TABLE 1
HOFF VC HSCA SITE
MAXIMUM CONTAMINANT CONCENTRATION
Wells with Detections above MCLs

COMPOUND		**Maximum Contaminant Levels:**	Apartment Building 326 Layfield	318 Layfield Road	314 Layfield Road	322 Layfield Road	325 Layfield Road
Trichloroethylene	TCE	5	***58.4***	***624***	***16.3***	***306***	***47.7***
cis-1,2- Dichloroethylene	cis-1,2-DCE	70	***396***	***1580***	25.6	***1030***	***98.3***
1,1-Dichloroethylene	1,1-DCE	7	***96***	***106***	***33***	***322***	***28.3***
Vinyl Chloride	VC	2	***70.3***	***53.8***	0.858	***99.8***	***12.2***
1,2-Dichloroethane	1,2-DCA	5	1.38	***8.13***	0.576	***6.43***	0.825
Methyl Tertiary Butyl Ether	MTBE	20	**37.9**	**417**	6.21	***273***	***25.8***
Benzene	Benzene	5	3.6	***16.3***	0.285	***15.4***	1.37
1,4-Dichlorobenzene	1,4-DCB	75	49.3	***101***	0.72	71.5	7.56
1,2-Dichlorobenzene	1,2-DCB	600	384	***727***	5.71	484	52.2
Pentachlorophenol	PCP	1	***1.08***	ND	ND	ND	ND
1,4-Dioxane	1,4-Dioxane	6.4	***52.3***	***78***	***9.36***	***83.7***	***15.2***
	Total VOCs		1150	3711	99	2692	289

Notes
- Concentrations in ug/l
- Bold and Italic: Exceeds US EPA Maximum Contaminant Level (MCL) or PADEP Medium Specific Concentration (MSC)
- ND: Not Detected
- NS: Not Sampled