CHAPTER 3 – IDENTIFICATION AND SCREENING OF REMEDIAL TECHNOLOGIES (PROCESS OPTIONS)

3.0 INTRODUCTION

Process options are remedial technologies and/or techniques that can be used either individually or in combination to control risks to human health and the environment and satisfy the remedial action objectives unique to each contaminated site. The initial list of process options considered during the Feasibility Study were developed by PLS and its consultant: Fishbeck, Thompson, Carr, and Huber, Inc. (FTC&H). The MDEQ and a technical committee working on the project consisting of representatives of the City of Ann Arbor, Washtenaw County, the United States Geological Survey, and academia were given an opportunity to review the initial process option list and to provide feedback. After receiving such feedback, the list was then revised to reflect the comments received from both the MDEQ and the technical committee.

This Chapter: 1) presents the remedial technologies and process options that could potentially be used to achieve the remedial action objectives; 2) screens out the process options that are impractical given the site-specific conditions; and 3) assembles the surviving process options into remedial alternatives deemed capable of achieving the remedial action objectives. The available interim response process options are evaluated in Chapter 4 to determine the extent to which it is appropriate to implement such measures, either independently or in combination with one or more of the identified remedial alternatives. The remedial alternatives themselves are then evaluated and screened under the criteria discussed in Chapter 5. The surviving remedial alternatives are further evaluated in Chapter 6 and an alternative is selected in Chapters 6 and 7.

3.1 PROCESS OPTIONS POTENTIALLY AVAILABLE

The following process options were identified as potentially appropriate for remediation of the contaminated groundwater at the site:

1. General methods of controlling or addressing plume
    - a. No Action
    - b. Monitored Attenuation
    - c. Institutional Controls
    - d. Groundwater Extraction and Ex-situ Treatment
    - e. In-situ Treatment
2. Methods of Extracting Groundwater
    - a. Vertical Well
    - b. Horizontal Well
3. Methods of treating groundwater contamination
    - a. No treatment
    - b. Ex-situ groundwater treatment.
        - i. Ultra-Violet Light and Hydrogen Peroxide Oxidation
        - ii. Ozone and Hydrogen Peroxide Oxidation
    - c. In-situ groundwater treatment

i. Recirculating Ozone Wells
ii. Fenton's Reagent
iii. Ozone-Rich Water Injection
iv. Ozone Sparging
v. Ozone Sparging and Hydrogen Peroxide Injection
vi. Hydrogen Peroxide Injection only

4. Treatment Location

a. PLS-Wagner Road Facility
b. Property near Maple Road
c. Property near Huron River

5. Methods of Transferring Purged Water

a. New Pipelines
b. Tanker Truck
c. Montgomery Well Pipeline

6. Water Discharge Options

a. Treated Water Discharge Points
   i. Surface Water Discharge
      1. County Drain (Allen Drain)
      2. Sanitary Sewer and Publicly Owned Treatment Works
      3. Huron River
      4. Honey Creek
      5. First Sister Lake

   ii. Below Grade Discharge into Unit E
      1 greater than 85 ppb
      2. between 1 ppb and 85 ppb
      3. less than 1 ppb

b. Untreated Water Discharge Points
   i. Deepwell Injection into Simon Formation
      1. Wagner Road Facility
      2. Near Maple Road

These process options and how they fared in the initial screening are summarized in Table 1.

3.2 INITIAL SCREENING OF PROCESS OPTIONS

The purpose of this section is to review the initial list of process options and screen that list to eliminate those options that are not appropriate to Unit E in accordance with the screening criteria identified in the Feasibility Study rule (Rule 530(4) of Part 201, Mich Adm Code R. 299.530(4)). Under the Feasibility Study rule, process options must be evaluated in terms of their effectiveness, cost, timeliness, and whether they are considered acceptable engineering practices given the option's feasibility for the location and reliability.

PLS applied these regulatory criteria to the site-specific information such as geologic or hydrogeologic conditions and contaminant type and concentration. Published and personal accounts of technology performance and professional judgment were also included in the evaluation process. Reasons for eliminating remedial technologies and process options are presented in Section 3.3 below and summarized in Table 1. Surviving options are then combined into remedial alternatives, which receive a more detailed review in Chapters 5 and 6 of this Feasibility Study.

3.3 ELIMINATED PROCESS OPTIONS

Thirteen process options were eliminated prior to forming the preliminary remedial alternatives. The basis for elimination of each is described below. These process options are denoted with "no" in the final column of Table 1.

3.3.1 Methods of Extracting Groundwater (1)

Two groundwater recovery options were identified for extraction of groundwater from the Unit E – vertical wells and horizontal wells. Vertical wells are retained as a groundwater recovery option. For the reasons explained below, horizontal wells are screened out.

Horizontal wells - Contaminated groundwater can be recovered with either vertical or horizontal wells. Three primary characteristics of the Unit E contamination are the depth, volume, and rate of movement of the contaminant plume. The use of horizontal wells for the Unit E was screened out because the dimensions and depth of the contamination make it unduly challenging (and perhaps infeasible) to construct such a well. A horizontal well is also unduly difficult to maintain in a residential neighborhood due to access and waste generation and disposal issues (waste generated from the "pigging" process). A horizontal well is also far more costly to install and maintain compared to vertical well construction techniques that could accomplish the same goals.

The contamination in Unit E plume is over 100 feet below grade and the Unit E is very thick, with contamination at different elevations depending on the area of Unit E that is being evaluated. Construction of a horizontal well or wells, which descend at an angle, to this depth would require a total casing and screen of significant length. It will be difficult to screen at the proper depth to maximize capture of the contaminant. Without detailed design work, it is difficult to know if there are available and suitable properties for access for drilling given the length, depth and angles required. There are a limited number of contractors available to drill such wells. A system relying on this type of construction lacks flexibility (the well cannot be moved or relocated, additional wells would have to be of vertical construction).

The process required to drill such wells is much more complicated than drilling vertical wells. As such, the time and cost to install such a well are often much higher than vertical wells.

Maintenance is required of all groundwater recovery or injection wells. It typically involves the use of a large service or drill rig, chemical treatment, and the collection and shipment of reagents or development water. The maintenance of horizontal wells is complicated by their great length and horizontal position, which makes removal and replacement of a pump more time-consuming and difficult and increases the quantity of acid or base used. The amount of waste produced during cleaning (pigging) a horizontal well is significantly higher than for vertical wells and this may complicate community relations in addition to requiring more trucks for hauling and disposal.

For the reasons above, this process option was eliminated.

3.3.2 Methods of Treatment

Ultra-violet light/Hydrogen Peroxide – PLS has used this treatment technology at its Wagner Road facility to treat the contaminated groundwater removed from other aquifers. There are, however, a number of considerations that make this technology unsuitable for use outside the Wagner Road facility. Ultraviolet light/hydrogen peroxide oxidation consumes a tremendous amount of electricity. Preliminary contact with electrical utilities indicates that sufficient service may not be available near Maple Road. Even if available, there are unacceptable risks associated with placing the necessary electrical service in the residential, recreational or even commercial settings present near Maple Road. This technology also requires large quantities of dangerous chemicals, most notably sulfuric acid. The risks posed by the delivery, storage and use of such chemicals in the residential, recreational or even commercial settings present near Maple Road are considered to be unacceptable.

For these reasons, this process option was eliminated for the Maple Road location.

3.3.3 Treatment Locations

Near Huron River - Treating purged groundwater near the Huron River was eliminated as a process option under any of the remedial alternatives that attempts to capture the leading edge near its current location. Such a scenario would involve transporting untreated water from the current location of the leading edge to the Huron River. There would likely be public resistance to any option that involves transporting untreated water a significant distance through congested residential neighborhoods. The cost of installing a double walled pipeline all the way from the proposed extraction well system to the Huron River would also be prohibitive.

This treatment location would, however, be appropriate under a remedial alternative that involves capturing the leading edge of contamination closer to the Huron River. It has been retained for that alternative.

3.3.4 Methods of Transferring Purged Water (2)

As explained below, two options for transfer of untreated groundwater were screened out – tanker trucks and the existing Montgomery well pipeline. A third option – construction of a new pipeline to convey water, was retained.

Tanker trucks - Tanker trucks could be used to convey recovered water to the PLS facility on Wagner Road for treatment. This option has been eliminated because it is not adequately reliable, presents a significant, unnecessary burden on the neighborhood, and presents an undue risk of accidental release.

At the pumping rate needed to control and reduce the plume and the anticipated time required to purge clean the aquifer, thousands of 5,000-gallon tanker trucks, approximately one every ten minutes, would be needed. These trucks would have to run 24 hours per day, 365 days per year, regardless of the weather. The high frequency of trucks would increase traffic volume, particularly during non-business hours. Also, the additional volume of heavy trucks will likely accelerate road degradation. Intense use of local surface streets in this manner is inconsistent with current uses and unduly burdensome.

Over the probable life of the remediation in excess of 1,000,000 tanker truck circuits would likely be required. The probability of at least one serious vehicular accident during this time is high. Injuries to persons or property due to truck-vehicle collision are significantly more likely than risks due to exposure to 1,4-dioxane in the groundwater.

For these two reasons, this process option was eliminated.

Existing Montgomery Well pipeline – The City of Ann Arbor Montgomery Well was taken off-line after the discovery of trace amounts of 1,4-dioxane in the well. The well is connected to the Ann Arbor Water Treatment Plant by a pipeline. With the Montgomery Well having been taken out of service, PLS considered adopting this existing pipeline for transmittal of purged water from the area of the Plume closer to the Huron River.

This option was eliminated as infeasible. PLS' investigation of this option revealed that the pipeline is currently used to transfer water from the City's Steer Farm Well Field to the Water Treatment Plant. Consequently, it is not available for use by PLS.

3.3.5 Water Discharge Options

Several options for discharge of treated or untreated groundwater were reviewed. As detailed below, discharge to the Allen Drain (Washtenaw County and City of Ann Arbor storm drain system), discharge to the City of Ann Arbor sanitary sewer system, and discharge to First Sister Lake were screened out. Discharge of untreated water to the Mt. Simon formation from a location near Maple Road was screened out. The process options involving discharge of treated water to the Huron River, , the Honey Creek tributary, and the three below grade groundwater re-injection options were all retained as was the below-grade discharge of untreated water to the Mt. Simon formation from a location on PLS' Wagner Road property.

County drain (Allen Drain) – The Allen Drain refers to the local storm water system. Portions of the Drain are administered by the Washtenaw County Drain Commissioner and other portions by the City of Ann Arbor. Part of the drain is still an open watercourse. As with all drains, its primary purpose is to carry storm water and run-off. PLS has in the past contacted both the Drain Commissioner and the City of Ann Arbor to determine if the Allen Drain could accept purged groundwater. Although both entities considered the request seriously, PLS has been informed that discharge of groundwater (treated or untreated) would not be permitted because the drain lacks capacity as is, and is not considered adequately isolated from exfiltration. Also, although a state discharge permit could be obtained, local ordinances of the City generally prohibit discharges of groundwater to the City's storm system and the Drain Commission has passed a resolution barring such discharges to the Allen Drain.

Therefore, this process option was eliminated as technically and practically infeasible.

Sanitary sewer – The local sanitary sewers are constructed and maintained by the City of Ann Arbor's Utilities Department. Treated groundwater could be discharged to the sanitary sewer for processing and incidental further treatment at the publicly owned treatment works, under a city permit.

This discharge is technically infeasible because the Utilities Department has notified PLS that there is inadequate capacity in the local sewer lines to carry the volumes of water needed. Although the City of Ann Arbor has in the past made some capacity available to PLS, this was on a temporary emergency basis and did approach the volumes needed for Unit E.

Therefore, this process option was eliminated as technically and practically infeasible.

First Sister Lake – First Sister Lake is located east of the PLS facility. This lake is entirely surrounded by the City's Dolph Park. First Sister Lake and it's the neighboring Second Sister Lake are the only naturally formed lakes in the City of Ann Arbor. Both lakes are hydraulically connected to the same unnamed tributary (a tributary to Honey Creek) into which PLS currently discharges treated groundwater.

First Sister Lake is a potential discharge location for treated groundwater from extraction options involving treatment in the Maple Road area. The advantage of this site would be the potential for a shorter pipeline route as compared to the one needed to bring the water back to the PLS facility on Wagner Road. This one advantage, however, does not appear to outweigh the many disadvantages of this process option.

The lake is in an important recreational property and a valuable natural resource for the community. It is unlikely that the community would find that use of the lake as a discharge point would be acceptable.

The lake's ability to efficiently convey additional water to the exiting tributary appears to be poor. Visual observations and a review of aerial photographs suggest this connection may be poor due to heavy vegetation bordering the lake. As such, discharge into First Sister Lake may tend to raise the lake levels before water would begin to convey out to the tributary. This would create hydrological and ecological uncertainties and complications and could negatively affect the public's enjoyment of Dolph Park. It may also adversely affect the wetlands currently bordering First Sister Lake.

Performing routine services such as line cleaning would also be very difficult in a park setting. Furthermore, the discharge point, even if it were designed to be unobtrusive, would likely change natural landscape.

Based on the above, this process option was eliminated as being politically and practically unacceptable.

Deepwell Injection Near Maple Road -- Deepwell injection for industrial disposal in Southeastern Michigan is typically into the Eau Claire and Mt. Simon sandstones. These zones are chosen due to their good injection potential and the depth of the injection interval. These formations are part of the Munising Group and are located directly above the basement Precambrian rocks. Other potential zones such as the Sylvania sandstone and the Dundee Limestone are located too shallow to be used for injection in Southeastern Michigan. A location where the formation could accept the necessary volume of water would have to be determined.

Placing a deepwell injection location near Maple Road would have the advantage of reducing the length (and cost) of the pipeline needed to convey the water from the extraction well system. This advantage, however, is negated by the legal challenges associated with this discharge location. Authorization for any discharge to the Mt. Simon or other formation must be obtained in the form of a permit from US. EPA. One of the permit requirements is that the permitee own the property on which the proposed well is to be located. Therefore PLS would be required to purchase property near Maple Road. Another requirement is that the property be properly zoned for such an industrial activity. Use of property by PLS for deep injection would be inconsistent with current zoning and the prospect of an acceptable change in zoning to accommodate this change in use is deemed to be very low. Therefore, this process option was eliminated.

3.3.6 In-Situ Groundwater Treatment (3)

Six options for in-situ groundwater treatment were considered. Five have been screened out.

Recirculating Ozone Treatment Well - Groundwater can be treated in large-diameter wells with two screened intervals. Ozone could be introduced at the base of the well, and circulation between the screen zones would, in theory, set up a treatment cell in and around the well. Contaminants are oxidized as water moves within the well or after it has returned to the aquifer.

This technology is proprietary and has had mixed results (see literature articles). This technology has not been demonstrated as effective for an extensive application such as remediation of the Unit E plume. For the reasons above, this process option was eliminated.

Fenton's reagent - Fenton's reagent is formed when aqueous solutions of hydrogen peroxide and ferrous iron ions are mixed. The reaction creates hydroxyl radicals, which is second only to elemental fluorine as an oxidant and much stronger than hydrogen peroxide. However, hydroxyl radicals are short-lived in the aquifer due to their strength. This limited life span mandates the use of closely spaced treatment wells, and numerous injection events.

Large volumes of concentrated hydrogen peroxide and sulfuric acid (powerful oxidants), sodium hydroxide (strong base), and ferrous sulfate (catalyst) would be required to treat the contaminant plume and manage the aquifer pH. Transport, storage, and use of these materials would pose risks to human health and the environment far in excess of that associated with the Unit E contamination

For the reasons above, this process option was eliminated.

Ozone-rich water injection - Ozone is 10 to 15 times more soluble in water than oxygen. In this remedial technique, water is saturated with ozone through reverse air stripping or sparging in an above-grade vessel. The enriched water is then injected into Unit E. There, the ozone, or hydroxyl radicals formed during its reaction with water, destroys contaminants.

However, ozone molecules are very reactive, therefore unstable. Hydroxyl radicals are also highly reactive and unstable. Both oxidants can react with natural organic and inorganic components of groundwater, as well as other oxidant species. It is probable that the majority of the oxidant species in the enriched water would react with the inner surface of the injection well, reducing the strength of the solution. Therefore, this process option was eliminated.

Ozone Sparging/ Ozone Sparging and Hydrogen Peroxide Injection – PLS' initial field-testing of ozone sparging last summer demonstrated that 1,4-dioxane contamination could be destroyed by the introduction of ozone into a shallow underground aquifer. PLS initiated a multi-phase field study of this potential in-situ technology to determine if ozone (in gas form) could be reliably delivered to the Unit E (a much deeper aquifer) and whether the ozone sparging would result in any harmful bi-products, given the water chemistry of the Unit E. Of particular concern was the potential for producing bromate. The bromate can be created by the reaction of ozone and bromide, a naturally occurring compound in groundwater.

Last fall, PLS conducted a five-phase field study of three potential in-situ technologies using Unit E wells located on its property. The first phase of the study involved the injection of hydrogen peroxide into the formation. The results from the injection of hydrogen peroxide showed destruction of 1,4-dioxane without the formation of bromate. This process option has been retained, pending further field studies to be conducted in February and March. This option will be evaluated following this study in the final version of this Feasibility Study.

Ozone and then a combination of ozone and hydrogen peroxide were injected during the field-testing. The results from both phases that included ozone sparging again reflected impressive destruction rates for

1,4-dioxane. Unfortunately, the introduction of ozone under either scenario resulted in the formation of bromate at levels above the USEPA Maximum Contaminant Level (MCL) of 10 ppb. Although the ozone sparging technology is promising, given its demonstrated ability to destroy 1,4-dioxane in the aquifer, it cannot be considered as an available in-situ process option for the Unit E at this time because it creates unacceptable levels of bromate. The high levels of naturally occurring bromide in the Unit E appear to have accentuated the bromate problem. Therefore, the ozone sparging and ozone sparging combined with hydrogen peroxide injection process options were eliminated.

Hydrogen Peroxide Injection – The first phase of the above-described field study involved the injection of hydrogen peroxide into the aquifer. The results of this portion of the study were promising but not conclusive. The study appeared to show that the injection of hydrogen peroxide by itself destroyed 1,4-dioxane without creating bromate. PLS has just implemented a follow up in-situ work plan near Maple Village to further examine the potential of this technology. Unfortunately, the results of this study indicate that that the injection of hydrogen peroxide only will not destroy 1,4-dioxane in the aquifer to a significant degree. Therefore, this process option is being eliminated for consideration and is not carried further in this Feasibility Study. PLS is currently in the process of supplementing this technology by combining the injection of hydrogen peroxide with Ferrous Iron (Fe++). If this in-situ technology shows promise, PLS may supplement this report in the future, as appropriate.

3.4 SURVIVING PROCESS OPTIONS

The below-listed process options survived the initial screening and will be used to form remedial alternatives:

1. General methods of controlling or addressing plume

   a. No Action
   b. Monitored Attenuation
   c. Institutional Controls
   d. Groundwater Extraction and Ex-situ Treatment
   e. In-situ Treatment

2. Methods of Extracting Groundwater

   a. Vertical Well

3. Methods of treating groundwater contamination

   a. No treatment
   b. Ex-situ groundwater treatment.
      i. Ultra-Violet Light and Hydrogen Peroxide Oxidation (but not near Maple Road)
      ii. Ozone and Hydrogen Peroxide Oxidation

4. Treatment Location

   a. Wagner Road Facility
   b. Property near Maple Road
   c. Property near the Huron River (under non-leading edge alternative)

5. Methods of Transferring Purged Water

   a. New Pipeline

6. Water Disposal Options

   a. Treated Water Discharge Points
      i. Surface Water Discharge
         1. Huron River
         2. Honey Creek
      ii. Below Grade Discharge
         1. greater than 85 ppb
         2. between 1 ppb and 85 ppb
         3. less than 1 ppb

   b. Untreated Water Discharge Points
      i. Deepwell Injection into Mt. Simon Formation at PLS Wagner Road Facility

3.5 DESCRIPTION OF REMEDIAL ALTERNATIVES

Using the surviving process options PLS has developed an array of remedial alternatives that can eliminate, reduce, or control the potential risks to human health and the environment present at the Site. The remedial alternatives are combinations of the surviving process options.

The remedial alternatives were developed in conformance with the criteria and standards presented in Rule 530 of Part 201 of the Natural Resources and Environmental Protection Act, 1994 P.A. 451, as amended (Rule 530). The following key Site-specific conditions were also considered during development of the Unit E alternatives:

- the distribution of 1,4-dioxane,
- existing remedial actions,
- a major transportation corridor (Interstate 94 crosses the contaminated area of Unit E), and
- the commercial and residential nature of the surface above the majority of the plume.

Seventeen remedial alternatives were developed from the above surviving process options. They differ primarily in the treatment location and the mode of treated water disposal. The alternatives are described below.

3.5.1 Alternative 1 - No Action

The No Action alternative (Alternative 1) would not actively control, treat, or monitor the impacted groundwater. The dissolved 1,4-dioxane would be allowed to migrate, dissipate, and decay naturally.

3.5.2 Alternative 2 - Monitored Natural Attenuation and Institutional Controls

Alternative 2 would include monitoring of groundwater conditions and contaminant movement while controlling potential exposure risks through either restrictive covenants or a local ordinance.

Changes in contaminant levels in the groundwater would be monitored by periodic sampling of groundwater from monitoring wells. Samples would be analyzed for 1,4-dioxane and selected monitored natural attenuation (MNA) parameters.

The components of this alternative include: initial hydrogeological investigations to determine the fate of 1,4-dioxane in the Unit E plume, the installation of a monitoring well network, long-term monitoring, and use of institutional controls to control exposure.

Initial Hydrogeological Investigations

Much of the investigations of the Unit E plume have been in or near the current boundaries of the plume. Outside and more specifically hydraulically downgradient of this area, there are limited hydrogeological data regarding aquifer conditions. Investigations will be required to determine aquifer characteristics such as groundwater flow direction, geometry and physical properties of aquifer materials. This investigation would be used to more reliably predict the migration pathway of the plume. It is assumed that this investigation will require a minimum of 10 strategically placed borings/wells. Vertical water quality and geological data would be collected at each of the well locations. Data from the investigation would be used to construct a groundwater flow and transport model to simulate the migration of the Unit E plume as it moves hydraulically downgradient.

Monitoring Well Network

Wells will need to be installed along the plume pathway to monitor the plumes fate in time and distance. It is assumed that a minimum of 10 additional monitoring wells (in addition to those installed for the investigation) will be necessary to provide adequate monitoring of the plume as it advances hydraulically downgradient. These wells would be used along with selected existing wells to monitor the Unit E plume over time and distance.

Long-Term Monitoring

Long-term monitoring of 1,4-dioxane and other MNA parameters will be necessary to document plume changes with time and distance. The monitoring will involve the collection of samples from wells inside and hydraulically downgradient of the Unit E plume.

Institutional Controls

A number of exposure control methods using institutional controls are potentially applicable to the Unit E plume:

Restrictive Covenants – Under this scenario, pursuant to Section 20120b(4) of Part 201, restrictive covenants prohibiting the withdrawal of contaminated groundwater for drinking water purposes would need to be recorded on any land that lies above the plume, including and any areas to which the plume would migrate at concentrations above the cleanup criteria. It is not possible to restrict property not owned by PLS. Such restrictions would require the consent of individual landowners in the plume area.

Given the large numbers of landowners from whom restrictive covenants would need to be obtained, it does not appear that this option is practical.

Local Ordinances – Under section 20120b(5) of Part 201, if the MDEQ determines that obtaining the necessary restrictive covenants would be impractical and that exposure to the groundwater contamination may be reliably restricted by an institutional control in lieu of restrictive covenants, the MDEQ may approve a cleanup that relies on other institutional controls, including an ordinance that prohibits use of groundwater. Arguably, the institutional controls prohibiting withdrawal of groundwater for drinking water purposes already exist in the form of Washtenaw County Heath Department regulations that prohibit the installation of drinking water wells in areas served by municipal water. But it is PLS' understanding that the MDEQ will not accept such existing institutional controls and that a specific ordinance meeting the requirements of section 20120b(5) would have to be adopted. This scenario would require the City of Ann Arbor to adopt such an ordinance. PLS has met with representatives of the City to determine if passage of such an ordinance could be accomplished, but at this time it is not known whether this can be accomplished. Given the recent suit filed by the City, passage of this type of ordinance is deemed unlikely.

Combination of Existing Ordinances with Court Order – Existing Washtenaw County ordinances effectively prevent exposure to contaminated drinking water wells. As detailed in Chapter 7 in connection with PLS' discussion of the waiver requirements, the existing ordinance provisions could be supplemented by a stipulated court order that would satisfy the statutory requirements for institutional controls.

3.5.3 Alternatives 3a-e - Groundwater Pumping - Pipeline to PLS Wagner Road Facility, Treatment Using Ozone/Hydrogen Peroxide or Ultra-violet Light/Hydrogen Peroxide

Five alternatives comprise this group. All four share:

- recovery of groundwater from multiple vertical extraction wells at the leading edge,
- transmission of recovered water through individual pipelines, which combine with others up stream of a new pipeline,
- transmission of the total flow of all individual wells through the new pipeline to the PLS facility,
- chemical oxidation of 1,4-dioxane using either the Ultra-violet light/Hydrogen Peroxide or Ozone/Hydrogen Peroxide oxidation technology without production of by-products at concentrations that pose risks, and
- disposal of treated water.

The alternatives within this group are distinguished by the treatment method and location where the treated water would be discharged.

Shared Challenges

The key challenges that are common to all of alternatives in this group are the installation of a new transmission pipeline able to convey water to the PLS Wagner Road facility and the location of extraction wells and related infrastructure east of Maple Road, where the plume has migrated under Veterans Park and densely populated residential neighborhoods. The technical feasibility of constructing and installing such infrastructure is well established both at this site and others. The lengthy and uncertain construction timeline associated with construction of these elements, however, calls into question the practical feasibility of any of the alternatives within this group. For example, the transmission pipeline back to the Wagner Road facility would have pass under Interstate 94, a significant physical obstacle. Obtaining the necessary access to both public and private property and then constructing the pipeline would be a difficult and lengthy process. Similarly, installing the extraction wells and the necessary infrastructure in the residential areas where the leading edge of the plume is currently located will necessarily cause disruption to residents and users of the area roads. Many residents have previously expressed resistance to PLS' efforts to install monitoring and test wells in their neighborhood and the disruption associated with the scale of construction necessary to implement any of these alternatives would be much greater and last for a longer period of time. Such community opposition to the construction of this infrastructure could delay the project.

The uncertainty regarding the length of time needed to obtain access and then to construct the necessary infrastructure will make it difficult to determine where the leading edge of the plume would be when such infrastructure is ready. Such delays would delay initiation of purging, which would allow the plume to migrate farther to the east, potentially requiring re-positioning of the recovery wells. This would in turn increase the level of disruption. Consequently, the practical feasibility of any of the remedial alternatives that involve construction of lengthy pipelines across property not owned by PLS is uncertain.

The increased control of groundwater treatment systems and reagents possible at the Wagner Road facility is a potentially compensating benefit.

Alternative 3a – Under this alternative, after the purged water is transported back to the PLS facility, it will be treated with either Ozone and hydrogen peroxide or ultra-violet light and hydrogen peroxide technology. The treated water would transported via a new pipeline directly to the Huron River where it would be discharged under a NPDES permit. A new, treated water pipeline to the Huron River would be as difficult and costly to construct as the pipeline from Maple Road to the Wagner Road facility. Installation of the pipeline would require access from three governmental units and numerous private landowners. The uncertainties discussed above regarding delays in obtaining access and building such a long pipeline would apply to this pipeline as well, injecting even greater uncertainty into PLS' ability to capture the leading edge of the contamination under this alternative.

Alternative 3b – Under this alternative, after the purged water is transported back to the PLS facility, it will be treated with either Ozone and hydrogen peroxide or Ultra-violet light and hydrogen peroxide technology. The treated water would then be injected into Unit E through multiple new wells at locations where 1,4-dioxane levels exceed 85ppb pursuant to Rule 2210(u) of the Part 22 Rules, R. 323.2210(u), which exempts groundwater injection back into the plume from the groundwater discharge permit requirement.

In addition to the shared issues associated with constructing pipeline from the extraction wells back to the PLS facility, the defining challenge associated with each of the reinjection alternatives is locating a sufficient number of injection wells to handle the necessary volume of water. Injection well locations must be carefully chosen to minimize dilution and, more importantly, deflection of the plume, both of which would reduce the effectiveness and efficiency of the plume and extend the remediation. Access to locations on the PLS property, as well as the construction of injection wells and pipelines from the treatment center would be simpler than if the wells were on property not owned by PLS. In addition, injecting the same amount of water into the plume as extracted will make capturing the plume difficult. A compensating potential benefit of this alternative is that the injection wells would likely be placed on PLS property, thus making the construction of injection wells and pipelines from the treatment center simpler than alternatives where wells would be installed off site.

<u>Alternative 3c</u> – Under this alternative, after the purged water is transported back to the PLS facility, it will be treated with either ozone and hydrogen peroxide or ultra-violet light and hydrogen peroxide technology. The treated water would then be injected into Unit E through multiple new injection wells at locations where 1,4-dioxane levels are less than 85 ppb but exceed 1 ppb. Discharge into this portion of the Unit E would be authorized under Rule 2213(5) of the Part 22 rules, R. 323.2213(5), which provides for a "permit by rule" for such discharges. The same concerns and challenges regarding locating the necessary injection wells in locations that would not exacerbate the contamination apply to this alternative as well. Moreover, the injection wells for this alternative may need to be installed off the PLS property, making access and construction more difficult.

<u>Alternative 3d</u> – Under this alternative, after the purged water is transported back to the PLS facility, it will be treated with either Ozone and hydrogen peroxide or ultra-violet light and hydrogen peroxide technology and then injected into Unit E through multiple new wells at locations where 1,4-dioxane levels are less than 1 ppb. A groundwater discharge permit under Rule 2218 of the Part 22 Rules (R. 323.2218) would be required to authorize a groundwater discharge to an uncontaminated portion of the Unit E. The Part 22 rules prohibit the effluent being discharged into an uncontaminated portion of the aquifer from containing any detectable amounts of contaminants. The ultra-violet light and hydrogen peroxide treatment technology has in the past been able to, in limited circumstances (e.g., low influent concentrations), reduce contaminant levels to non-detect levels for certain periods of time, but not continuously. Even under favorable conditions, large amounts of electricity and precise, non–linear control of the remedial equipment are needed to achieve this level of performance. PLS' ozone and hydrogen peroxide technology is unlikely to achieve significantly better treatment efficiencies, without additional testing and refining of the technology. Maintaining consistent non-detect effluent would be a considerable challenge with either technology.

The same concerns and challenges regarding installation of the necessary injection wells in locations that would not exacerbate the contamination apply to this alternative as well. In particular, it would likely be very difficult to find a location around the PLS site where 1,4-dioxane concentrations in the Unit E are below 1 ppb. Consequently, injection wells for this alternative may need to be installed off the PLS property, complicating the issues associated with access and construction of the injection wells and the pipelines from the treatment center.

Alternative 3e –Under this alternative, after the purged water is transported back to the PLS facility, it will be treated with either ozone and hydrogen peroxide or ultra-violet light and hydrogen peroxide technology. The treated water would then be discharged to the Honey Creek Tributary pursuant to an amendment of PLS' existing NPDES permit. Based on past permit challenges, increasing the volume discharge limit of the NPDES permit would be controversial. Any challenge to the permit amendment would delay implementation of this remedy and add to the difficulty of capturing the leading edge of the contamination.

One alternative to increasing the discharge volume limit to accommodate the approximately 500 gpm of additional water associated with the Unit E cleanup would be to reduce the volume of water currently being purged from the D_2 and C_3 aquifers by 500 gpm. The remaining 800 gpm would be more than enough to satisfy the Consent Judgment's remedial objectives of containing the plumes in these aquifers. The reduced purge rate would not, however, be adequate to accomplish the goal set forth in Judge Shelton's July 21, 2000 Remediation and Enforcement Order of completing the cleanup for these aquifers by July 2005. Consequently, relief from the Court would be necessary before this option would be available

3.5.4 Alternatives 4a-d - Groundwater Pumping – Treatment near Maple Road

Four alternatives fall within this group. All four share:

- recovery of groundwater from multiple vertical wells,
- transmission of recovered water through individual pipelines, which combine with others or proceed directly to a water treatment compound built on PLS-owned or PLS-leased property near Maple Road,
- chemical oxidation of 1,4-dioxane without production of by-products at concentrations that pose risks, and
- disposal of treated water.

As with the Group 3 alternatives above, the alternatives within this group are differentiated from each other by treatment method and the point of treated water disposal.

Shared Challenges

Though treatment of recovered groundwater at a location near Maple Road would eliminate the need for a pipeline from this area to the Wagner Road facility, this reduction in scope would be offset by challenges associated with locating one or more chemical oxidation treatment units in either congested commercial properties or Veterans Park and the need to site and install treated water injection wells (alternatives 4b, 4c, and 4d). Examples of these challenges are:

- Reagent handling and storage –The treatment process combines hydrogen peroxide with ozone. Concentrated hydrogen peroxide, the form in which the reagent would be received, is an energetic compound, which can explode under certain conditions. Transportation, handling, storage, and use of hydrogen peroxide near Maple Road, particularly in Veterans Park, may present unacceptable risks to human health and safety.
- System control and reliability – Either oxidation method incorporates remedial system components, which pose electrical shock and direct contact risks, in addition to those posed by direct contact with untreated water. Fences will have to be erected and maintained to protect the public from direct contact risks with contaminated media and remedial equipment.
- Number of treatment locations – Specific system performance and reliability issues may be multiplied if more than one treatment location is utilized. Conversely, any upset would impact only its proportionate share of total system capacity and performance.

There are additional challenges associated with the installation of the extraction wells, transmission pipelines, and related infrastructure in the densely populated residential areas where the leading edge of the plume is currently located. This effort will necessarily cause significant disruption to residents and users of the area roads. Many residents have already expressed concern with PLS' past efforts to install monitoring and test wells in their neighborhood and the disruption associated with the scale of construction necessary to implement this alternative would be much greater and last for a longer period of time. Given the amount of community disruption and the possibility of the lack of public acceptance, delays are anticipated for installation of recovery wells, allowing the plume to migrate farther east, requiring PLS to re-position the recovery wells further downgradient. This would in turn increase the scope of disruption.

Alternative 4a – Under this alternative, the purged groundwater would be treated at a location near Maple Road with ozone and hydrogen peroxide technology and then conveyed directly to the Huron River by a new pipeline for disposal under an NPDES permit. A new, treated water pipeline to the Huron River would be as difficult and costly to construct as a pipeline from Maple Road to the Wagner Road facility, or one from the Wagner Road facility to the Huron River. The pipeline would originate near Maple Road. It will be constructed below grade and traverse both public and private property. It will also pass under Interstate 94. Obtaining access to both public and private property will be difficult and/or expensive or, in some cases, impossible. The uncertainty regarding the length of time needed to obtain access and then to construct the necessary infrastructure will make it difficult to determine where the leading edge of the plume would be when such infrastructure was ready. Consequently, under this alternative, PLS will be unable to effectively capture the leading edge of the plume unless the extraction wells are located a significant distance downgradient of the current leading edge so as to accommodate the lengthy and uncertain access/construction timeline.

Alternative 4b – Under this alternative, the purged groundwater would be treated at a location near Maple Road with ozone and hydrogen peroxide technology. The treated water would then be injected into Unit E through multiple new wells at locations where 1,4-dioxane levels exceed 85 ppb pursuant to Rule 2210(u) of the Part 22 rules (R. 323.2210(u)), which exempts groundwater injection back into the plume from the groundwater discharge permit requirement.

Injection well locations must be carefully chosen to minimize dilution and, more importantly, deflection of the plume, both of which would reduce the effectiveness and efficiency of the purge well capture zones and extend the remediation as well as PLS' ability to capture the leading edge. Given the volume of water that would need to be injected (at least 570gpm) and the very complicated geology of the aquifer in the Veterans Park/Maple Road area, siting a sufficient number of injection wells would be a shared challenge of all of the injection alternatives (4b-d). Additionally, injecting the same amount of water as is being extracted this close to the location of the extraction wells will make capturing the plume difficult – more difficult than if the water were transferred back to the PLS site.

Finally, access to such locations, which would not be on PLS-controlled property, as well as the construction of injection wells and pipelines from the treatment center, would be more difficult to obtain than for wells on PLS property.

Alternative 4c – Under this alternative, the purged groundwater would be treated at a location near Maple Road with either ozone and hydrogen peroxide or ultra-violet light and hydrogen peroxide technology. The treated water would then be injected into Unit E through multiple new wells at locations where 1,4-dioxane levels are less than 85 ppb but exceed 1ppb. Discharge into this portion of the Unit E would be authorized under Rule 2213(5) of the Part 22 rules (R. 323.2213(5)), which provides for a "permit by rule" for such discharges. The same concerns and challenges regarding locating the necessary injection wells in locations that would not exacerbate the contamination apply to this alternative as well

Alternative 4d - Under this alternative, the purged groundwater would be treated at a location near Maple Road with either ozone and hydrogen peroxide or ultra-violet light and hydrogen peroxide technology. The treated water would then be injected into Unit E through multiple new wells at locations where 1,4-dioxane are less than 1 ppb. A groundwater discharge permit under Rule 2218 of the Part 22 (R. 323.2218) would be required to authorize a groundwater discharge to an uncontaminated portion of the Unit E.

The Part 22 rules prohibit effluent being discharged into an uncontaminated portion of an aquifer from containing any detectable amounts of contaminants. The ultra-violet light and hydrogen peroxide treatment technology has in the past been able to, in favorable circumstances (e.g., low influent concentrations), reduce contaminant levels to non-detect levels for limited periods of time, but not continuously. Even under such favorable conditions, large amounts of electricity and precise, non–linear control of the remedial equipment would be needed to achieve this level of performance. PLS' ozone and hydrogen peroxide technology would not be expected to achieve significantly greater treatment efficiencies without additional testing and refinement. Maintaining consistent non-detect effluent would be a considerable challenge with either technology.

The same concerns and challenges regarding locating the necessary injection wells in locations that would not exacerbate the contamination apply to this alternative as well. In particular, locating sites in the Unit E where concentrations are below 1 ppb would be very difficult.

3.5.5 Alternative 5 - Groundwater Pumping – Injection into Deep Formation

Alternative 5 – Under this alternative, the untreated groundwater would be injected via a deep well located at the PLS Wagner Road facility. As discussed in the initial screening, this alternative utilizes injection of untreated groundwater into a deep geologic formation (e.g. the Mt. Simon formation, which lies deeper than 5,000 feet below ground level) for disposal of the purged groundwater. Because the depth of the receiving formation isolates it from any usable aquifers, the groundwater does not require treatment before it is injected.

The primary challenges associated with this alternative are: 1) identification of a deep formation that can accept at least 500 gallons per minute of untreated water; and 2) approval of a USEPA Underground Injection Control (UIC) Program permit for construction and operation of a deep disposal well. It is anticipated that both challenges could be met, though the permitting process could be lengthy. Since a Class I injection well had been installed on the PLS property in the past, the permitting process for a new well may be streamlined as compared to locating the well off-site. Also, there should be no concerns regarding zoning or inconsistent use of property with this alternative.

Based on past experience with previous deep well applications, some public opposition should be anticipated based on concerns that the untreated water may somehow "leak" back into the usable aquifers and/or because a significant portion of the groundwater resource will be depleted and placed beyond reach.

Additional challenges for this alternative will be construction of: 1) extraction wells in a densely populated residential area; 2) the pipeline from the leading edge to the PLS Wagner Road facility; and 3) the deep injection well itself. The uncertainty regarding the length of time needed to obtain access and then to construct the necessary infrastructure will make it difficult to determine where the leading edge of the plume would be when such infrastructure is ready. Consequently, the practical feasibility of this alternative is uncertain.

3.5.6 Alternative 6 – Groundwater Pumping -- Active Remediation and Treatment Proximate to the Huron River.

This alternative is similar to Alternatives 3a and 4a in that extraction wells would be used to control the plume and the purged groundwater would be conveyed to the Huron River via a new pipeline and then treated and discharged to the river under a new NPDES permit. The feature that distinguishes this alternative from the other active remediation alternatives is that the groundwater extraction, if necessary, would occur at a location closer to the Huron River. By implementing the active remediation proximate to the Huron River, this alternative would minimize the community disruption, potential delays, and uncertainties associated with the installation of the longer pipelines necessary under the other alternatives, while still being protective of any potential receptors. The institutional controls called for under Alternative 2 would not be required because, in the event that groundwater monitoring data indicate 1,4-dioxane concentrations at a receptor will exceed a Part 201 Generic Cleanup Criteria (e.g., water entering the Huron River with 1,4-dioxane above GSI or approaching drinking water wells at levels above 85 ppb), an active groundwater remedial system would be implemented. Thus, this alternative is not dependant on governmental decisions beyond PLS' control.

Investigation and Remediation Plan

The potential downgradient receptors are domestic water wells and the Huron River. Immediately upon MDEQ approval of the necessary work plan, PLS would undertake a hydrogeological investigation to determine the fate of the Unit E plume and what receptors are implicated. This investigation would determine if, when, and at what concentrations 1,4-dioxane would arrive at the receptors. The migration of the Unit E plume would then be closely monitored to confirm its fate. Under this alternative, if groundwater monitoring data indicate 1,4-dioxane concentrations at a receptor will exceed the applicable Part 201 Generic Cleanup Criteria, an active remediation plan would be implemented near the Huron River as need to protect the relevant receptors.

The active remediation currently contemplated would involve the installation of extraction wells and a plume containment system. Such a system would employ technologies appropriate and available at the time of installation. Since the active remediation system may not be necessary for a number of years, it is expected that there could be advancements in remedial technologies that may have application to controlling the plume.

CHAPTER 4 – IDENTIFICATION AND SCREENING OF INTERIM RESPONSE PROCESS OPTIONS

4.0 Introduction

Part 201 defines "interim response activity" as "the cleanup or removal of a released hazardous substance or the taking of other actions, prior to the implementation of a remedial action, as may be necessary to prevent, minimize, or mitigate injury to the public health, safety, or welfare, or to the environment. . . ." MCL 324.20101(u). MDEQ has promulgated rules governing interim response actions in Rule 526, Mich Adm. Code R. 299.5526. In this context, interim response would take to form of "source control" or response actions aimed at removing the most highly concentrated areas of contamination.[1] PLS will implement such actions to the extent it is appropriate to do so. Under Part 201, interim response measures are appropriate if they "technically practical, cost effective" and if they "provide protection to the environment." Rule 526(1) also provides guidance with respect to factors to be considered, if relevant to the facility, in determining the appropriateness of an interim response activity. These criteria are evaluated below in the context of protecting the potential receptors.

4.1 Potential Interim Response Options

PLS evaluated several potential interim response actions. At this time, PLS considers groundwater extraction to be the only viable interim response action. Treated groundwater would then be discharged to either surface water or via groundwater injection depending on the location of the purge wells. For many of the reasons discussed later in this Feasibility Study, groundwater extraction from two areas: on or near the PLS Wagner Road facility and in the area of Maple Road, are the only two areas considered practical for an interim response.

Conceptual layouts for the proposed interim response actions are shown on Figure 5 and are described below.

4.1.1 On-Site Groundwater Extraction

PLS proposes to increase extraction from the Unit E at and near its Wagner Road facility. PLS currently purges approximately 160 gpm from two Unit E wells located on the property, TW-11 and TW-12. 1,4-Dioxane concentrations in purge wells TW-11 and TW-12 are approximately 870 and 100 ug/L, respectively. Operation of these wells is helping to reduce the mass of 1,4-dioxane in the Unit E and minimize further off-site migration. PLS intends to continue pumping TW-11 and TW-12 to reduce 1,4-dioxane mass in the portion of the Unit E plume closest to the PLS facility. The infrastructure for TW-11 and TW-12 is installed and water generated from these wells can be discharged to surface water under the existing NPDES permit. .

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[1] PLS agrees that a discussion of interim responses in connection with the Final Feasibility Study is appropriate given the impracticality of implementing a traditional leading edge purge program. This discussion does not, however, directly or indirectly establish an independent legal obligation on PLS to implement interim response to the Unit E. The Consent Judgment's requirement to purge the "Core Area" is limited to the portion of the C_3 aquifer that contains 1,4-dioxane above 500 ppb and has no application to the Unit E. And, contrary to the suggestion of some in the community, Part 201does not require PLS to take interim response actions. Although Section 14(1)(d) of Part 201 requires liable persons to implement source control and removal measures under certain conditions, this mandate only applies to hazardous substances that are released to the environment after the date of the 1995 amendments. PLS' predecessor stopped using 1,4-dioxane in 1986 and PLS has never used this substance at the Scio Township facility. Thus, PLS is not required to undertake interim response measures under Part 201.

PLS will also install at least one additional purge well to assist TW-11 and TW-12 in reducing migration from the source area. PLS recently installed a boring near TW-14 to evaluate this location as a future Unit E extraction well. PLS is in the process of installing a well at this location. The new well will be identified as TW-17.

PLS will also undertake an investigation of groundwater quality within the plume in the area bounded by Wagner Road, Dolph Park, and the PLS Property to determine if 1,4-dioxane concentrations in this area are high enough to prevent the Maple Road response measures discussed below from effectively protecting potential receptors. This area is shown on Figure 5. Based on the results of this investigation, PLS may install an additional extraction well in this area to further reduce mass in order to ensure that all potential receptors are protected.

Groundwater extracted from these Unit E wells will be transferred to the PLS Wagner Road treatment facility for treatment using the PLS treatment system. Treatment system effluent will be discharged to the Honey Creek Tributary pursuant to the existing NPDES permit.

Operation of TW-11 and TW-12, or other wells in the vicinity of these wells, will help reduce the mass and concentration of 1,4-dioxane moving hydraulically downgradient. As additional treatment/discharge capacity becomes available as purging from other aquifer systems is reduced, it may be feasible to increase purging from the Unit E in the area around the facility if it is necessary to meet the primary objective of receptor protection. 1,4-Dioxane concentrations at TW-12 have already nearly been reduced to below 85 ug/L. Continued groundwater extraction at his location may not make sense in the near future. PLS will monitor the effectiveness of these wells over time and adjust extraction rates accordingly. It is anticipated that the planned investigation in the Wagner Road area will provide guidance with respect to how to most efficiently utilize the purge and treat capabilities at this end of the Unit E.

4.1.2 Groundwater Extraction and Injection in Area of Maple Village

PLS proposes to install a groundwater extraction well in the Unit E near Maple Road east of MW-85. 1,4-dioxane concentrations in this area are approximately 2,000 ug/l. This location is interpreted to be along the longitudinal axis of the Unit E plume. The Unit E hydrogeological and 1,4-dioxane distribution data indicate the area west of Maple Road would be a comparatively effective location for groundwater extraction. As the 1,4-dioxane plume migrates eastward toward Maple Road, the plume is following a relatively defined channel with boundaries that have been mapped by several monitoring wells. Once east of Maple Road, the plume reduces in concentration by almost one order of magnitude, and the aquifer thins out and becomes more complicated. Furthermore, access for wells and associated infrastructure downgradient of Maple Road becomes very challenging. For these and other reasons, accessing the plume along Maple Road is much more practical than attempting to control the plume further downgradient.

Conversely, extracting water upgradient of Maple Road (for example, in the vicinity of MW-72) would address a smaller portion of the plume and allow the relatively high concentrations near Maple Road to migrate east. Although it may be possible to purge upgradient and still meet the objectives of controlling exposures of receptors, it would be less efficient than applying the same level of effort at Maple Village. As such, purging further upgradient is not a favored approach.

Groundwater purged from the Maple Road area would be treated at a location near the extraction well. The location of the treatment center has not been determined. For calculation purposes, PLS is assuming the system would be positioned as indicated on Figure 5.

PLS proposes to treat 1,4-dioxane using an ozone/peroxide treatment unit. PLS has an ozone/peroxide treatment unit that can be mobilized to the treatment site once access is secured. Effluent 1,4-dioxane concentrations from the treatment unit will be less than 20 ug/L and effluent concentrations of bromate will be less than 10 ug/L. Treated water would be discharged back into the plume using injection wells. The wells will be placed north and south of the extraction well within the Unit E plume. PLS proposes to use the existing TW-16 as one injection well. Another injection well would need to be placed north of the extraction well and completed in the Unit E aquifer. The proposed injection wells are located in areas were the Unit E has sufficient capacity to accept the treated water. It is anticipated that there should be little, if any, distortion of the plume boundaries due to injection at these locations.

PLS proposes to operate the Maple Road area interim response until it can be demonstrated through hydrological investigations that 1,4-dioxane concentrations at potential receptors will remain below applicable criteria.

4.2 Evaluation of Interim Response Options

Under Part 201, interim response measures are appropriate if they are: (1) technically practical; (2) cost effective; and if they (3) provide protection to the environment. MCL 324.20114(1)(d). Rule 526(1) also lists ten factors to be considered, if relevant to the facility, in determining the appropriateness of an interim response activity. Five factors are not relevant to this site.[2] The statutory criteria and the remaining five factors listed in Rule 526(1) are discussed below.

4.2.1 Protective of the Environment -- Protection of Receptors

This statutory criterion is reflected in several subsections of Rule 526. Rule 526(1)(a), which requires an evaluation of actual or probable threats to the public health, safety, or welfare or to the environment, and the severity of that threat. In addition, Rule 526(1(b) requires evaluation of actual or probably contamination of drinking water supplies, including wellhead protection zones in the vicinity of the facility and evaluation of the impact of the facility on any such zones. Rule 526(1)(j) requires evaluation of whether an interim response will accomplish significant risk reduction. These three factors are considered together in the overall context of protection of receptors.

As discussed below, none of the potential receptors will be threatened by contaminant concentrations above applicable criteria even if no active remediation is undertaken. Water level data collected by the City of Ann Arbor's consultant indicates the Unit E plume will follow a pathway that is east-north east toward the Huron River. The model WinTran was used to simulate 1,4-dioxane concentrations over time as the Unit E plume migrates towards the Huron River without the benefit of the proposed interim response actions. Documentation for the modeling is provided in Appendix C. The modeling analysis indicates that 1,4-dioxane concentrations will remain below applicable criteria at all potential receptors, even if the plume were not controlled with an interim response action. Natural attenuation in the form or dispersion, dilution and sorption will act to reduce concentrations to acceptable levels before the plume reaches potential receptors. This analysis suggests protection of downgradient receptors does not require the entire plume to be halted or even partially captured. The Huron River is the only potential receptor positioned along this pathway. 1,4-Dioxane concentrations arriving at the Huron River are predicted to

[2] The following five factors were not considered as irrelevant: 526(1)(c) (discarded containers); 526(1)(d) (impact of weather conditions); 526(1)(e) (demolition); 526(1)(f) (threat of fire or explosion); and 526(1) (g) (immediate prevention of injury to public health, safety, or welfare or to the environment).

be well below the GSI criteria. Other identified receptors lie south of the projected pathway. As such, arrival concentrations at the identified well locations are predicted to be below any applicable criteria. .

Despite this analysis, PLS believes that it is still appropriate to consider interim response measures in the form of mass removal in order to provide additional protection to these receptors and to reduce the possibility that active remediation closer to the receptors will be necessary in the future.

To determine the benefit of implementing the interim response actions, the model was used to simulate 1,4-dioxane concentrations at the potential receptors. Documentation for this modeling is provided in Appendix C. For the modeling, PLS assigned the following flow rates to the extraction scenerios:

TW-11 = 75 to 100 gpm
TW-12 = 25 to 50 gpm
TW-17 (proposed) = 100 gpm

Maple Road Area = 200 gpm
Maple Road Injection = 200 gpm (two wells each at 100 gpm)

Implementation of the proposed interim response actions provides little benefit if the plume migrates along a flow pathway suggested by the water level data collected by F&V. There is, of course, some degree of uncertainty regarding the accuracy of any predicted flowpath.

The value of the proposed interim response at Maple Village is that it can, therefore, reduce the threat to drinking water supplies and to the Huron River by reducing mass in the aquifer and accelerating the rate at which the aquifer will meet the target criteria. The purging near the source area reduces the work that will have to be done at Maple Road and makes that system more robust. Accordingly, while modeling and existing data show only a low potential threat to drinking water supplies or other protected systems, interim response can materially reduce the risks inherent in the uncertainty of modeling the impacts.

4.2.2 Technical Practicality and Feasibility of Implementing Response Activity Independent of Other Response Activities -- Rule 526(1)(h)

Both response actions were considered to be technically practical. Groundwater extraction and treatment is a known method to reduce contaminant mass and concentrations and PLS has extensive experience with the implementation of groundwater purge and treat systems. As such, the proposed interim response actions are considered practical and applicable to the problem.

Installing extraction/injection wells and associated infrastructure on-site and in the Maple Road area is much more practical and safe than if the interim response were implemented further east in the Veterans Park area or in congested residential neighborhoods. Access for well and infrastructure will need to be obtained from property owner(s). PLS will need to obtain approval from MDEQ to inject treated groundwater. Disposing of the volumes of water involved in the proposed interim response actions is deemed practical in contrast to the disposal problems associated with any alternative that involves capturing the entire width of the plume. Groundwater extracted from the western portion of the plume can be conveyed back to PLS for treatment and disposal in surface water. Groundwater extracted in the Maple Village area will be approximately 200 gpm, which is considered within the range acceptable for reinjection.

The interim response activity can potentially interfere with the implementation of other response activities at the PLS site. This applies with respect to that portion of the interim response addressing the western end of the Unit E plume. As planned, however, the current on-site systems for addressing other aquifers will not be burdened, but the interim response must be tailored such that capacity is available for discharge of the additional purged and treated groundwater.

4.2.3 Cost Effectiveness – MCL 324.20114(1)(d)

The cost of implementing the interim response actions is considered cost effective if they are needed to protect potential receptors. The annual costs of implementing the proposed interim response are set forth in Appendix G. That is, it makes no sense to implement these actions unless there is a threat to proposed receptors. Similarly, absent a legal requirement to do so, it makes no sense to implement such measures while at the same time capturing the leading edge of the plume, since such measures would not add any additional protection.

Although current data indicate that the proposed interim measures are not needed to protect downgradient receptors, PLS believes that they should be considered cost effective because of the conservatism they will provide against any uncertainties regarding downgradient aquifer conditions. On the other hand, implementation of the interim response actions in combination with other remedial actions that result in capturing the migration of the plume would not be cost effective.

4.2.4 Whether Taking Interim Response Actions Will Speed Completion of A Remedial Action – Rule 526(1)(i)

All of the final remedial actions examined here will take a long time to complete due to the nature and extent of the plume. The proposed interim response may shorten the time horizon somewhat, but this is not considered a material benefit.

4.3 Future Interim Response Actions

PLS will continue to evaluate technologies that may hold promise in the treatment of the Unit E plume and the protection of potential receptors. PLS recently completed a test of In-situ Chemical Oxidation using hydrogen peroxide. The testing suggested hydrogen peroxide injection is relatively ineffective in treating 1,4-dioxane in-situ. PLS is currently testing the application of hydrogen peroxide with an iron additive. PLS may also make changes in its interim response program in the Wagner Road/Dolph Park area based on the results of its planned investigation.

4.4 Summary of Proposed Interim Response Actions

PLS intends to purge approximately 450 gpm from the Unit E from the two locations specified above. This is a significant addition to PLS's current purge and treat system, already one of the largest in the state. The level of effort required under this program will be comparable to that of any of the "leading edge" alternatives (compare 450 gpm to 570+ gpm). But because the concentrations of 1,4-dioxane at the proposed interim response locations are currently much higher than what would be extracted at leading edge wells, these interim response actions will remove more contaminant mass in the near term than a leading edge alternative. More importantly, they are practical and can be implemented much sooner than any potential leading edge option because they involve manageable volumes of water for which disposal capacity is available near the point of extraction. As indicated later in this Feasibility Study, reinjection of treated groundwater is not feasible in connection with an attempt to completely capture the plume. There simply is not enough reliable capacity in the aquifer system to reinject the 570 to 650 gpm that would be needed to capture the entire width of the leading edge of the plume. By the same token, other discharge options all involve the installation of miles of pipelines and will take years to implement (if they could be implemented at all). By "chewing off" a smaller portion of the plume – 200 gpm near Maple Road -- PLS has the ability to reinject the treated water without distorting the plume and can implement this plan within a reasonable timeframe. Similarly, the additional 250 gpm from wells located near PLS' Wagner Road facility can be accommodated by PLS' current treatment system and its' NPDES permit discharge capacity of 1,300 gpm. As demonstrated above, purging these volumes at these locations is more than sufficient to accomplish the goal of protecting all potential receptors.

CHAPTER 5 - SCREENING OF REMEDIAL ALTERNATIVES

5.0 INTRODUCTION

In this Chapter, each of the 13 remedial alternatives described in Chapter 3 are subjected to an initial screening under the criteria specified in the Part 201 rules, as described below. The remedial alternatives that survive this screening are then subjected to a detailed evaluation in Chapter 5, which results in the identification of the preferred remedial alternative.

5.1 CRITERIA FOR SCREENING OF ALTERNATIVES

The anticipated construction and performance of each alternative were screened with respect to six criteria codified in Rule 530 (4) of the Part 201 rules, R 299.7530(4). The context of their use is described below. These criteria are then applied to the remedial alternatives in Section 4.2. The screening of the alternatives is summarized in Section 4.3.

- **Effectiveness**

  This criterion considers whether a control method or remedial technology will operate in the intended manner and have the desired impact on contaminant levels and risk.

- **Cost**

  Both the cost to install and the cost to operate, maintain, and monitor are considered.

- **Time**

  This criterion considers the total anticipated life of a project, which can be subdivided between construction and operation.

- **Acceptable Engineering Practices**

  The three engineering practices criteria are as follows:

  <u>Feasibility For The Location And Conditions Of Release</u> - Feasibility considers whether a method or technology is suitable for the physical, chemical, and biological system and whether it can be implemented.

  <u>Applicability To The Problem</u> – This criterion considers whether a remedial technology or risk control method can legally be applied. State and local government rules and regulations determine this question.

  <u>Reliability</u> – Reliability judges whether a technology or method can be depended upon to perform as designed in both the short and long-term.

5.2 Initial Screening of the Remedial Alternatives

As set forth below, each of the remedial alternatives is evaluated with respect to the five criteria that differ meaningfully among alternatives. All alternatives were created from process options that were individually considered effective for eliminating the risks posed by 1,4-dioxane in Unit E and each of the remedial alternatives themselves are effective. Therefore, this criterion is not discussed further within the discussion of each remedial alternative.

A narrative explanation of the initial screening is provided in the following text sections. The initial alternative screening is also summarized in tabular form in Table 2. In Table 2, each criterion, except cost, was ranked on a scale ranging from highly or moderately beneficial to little value to the project. Cost was ranked at five levels, due to the range in costs. Those five levels were: high, moderate-high, moderate, moderate-low, and low. The alternatives are ranked in accordance with their respective scores for each of the criteria.

5.3 Individual Alternatives

5.3.1 Alternative 1 - No Action

The No Action alternative would not actively control, treat, or even monitor the impacted groundwater. The dissolved 1,4-dioxane would be allowed to migrate, dissipate, and decay naturally.

Cost: There would be no capital or operating, maintenance, or monitoring cost for this alternative. It would be the least expensive alternative.

Time: Concentrations of 1,4-dioxane, a recalcitrant compound, would remain above clean-up goals until natural attenuation processes degrade or disperse the contaminant mass. Literature reports both aerobic and anaerobic biodegradation of 1,4-dioxane in nature. Groundwater dispersion, adsorption and biodegradation will continue to reduce 1,4-dioxane concentrations in the plume. The period of time required to achieve the applicable cleanup standard with no action would be dependant on the fate of the plume, identification of the receptor(s) potentially affected and the observed rate of attenuation. Additional investigation to obtain these data is necessary to determine when the applicable cleanup standard will be achieved under this alternative. It is anticipated that the cleanup horizon for this alternative would be somewhat longer than under the active remediation alternatives, but not significantly so.

Acceptable Engineering Practices:

Feasibility for the location and conditions of release -- The release is not threatening existing water supplies. The plume underlies and will spread under a densely populated area. This alternative avoids disruption of established uses. It is considered acceptable for the location and conditions of the release in the Unit E, making it moderately beneficial to the project.

Applicability to the problem – This alternative does not satisfy any of the remedial objectives under the Consent Judgment or Part 201 and, therefore, would not be acceptable to state and local governments and the public. It also would not include monitoring of remedial performance. Therefore, it does not satisfy this criterion.

Reliability – The only risk control methods are natural processes, which require no outside energy or resources to proceed; therefore, the alternative is reliable, though extremely slow.

This alternative was eliminated from further consideration.

5.3.2 Alternative 2 - Monitored Natural Attenuation With Interim Response and Institutional Controls

Alternative 2 would include monitoring of groundwater conditions and contaminated movement while controlling potential exposure risks through either deed restrictions or a local ordinance.

Cost: There would a limited amount of capital (it is assumed that up to 10 additional monitoring wells would be constructed) or operating and maintenance cost for this alternative. Monitoring costs would continue for an extended period of time, therefore, though the frequency of sampling, the number of monitoring wells sampled, and the number of analytes would decrease over time, total monitoring costs would be substantial. Also, legal costs may comprise an important component of this alternative due to the need to negotiate restrictive covenants or develop an appropriate ordinance. Enforcement (maintenance) of the restrictive covenants and/or the city ordinances would be triggered when a property sold or when construction permits or utility service are sought.

Time: Concentrations of 1,4-dioxane would remain above clean-up goals until natural attenuation processes degrade or disperse the contaminant mass. The period of time required to achieve the applicable cleanup standard would be dependant on the fate of the plume, identification of the receptor(s) potentially affected and the observed rate of attenuation. Additional investigation to obtain these data is necessary to determine when the applicable cleanup standard will be achieved under this alternative. It is anticipated that the cleanup horizon for this alternative would be somewhat longer than under the active remediation alternatives, but not significantly so.

Acceptable Engineering Practices:

Feasibility for the location and conditions of release -- The release is not threatening existing water supplies. The plume underlies and will spread under a densely populated area. This alternative avoids disruption of established uses. It is considered acceptable for the location and conditions of the release in the Unit E, making it moderately beneficial to the project.

Applicability to the problem – This alternative must meet two conditions: 1) that no adverse impact occurs as a result of contaminant migration, and 2) that enforceable land use restrictions or other institutional controls (such as a local groundwater control ordinance meeting the requirements of Part 201) prevent unacceptable risk from exposure to hazardous substances. Either of the two institutional control measures would adequately control risks to human health and the environment posed by the 1,4-dioxane in Unit E and would satisfy this criterion.

Reliability – The only risk control methods associated with natural attenuation are natural processes, which require no outside energy or resources to proceed. Deed restrictions and enforceable city ordinances would be easily maintained and essentially self-enforcing. Consequently, this alternative is reliable

This alternative was retained for detailed evaluation.

5.3.3 Alternatives 3a-e - Groundwater Pumping - Pipeline to and Treatment at Wagner Road

Five alternatives comprise this group. All five share:

- recovery of groundwater from multiple vertical wells,

- transmission of recovered water through individual pipelines, which combine with others up stream of a new pipeline,
- transmission of the total flow from all individual wells through the new pipeline to the PLS facility,
- chemical oxidation of 1,4-dioxane using either Ozone/Hydrogen Peroxide or Ultra-violet light/Hydrogen Peroxide technology without production of by-products at concentrations that pose risks, and
- disposal of treated water.

The alternatives within this group are distinguished by the treatment method and location where the treated water would be discharged. There are a number of considerations that are common to each of the alternatives in this group. Rather than repeat the discussion within each alternative, these issues are evaluated in summary fashion below:

Time: The time for adequate remediation would be in the same range for all alternatives that incorporate active remediation (groups 3, 4, 5, and 6) because overall duration would be primarily controlled by the natural rate of groundwater movement due to the large mass of contaminated groundwater. However, Alternative 3c would increase the clean-up duration by diluting or stalling the contaminant plume core.

Cost: The treatment system capital cost would be the same for each of the alternatives. (Of course, within each alternative, the cost of ozone and hydrogen peroxide treatment equipment would be less than for the UV/hydrogen peroxide system). The operating cost of groundwater recovery, transmission, and disposal would also be very similar. The capital cost of recovery wells, pumps, and the pipeline to the PLS Wagner Road facility would also be comparable among the four alternatives in this group. The cost of building the treated water disposal pipeline to the Huron River, however, would make Alternative 3a much more expensive than the other four in this group. Alternative 3e (Discharge to Honey Creek Tributary) would be the least expensive of the options within this group because it avoids the operation and maintenance costs associated with the three alternatives that use groundwater injection to dispose of the treated water.

Acceptable Engineering Practices:

Feasibility for the location and conditions of release – The key challenges that are common to all of alternatives in this group are the installation of a new transmission pipeline able to convey water to the PLS Wagner Road facility and the location of extraction wells and related infrastructure east of Maple Road, where the plume has migrated under Veterans Park and densely populated residential neighborhoods. The technical feasibility of constructing and installing such infrastructure is well established both at this site and others. The lengthy and uncertain construction timeline associated with construction of these elements, however, calls into question the practical feasibility of any of the alternatives within this group. For example, the transmission pipeline back to the Wagner Road facility would have pass under Interstate 94, a significant physical obstacle. Obtaining the necessary access to both public and private property and then constructing the pipeline would be a difficult and lengthy process. Similarly, installing the extraction wells and the necessary infrastructure in the residential areas where the leading edge of the plume is currently located will necessarily cause disruption to residents and users of the area roads. Many residents have objected to PLS' previous efforts to install monitoring and test wells in their neighborhood and the disruption associated with the scale of construction necessary to implement any of these alternatives would be much greater and last for a longer period of time. Such community opposition to the construction of this infrastructure could delay the project.

The uncertainty regarding the length of time needed to obtain access and then to construct the necessary infrastructure will make it difficult to determine where the leading edge of the plume would be when such infrastructure is ready. Such delays would delay initiation of purging, which would allow the plume to migrate farther to the east, potentially requiring re-positioning of the recovery wells. This would in turn increase the level of disruption. Consequently, the practical feasibility of any of the remedial alternatives that involve construction of lengthy pipelines across property not owned by PLS is uncertain.

<u>Applicability to the problem</u> – All four alternatives in this group actively recover contaminated groundwater; treat the recovered water to reduce contaminant levels to required levels; and return treated water to the environment under one or more permits. They would all be applicable to the problem under present rules and regulations.

<u>Reliability</u> --

> <u>Treatment Technology</u>. Each of the alternatives within this group would utilize oxidation treatment technology, either ozone and hydrogen peroxide or UV/hydrogen peroxide. Both methods of removing 1,4-dioxane are considered reliable and properly engineered and operated systems are consistently able to reduce contaminants to below clean-up criteria.

> <u>Infrastructure</u>. Recovery and transmission of impacted groundwater, treatment, and disposal of treated water in the manner contemplated by these alternatives involve well-proven basic engineering procedures, construction materials, and O&M procedures. Most components of this system would be reliable to the same degree as any well-engineered public water supply or wastewater treatment system.

The above evaluations apply to each of the alternatives within this group. The differences between the alternatives are discussed and evaluated below:

<u>Alternative 3a</u> – Treated groundwater is transmitted through a new pipeline to the Huron River for disposal under an NPDES permit.

Cost: The cost of constructing a transmission pipeline to the Huron River would make this the most expensive of the alternatives in this group.

Acceptable Engineering Practices:

<u>Feasibility for the location and conditions of release</u> -- In addition to the shared issues associated with constructing pipeline from the extraction wells back to the PLS facility, this alternative presents the challenges and potential delays associated with the construction of a lengthy transmission pipeline needed to convey treated water from the PLS Wagner Road facility to the Huron River. Access for this pipeline would have to be obtained from three governmental bodies as well as private landowners. The feasibility of this alternative is believed to be comparable to the reinjection alternatives, each of which presents analogous challenges associated with the placement of multiple injection wells. Alternative 3e (Discharge to Honey Creek Tributary) involves the fewest construction/access issues and is considered the most feasible alternative within this group.

Reliability -- Under this alternative, control of biological growths and precipitated inorganics will be less difficult than for alternatives 3b, 3c, and 3d because a single, large-diameter pipeline to the Huron River, rather than individual smaller pipelines to each injection well are used. This reduces the total footage of pipeline as well as the footage of small diameter piping, whose diameter, overall cross-section, and transmission capability is more greatly impacted by a similar degree of coating than is that of a larger pipeline.

This alternative was retained for further evaluation.

Alternative 3b – Treated groundwater is injected into the Unit E through multiple new injection wells at locations where 1,4-dioxane levels exceed 85 ppb under Part 22 permit.

Acceptable Engineering Practices:

Feasibility for the location and conditions of release -- In addition to the shared issues associated with constructing pipeline from the extraction wells back to the PLS facility, the defining challenge associated with each of the reinjection alternatives (3b- 3d) is locating a sufficient number of injection wells that are able to receive the necessary volume of water and do so without disruption of capture or other remedial objectives. Injection well locations must be carefully chosen to minimize dilution and, more importantly, deflection of the plume, both of which would reduce the effectiveness and efficiency of the plume and extend the remediation. In addition, injecting the same amount of water into the plume as extracted will make capturing the plume difficult. A compensating potential benefit of this alternative is that the injection wells would likely be placed on PLS property, thus making the construction of injection wells and pipelines from the treatment center simpler than alternatives where wells would be installed off site. The reinjection alternatives also avoid the Huron River transmission pipeline called for in alternative 3a.

Reliability -- Injection of treated water within the most contaminated portion of the plume would have two significant adverse effects on the overall remediation: 1) contamination would be diluted, increasing the total volume of water that would have to be treated to destroy the targeted 1,4-dioxane mass and the length of the remediation: and 2) the injection of water within the plume core would be expected to occur up gradient of the recovery wells; this would stall or retard the down gradient movement of contaminated groundwater up gradient of the injection wells. Reliability of this alternative for containment of the plume is uncertain because the addition of water upgradient into contaminated portions of the plume may cause the plume to override current flow patterns and compromise capture.

Consistent pipeline and production and injection well cleaning and maintenance to remove biological growths and precipitated, oxidized materials will be necessary to maintain disposal rates. This process is extremely important given the much greater impact of a coating of similar thickness inside a small diameter pipe versus a larger pipe.

The alternative was eliminated due to plume distortion and dilution and increased project duration.

Alternative 3c – Treated groundwater is injected into the Unit E through multiple new wells at locations where 1,4-dioxane levels are less than 85 ppb but exceed 1 ppb under a Part 22 permit.

Acceptable Engineering Practices:

Feasibility for the location and conditions of release -- In addition to the shared issues associated with constructing pipeline from the extraction wells back to the PLS facility, the defining challenge associated with each of the reinjection alternatives (3b- 3d) is locating a sufficient number of injection wells that are able to accept the necessary volume of water and do so without disruption of containment or other remedial objectives. Injection well locations must be carefully chosen to minimize dilution and, more importantly, deflection of the plume, both of which would reduce the effectiveness and efficiency of the plume and extend the remediation. In addition, injecting the same amount of water into the plume as extracted will make capturing the plume difficult. A compensating potential benefit of this alternative is that the injection wells would likely be placed on PLS property, thus making the construction of injection wells and pipelines from the treatment center simpler than alternatives where wells would be installed off site. The reinjection alternatives also avoid the Huron River transmission pipeline called for in alternative 3a.

Reliability – The reliability of this option are similar to that of Alternative 3b, with one main difference. Treated groundwater would be injected into the contaminated groundwater plume at points where 1,4-dioxane concentrations are below the clean-up goal of 85 µg/L and above 1 µg/L. Careful placement and use of these wells could force more impacted water toward the centerline of the plume and toward the recovery wells, which would increase the reliability of this alternative and potentially shorten the cleanup horizon.

This alternative was retained for detailed evaluation.

Alternative 3d – Treated groundwater is injected into the Unit E through multiple new wells at locations where 1,4-dioxane levels are less than 1 ppb under a Part 22 permit.

Acceptable Engineering Practices:

Feasibility for the location and conditions of release -- In addition to the shared issues associated with constructing pipeline from the extraction wells back to the PLS facility, the defining challenge associated with each of the reinjection alternatives (3b- 3d) is locating a sufficient number of injection wells to handle the necessary volume of water. Injection well locations must be carefully chosen to minimize dilution and, more importantly, deflection of the plume, both of which would reduce the effectiveness and efficiency of the plume and extend the remediation. In addition, injecting the same amount of water into the plume as extracted will make capturing the plume difficult. A compensating potential benefit of this alternative is that the injection wells would likely be placed on PLS property, thus making the construction of injection wells and pipelines from the treatment center simpler than alternatives where wells would be installed off site. The reinjection alternatives also avoid the Huron River transmission pipeline called for in alternative 3a.

Reliability –

Treatment Technology. A groundwater discharge permit under Part 22 would be required to authorize a groundwater discharge to an uncontaminated portion of the Unit E. The Part 22 rules prohibit the effluent being discharged into an uncontaminated portion of the aquifer from containing any detectable amounts of contaminants. The ultra-violet light and hydrogen peroxide treatment technology has in the past been able to, in limited circumstances (e.g., low influent concentrations), reduce contaminant levels to non-detect levels for certain periods of time, but not continuously. Even under favorable conditions, large amounts of electricity and precise, non–linear control of the remedial equipment are needed to achieve this level of performance. PLS' ozone and hydrogen peroxide technology is unlikely to achieve significantly better treatment efficiencies, without additional testing and refining of the technology. Maintaining consistent non-detect effluent would be a considerable challenge with either technology.

Infrastructure. The injection wells would be placed outside the identified contaminant plume. The treated water pipelines connecting the treatment center to each injection well would be longer, presenting a statistically greater probability of failure than for alternatives 3b and 3c. Control of biological growths and precipitated inorganics will be slightly more difficult that in alternatives 3b and 3c because individual treated-water pipelines to each injection well will be longer.

This alternative was eliminated based on the lack of a reliable technology that would consistently reduce 1,4-dioxane to non-detectable levels, as would be required by an injection permit.

Alternative 3e -- Groundwater Pumping, Pipeline to Wagner road Facility, Treatment at Wagner Road, Discharge into Honey Creek Tributary

Cost: This is the least costly alternative within this group because it avoids both the need for an extremely long pipeline from the Wagner Road facility to the Huron River and the placement of multiple injection wells.

Acceptable Engineering Practices:

Feasibility for the location and conditions of release – This alternative is the most feasible of the alternatives in this group because it avoids the potential delays and uncertainties associated with both the construction of the transmission pipeline from the Wagner Road facility to the Huron River and the placement of multiple injection wells. There has, however, been stiff community opposition to the current NPDES permit discharge to Honey Creek and to past efforts to modify that permit. The opposition has contended that discharge to the Honey Creek of significant volumes of water is inappropriate for that watercourse given downstream uses. PLS does not agree with these contentions.
Applicability to the problem – Based on experience with past NPDES permit amendments, it is expected that any attempt to increase the discharge volume limit of the permit will be opposed. Although such opposition may delay implementation of this remedy, such a permit amendment is considered likely to be granted in compliance with the relevant regulations.

This alternative was retained for further evaluation.

5.3.4 Alternative 4a-d - Groundwater Pumping – Treatment near Maple Road

Four alternatives fall within this group. All four share:

- recovery of groundwater from 3 vertical wells,
- transmission of recovered water through individual pipelines, which combine with others or proceed directly to a water treatment compound built on PLS-owned or PLS-leased property near Maple Road,
- chemical oxidation of 1,4-dioxane without production of by-products at concentrations that pose risks, and
- disposal of treated water.

The alternatives within this group are distinguished by the treatment method and location where the treated water would be discharged. The four alternatives within this group are very similar to those of Group 3. The primary difference is the location of the treatment equipment: at one or more locations near Maple Road in Group 4 versus at the PLS Wagner Road facility in Group 3. As a result, the screening of the alternatives in Group 4 produces analogous results to that of Group 3.

There are a number of considerations that are common to each of the alternatives in this group. Rather than repeat the discussion within each alternative, these issues are evaluated in summary fashion below:

Time: As stated above, the time for remediation is anticipated to be approximately the same for all active alternatives in Groups 3, 4, 5, and 6 because overall duration would be primarily controlled by the natural rate of groundwater movement. However, Alternative 4c would conceivably increase the clean-up duration by diluting or stalling the contaminant plume core.

Cost: The capital cost of recovery wells, pumps, and pipelines to a treatment center or centers near Maple Road would be comparable among the four alternatives in this group. The operating cost of groundwater recovery, transmission, and disposal would be similar for the four alternatives. However, the cost of treated water disposal via a pipeline to the Huron River would make Alternative 4a more expensive than the other three.

Acceptable Engineering Practices:

Feasibility for the location and conditions of release – The key challenges that are common to all of alternatives in this group are the location of extraction wells and related infrastructure east of Maple Road, where the plume underlies Veterans Park and has migrated under densely populated residential neighborhoods and the installation of transmission pipelines to convey water from the recovery wells to the treatment center located near Maple Road. The technical feasibility of constructing and installing such infrastructure is well established both at this site and others. The lengthy and uncertain construction timeline associated with construction of these elements, however, calls into question the practical feasibility of any of the alternatives within this group. For example, installing the extraction wells and the necessary infrastructure in the residential areas where the leading edge of the plume is currently located will necessarily cause disruption to residents and users of the area roads. Many residents have objected to PLS' previous efforts to install monitoring and test wells in their neighborhood and the disruption associated with the scale of construction necessary to implement any of these alternatives would be much greater and last for a longer period of time. Community opposition to the construction of this infrastructure could delay the project. Obtaining access (for the duration of the project) to a property that is large enough to accommodate one or more treatment units in this congested area will be difficult, if not impossible. At a minimum obtaining access for the treatment center would be a lengthy process and would likely involve litigation. Although Veterans Park presents an attractive alternative, it is anticipated that there would be significant public opposition to locating a treatment center in such a heavily utilized recreational facility.

The uncertainty regarding the length of time needed to obtain access and then to construct the necessary infrastructure will make it difficult to determine where the leading edge of the plume would be when such infrastructure is ready. Such delays would delay initiation of purging, which would allow the plume to migrate farther to the east, potentially requiring PLS to re-position the recovery wells. This in turn would increase the level of disruption. Consequently, the practical feasibility of any of the remedial alternatives in this group is uncertain.

Applicability to the problem – All four alternatives in this group actively destroy contaminants and can reduce contaminant levels to required levels; therefore, they would be applicable to the problem under present rules and regulations.

Reliability --

> Treatment Technology. Each of the alternatives within this group would utilize the ozone and hydrogen peroxide treatment technology since UV/hydrogen peroxide technology was eliminated during the process option screening as inappropriate for this location. This method of removing 1,4-dioxane is considered reliable and properly engineered and operated systems are consistently able to reduce contaminants to below clean-up criteria.
>
> Infrastructure. Recovery and transmission of impacted groundwater, treatment, and disposal of treated water in the manner contemplated by these alternatives involve well-proven basic engineering procedures, construction materials, and O&M procedures. Most components of this system would be reliable to the same degree as any well-engineered public water supply or wastewater treatment system.

The above evaluations apply to each of the alternatives within this group. The differences between the alternatives are discussed and evaluated below:

Alternative 4a – Ozone and hydrogen peroxide treatment followed by transmission through a new pipeline to the Huron River for disposal under an NPDES permit.

Cost: The cost of constructing a transmission pipeline to the Huron River would make this the most expensive of the alternatives in this group.

Acceptable Engineering Practices:

Feasibility for the location and conditions of release -- A new, treated water pipeline to the Huron River would be as difficult and costly to construct as a pipeline from Maple Road to the Wagner Road facility, or one from the Wagner Road facility to the Huron River. The pipeline would originate near Maple Road. It will be constructed below grade and traverse both public and private property. It will also pass under Interstate 94. Access for this pipeline would have to be obtained from three governmental bodies as well as private landowners. The feasibility of this alternative is believed to be comparable to the reinjection alternatives, each of which presents analogous challenges associated with the placement of multiple injection wells.

Reliability --Biological growths and precipitated inorganics will be less problematic than for alternatives 4b, 4c, and 4d because a single, large-diameter pipeline to the Huron River, rather than smaller pipelines to each treated water disposal well would be used. This would reduce the total footage of pipeline and the footage of small diameter piping, whose transmission capacity is more greatly impacted by a similar degree of coating than is that of a larger pipeline.

This alternative was retained for further evaluation.

Alternative 4b – Ozone and hydrogen peroxide treatment followed by injection into Unit E through multiple new wells at locations where 1,4-dioxane levels exceed 85 ppb.

Acceptable Engineering Practices:

Feasibility for the location and conditions of release -- Injection well locations must be carefully chosen to minimize dilution and, more importantly, deflection of the plume, both of which would reduce the effectiveness and efficiency of the plume and extend the remediation as well as PLS' ability to capture the leading edge. Given the volume of water that would need to be injected (500 gpm) and the very complicated geology of the aquifer in the Veterans Park/Maple Road area, siting a sufficient number of injection wells would be a shared challenge of all of the injection alternatives (4b-d). Additionally, injecting the same amount of water as is being extracted this close to the location of the extraction wells will make capturing the plume difficult – more difficult than if the water were transferred back to the PLS site as contemplated under alternatives 3(b-d). The reinjection alternatives, however avoid the Huron River transmission pipeline called for in alternatives 3a and 4a. Finally, access to such locations, which would not be on PLS-controlled property, as well as the construction of injection wells and pipelines from the treatment center, would be more difficult to obtain than for wells on PLS property.

Reliability – Treated water injection within the plume core would have two significant adverse effects: 1) contamination levels would be lowered, increasing the total mass of water that would have to be treated to destroy the targeted 1,4-dioxane mass and, as a result, the length of the remediation; and 2) the injection of water up gradient of the recovery wells would stall the down gradient movement of contaminated groundwater and delay its capture by the recovery (production) wells. Reliability of this alternative for containment of the plume is uncertain because the addition of water upgradient into contaminated portions of the plume may cause the plume to override current flow patterns and compromise capture.

Consistent pipeline and well maintenance to remove biological growths and precipitants will be necessary to maintain disposal rates. This process is particularly important to the proper operation of the small diameter pipe associated with the reinjection alternatives within this group.

The alternative was eliminated due to plume distortion and dilution and increased project duration.

Alternative 4c – Ozone and hydrogen peroxide treatment followed by injection into Unit E through multiple new wells at locations where 1,4-dioxane levels are less than 85 ppb but exceed 1 ppb.

Acceptable Engineering Practices:

Feasibility for the location and conditions of release -- Injection well locations must be carefully chosen to minimize dilution and, more importantly, deflection of the plume, both of which would reduce the effectiveness and efficiency of the plume and extend the remediation as well as PLS' ability to capture the leading edge. Given the volume of water that would need to be injected (500 gpm) and the very complicated geology of the aquifer in the Veterans Park/Maple Road area, siting a sufficient number of injection wells would be a shared challenge of all of the injection alternatives (4b-d). Additionally, injecting the same amount of water as is being extracted this close to the location of the extraction wells will make capturing the plume difficult – more difficult than if the water were transferred back to the PLS site, as contemplated under alternatives 3(b-d). The reinjection alternatives, however avoid the Huron River transmission pipeline called for in alternatives 3a and 4a.

Finally, access to reinjection well locations, which would not be on PLS-controlled property, as well as the construction of injection wells and pipelines from the treatment center, would be more difficult to obtain than for wells on PLS property.

Reliability – Except as explained here, the reliability of this alternative is the same as Alternative 4b. The chemical, construction, and operational reliability of this option differs from that of Alternative 4b, in one important way. Treated groundwater would be injected into the contaminant plume where 1,4-dioxane concentrations are below the clean-up goal of 85 ppb and above 1 ppb. Careful placement and use of these wells could guide water with contaminant levels above clean-up goals toward the centerline of the plume and the recovery wells, which would increase the reliability of this alternative and potentially shorten the cleanup horizon.

This alternative was retained for detailed evaluation.

Alternative 4d - Treated groundwater is injected into the Unit E through multiple new wells at locations where 1,4-dioxane levels are less than 1 ppb under a Part 22 permit.

Acceptable Engineering Practices:

Feasibility for the location and conditions of release -- Injection well locations must be carefully chosen to minimize dilution and, more importantly, deflection of the plume, both of which would reduce the effectiveness and efficiency of the plume and extend the remediation as well as PLS' ability to capture the leading edge. Given the volume of water that would need to be injected (500 gpm) and the very complicated geology of the aquifer in the Veterans Park/Maple Road area, siting a sufficient number of injection wells would be a shared challenge of all of the injection alternatives (4b-d). Additionally, injecting the same amount of water as is being extracted this close to the location of the extraction wells will make capturing the plume difficult – more difficult than if the water were transferred back to the PLS site. Finally, access to reinjection well locations, which would not be on PLS-controlled property, as well as the construction of injection wells and pipelines from the treatment center, would be more difficult to obtain than for wells on PLS property.

Reliability –

Treatment Technology. A groundwater discharge permit under Part 22 would be required to authorize a groundwater discharge to an uncontaminated portion of the Unit E. The Part 22 rules prohibit the effluent being discharged into an uncontaminated portion of the aquifer from containing any detectable amounts of contaminants. The ultra-violet light and hydrogen peroxide treatment technology has in the past been able to, in limited circumstances (e.g., low influent concentrations), reduce contaminant levels to non-detect levels for certain periods of time, but not continuously. Even under favorable conditions, large amounts of electricity and precise, non-linear control of the remedial equipment are needed to achieve this level of performance. PLS' ozone and hydrogen peroxide technology is unlikely to achieve significantly better treatment efficiencies, without additional testing and refining of the technology. Maintaining consistent non-detect effluent would be a considerable challenge with either technology.

Infrastructure. The injection wells would be placed outside the identified contaminant plume. The treated water pipelines connecting the treatment center to each injection well would be longer, presenting a statistically greater probability of failure than for alternatives 4b and 4c. Control of biological growths and precipitated inorganics will be slightly more difficult that in alternatives 4b and 4c because individual treated-water pipelines to each injection well will be longer.

This alternative was eliminated based on the lack of a reliable technology that would consistently reduce 1,4-dioxane to non-detectable levels, as would be required by an injection permit.

5.3.5 Alternative 5 - Groundwater Pumping – Injection into Deep Formation at Wagner Road

Many of the criteria related to this alternative have been discussed in Section 4.3.3. (Alternatives 3(a-e) - Groundwater Pumping - Pipeline to and Treatment at Wagner Road) since this alternative involves conveying the purged groundwater via a new pipeline to the Wagner Road Facility. What differs in this alternative is that the water would not be treated but rather would be injected into a deep geologic formation, via a deep injection well to be constructed at the PLS site.

Time: The time for adequate remediation would be the same as for all alternatives that incorporate active remediation (groups 3, 4, 5, and 6) because overall duration would be primarily controlled by the natural rate of groundwater movement.

Cost: The capital cost of recovery wells, pumps, and the pipeline to the PLS Wagner Road facility would be comparable among with group 3 alternatives. The operating costs of groundwater recovery and transmission would be very similar to the group 3 alternatives. There would be no costs for treatment, but rather a cost for the installation of one or more deep injection wells. By eliminating treatment, there is a significant reduction in both capital and operation and maintenance costs over time. Even with the significant cost of installing a deep well, this cost is low relative to the alternatives that require treatment.

Acceptable Engineering Practices:

Feasibility for the location and conditions of release -- The key challenges associated with this alternative include the installation of a new transmission pipeline able to convey water to the PLS Wagner Road facility, and the location of extraction wells and related infrastructure east of Maple Road, where the plume underlies Veterans Park and has migrated under densely populated residential neighborhoods. The technical feasibility of constructing and installing such infrastructure is well established both at this site and others. The lengthy and uncertain construction timeline associated with construction of these elements, however, makes the feasibility of this alternative uncertain. For example, the transmission pipeline back to the Wagner Road facility would have pass under Interstate 94, a significant physical obstacle. Obtaining the necessary access to both public and private property and then constructing the pipeline would be a difficult and lengthy process. Similarly, installing the extraction wells and the necessary infrastructure in the residential areas where the leading edge of the plume is currently located will necessarily cause disruption to residents and users of the area roads. Many residents have previously objected to PLS' previous efforts to install monitoring and test wells in their neighborhood and the disruption associated with the scale of construction necessary to implement any of these alternatives would be much greater and last for a longer period of time. Community opposition to the construction of this infrastructure could delay the project.

The uncertainty regarding the length of time needed to obtain access and then to construct the necessary infrastructure will make it difficult to determine where the leading edge of the plume would be when such infrastructure is ready. Such delays would delay initiation of purging, which would allow the plume to migrate farther to the east, potentially requiring PLS to re-position the recovery wells. This would in turn increase the level of disruption. Consequently, the practical feasibility of any of the remedial alternatives that involve construction of lengthy pipelines across property not owned by PLS is uncertain.

Installation of the deep injection well itself uses well-established technology. Strict USEPA procedures are in place to ensure wells are installed to acceptable engineering practices. Gelman formerly installed and operated a deep injection well for process wastewater at the Wagner Road facility (and closed it when it reached the end of its life).

Applicability to the problem – This alternative actively recovers contaminated groundwater and returns water to the environment under one or more permits into a safe (inaccessible) environment. This alternative would be applicable to the problem under present rules and regulations.

Reliability -- A properly designed and maintained deep injection well is expected to be reliable.

This alternative has been retained for further evaluation.

5.3.6 Alternative 6 – Groundwater Pumping – Interim Response and Active Remediation and Treatment Proximate to Huron River.

This alternative is similar to Alternatives 3a and 4a in that extraction wells would be used to control the plume. Under each of these alternatives the purged groundwater would be conveyed to the Huron River via a new pipeline and then treated and discharged to the river under a new NPDES permit. The feature that distinguishes this alternative from the other active remediation alternatives is that the groundwater extraction, if necessary, would occur at a location closer to the Huron River.

Time: The period of time required to achieve the applicable cleanup standard would be dependant on the fate of the plume, identification of the receptor(s) potentially affected and the observed rate of attenuation. Additional investigation to obtain these data is necessary to determine when the applicable cleanup standard will be achieved under this alternative.

Cost: Costs for this alternative are expected to be very high in comparison to the other active remediation alternatives due to the additional costs associated with the required hydrogeological investigation/monitoring and the somewhat longer cleanup horizon if active remediation is necessary. The effect of these additional costs are offset to some degree because costs associated with implementing an active remediation system will not be incurred as soon as under the other alternatives. If active remediation were not necessary, costs would be comparable to Alternative 2.

Acceptable Engineering Practices:

Feasibility for the location and conditions of release -- The release is not threatening existing water supplies. The plume underlies and will spread under a densely populated area. This alternative avoids disruption of established uses and pushes the installation of infrastructure nearer to the river, where land uses are more suitable and pipe runs can be shorter. The active remediation plan assures that no downgradient receptors will be exposed to the plume as it migrates. By implementing the active remediation proximate to the Huron River, this alternative would minimize the community disruption, potential delays, and uncertainties associated with the installation of the longer pipelines necessary under the other alternatives, while still being protective of any potential receptors. The institutional controls called for under Alternative 2 would not be required because, in the event that groundwater monitoring data indicate 1,4-dioxane concentrations at a receptor will exceed a Part 201 Generic Cleanup Criteria (e.g., water entering the Huron River with 1,4-dioxane above GSI or approaching drinking water wells at levels above 85 ppb), an active groundwater remedial system would be implemented. Thus, this alternative is not dependant on governmental decisions beyond PLS' control. Both of these factors support the feasibility of this alternative, it is considered acceptable for the location and conditions of the release in the Unit E.

Applicability to the Problem – This alternative active remediation and natural processes to reduce contaminant levels to legally acceptable concentrations. As such, it is applicable to the problem.

Reliability – The initial hydrogeological investigation will be used to predict the fate of the Unit E plume. The actual migration of the plume would then be closely monitored with the placement of additional monitoring wells. Such investigatory techniques are considered reliable. The contemplated active remediation plan involves installation of groundwater recovery wells, pumps and pipelines. Groundwater recovery wells and pumps, pipelines, and ex-situ treatment vessels have been shown to be reliable during the chemical oxidation remediation of shallower 1,4-dioxane contaminated aquifers. Periodic inspection and cleaning of wells, pumps, and pipelines will maintain the mechanical efficiency of the system.

Pilot testing has indicated that a combination of ozone and hydrogen peroxide can destroy 1,4-dioxane during the time available for ex-situ treatment involving high volumes of groundwater. Ozone and hydrogen peroxide are energetic and reliably degrade 1,4-dioxane when applied in sufficient quantity. To assure the latter, 1,4-dioxane in the recovered groundwater will be measured periodically and the treatment system operating conditions changed as needed. This technology is currently under evaluation and appears to be promising. However, if it proves infeasible or inappropriate, the U-V oxidation system currently in use at the PLS site, or some other appropriate substitute, will be implemented.

This alternative has been retained for further analysis.