Preliminary Analysis of the Wolverine World Wide House Street Feasibility Study

Richard R. Rediske, Ph.D.

The Feasibility Study and Consent Decree

The Feasibility Study shall evaluate the following remedy options to (1) manage solid wastes at the House Street Disposal Site and (2) reduce and control potential migration of PFAS Compounds from soils and sludges into the groundwater from the House Street Disposal Site:

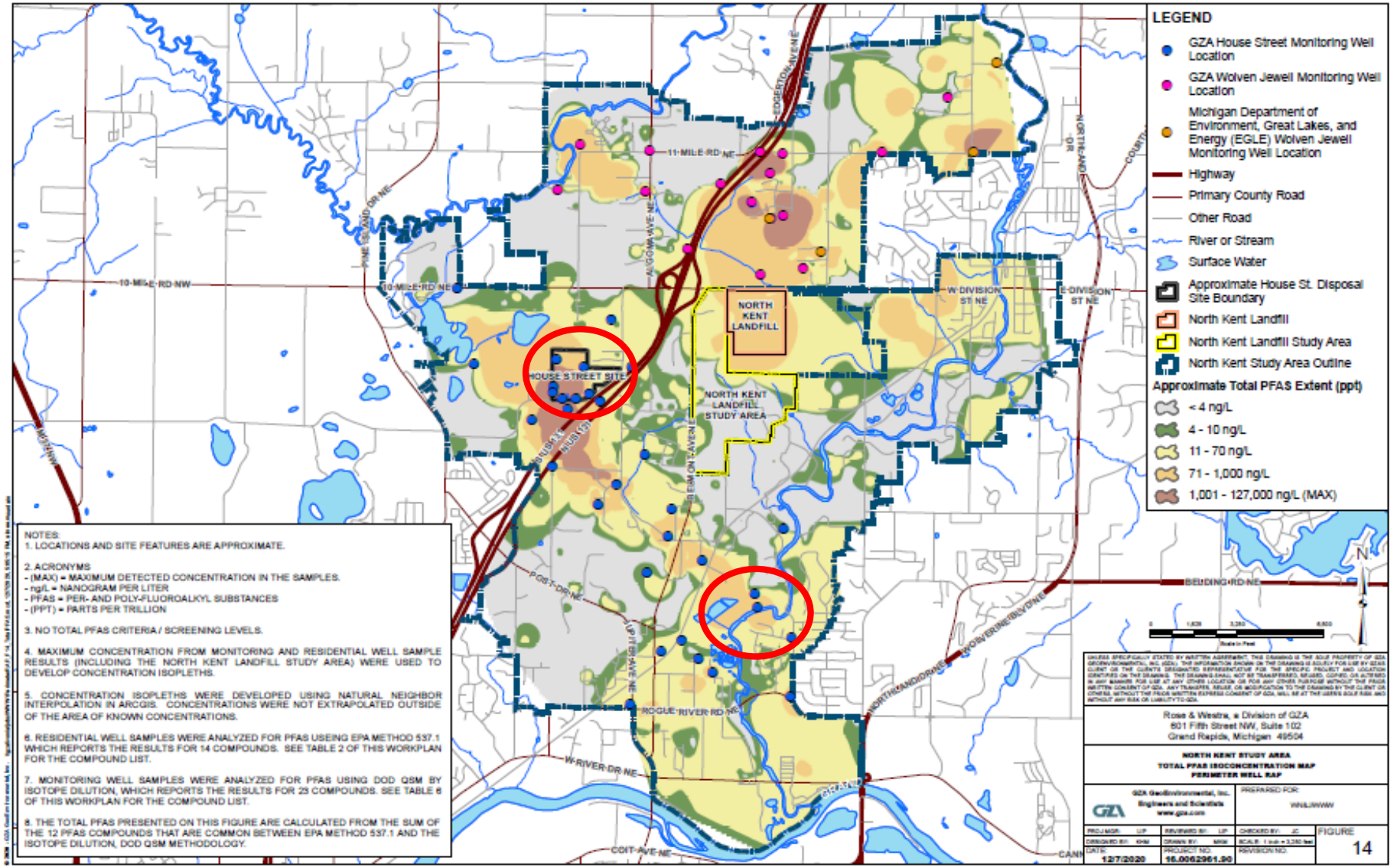
A. an approximately 30-acre surface cap without a bottom liner
B. an approximately 20-acre surface cap over an area in which materials are consolidated and placed above a liner with leachate collection
C. other alternatives that may include some combination of a smaller cap and groundwater interceptor, collection, or treatment systems

The Feasibility Study and Consent Decree

The Feasibility Study shall set forth and evaluate the remedy options under Part 201.

- There is no longer an unacceptable risk of exposure to PFAS from the HSP in drinking water. The drinking water pathway is applicable but no longer complete or relevant. Wolverine is providing protection to these receptors through both installation of municipal water and maintenance of water filtration (see CD Paragraphs 7.5 and 7.11).
- This FS evaluates the performance of remedy options to address the potential risk of exposure to groundwater from the HSP. The GSI pathway is applicable because PFOA+PFOS-containing groundwater migrating from the HSP discharges to the Rogue River. Wolverine is already investigating the GSI pathway under Paragraph 7.10 of the CD. Wolverine's investigation at the GSI, where PFAS-impacted groundwater intersects the Rogue River, will inform more impactful ways of addressing the potential surface water receptor.

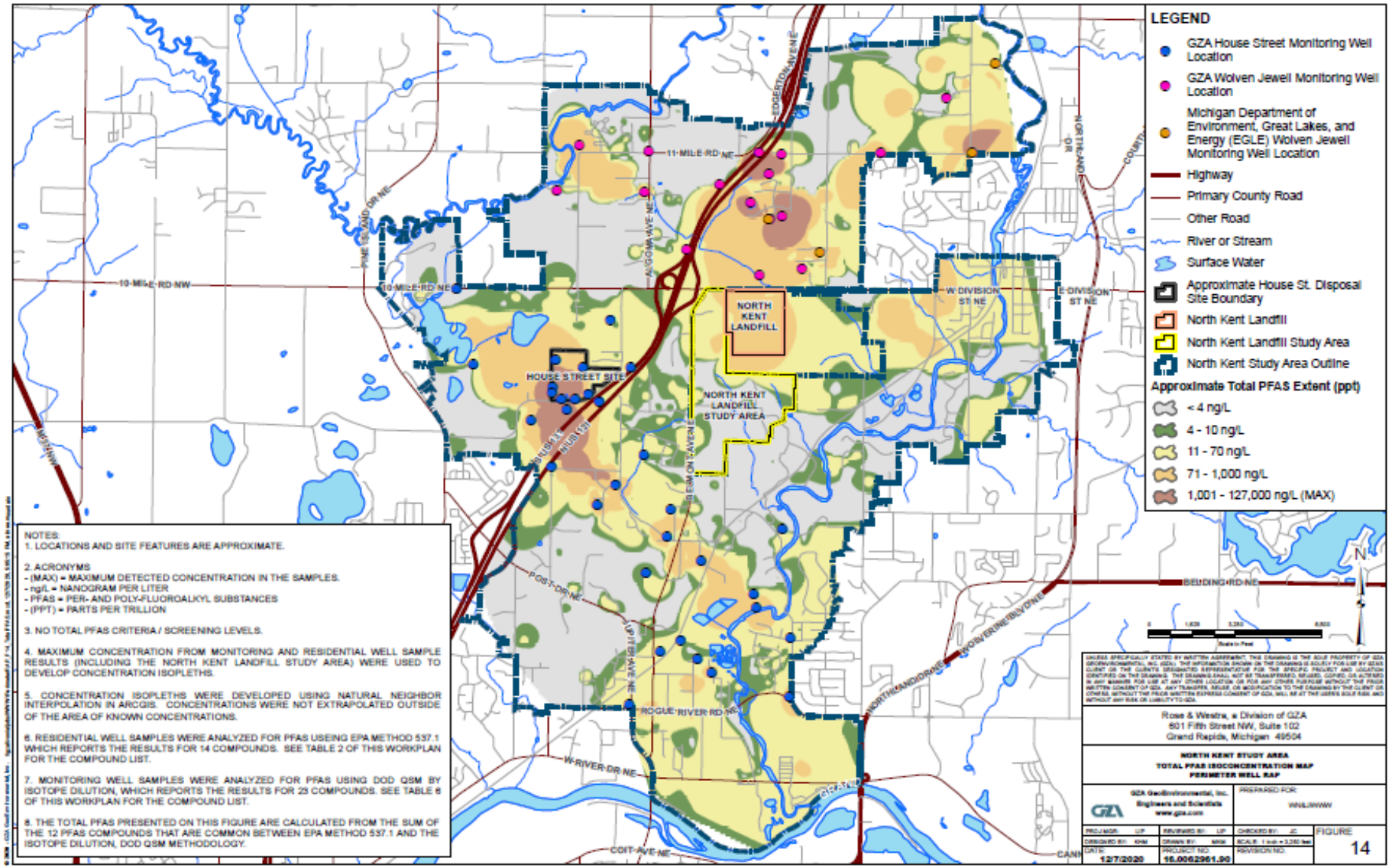
Where should we assess the effectiveness of the remedy?



House Street FS

1. We have enough information for a preliminary assessment of the relative performance of the alternatives at the House Street Site
2. We cannot assess the performance at the Rogue River without the groundwater modeling results for the status of the plume after 70-100 years under No Action, pump and treat, 30 Acre Cap, and Phyto-Cap scenarios and how the model input data were changed for each scenario.
    - How was the infiltration changed between No Action and Phyto-Cap?
    - “It will take hundreds of years for the Phyto-Cap Option to make measurable progress toward achieving the remedial objective of this FS.”
    - “It will take over 100 years for the Cap Option to make measurable progress toward achieving the remedial objective of this FS.”
    - “It will take over 70 years for the Pump and Treat Option to make measurable progress toward achieving the remedial objective of this FS.”

What will the plume look like after 100(s) of years?



Wolverine's Phyto-Cap

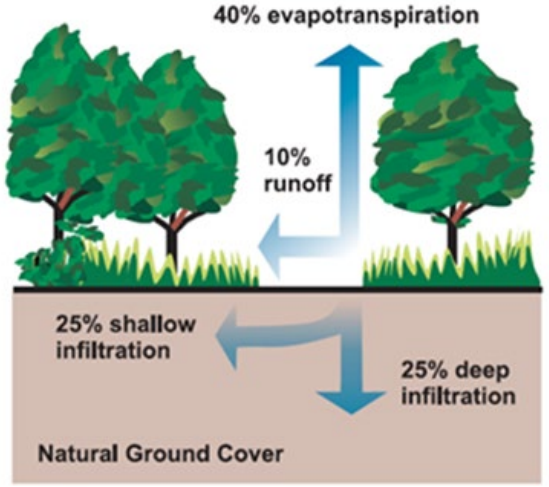
Wolverine is proposing to use phytoremediation and a small cap to (1) manage solid wastes at the House Street Disposal Site and (2) reduce and control potential migration of PFAS Compounds from soils and sludges into the groundwater from the House Street Disposal Site

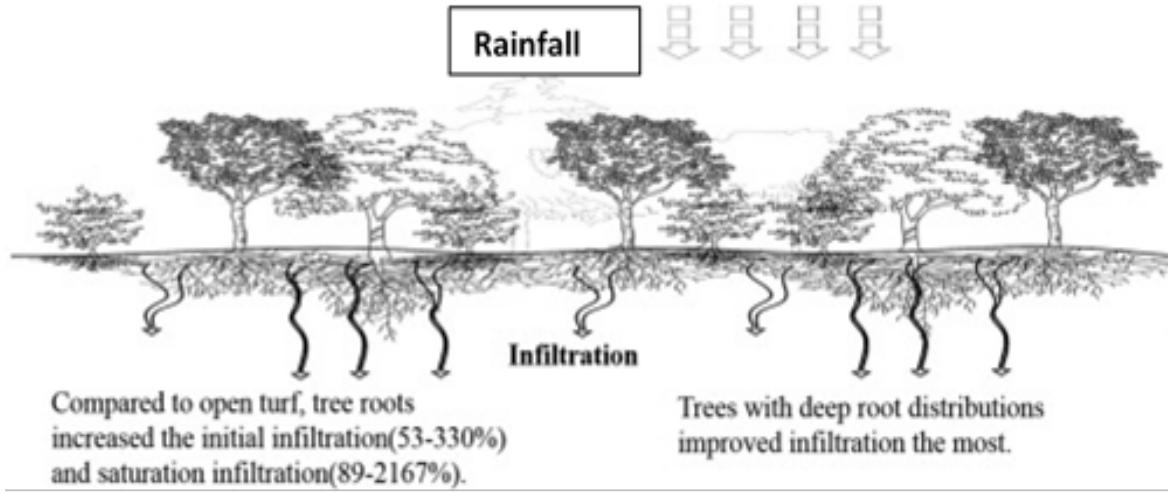
- Phytoremediation is the process where contaminants in the groundwater and soil can be removed from the subsurface environment and transferred into plant tissue.
- Water soluble contaminants can be taken up by plant roots and moved upward into the stems, trunks, and foliage by transpiration. The same process that plants use to transport water soluble nutrients from the soil can be applied to water soluble pollutants.
- EPA (1999) states: "general site conditions best suited for use of phytoremediation include large areas of low to moderate surface soil (0 to 3 feet) contamination or large volumes of water with low-level contamination subject to low (stringent) treatment standards. …. disadvantages include the long lengths of time required, depth limitations (3 feet for soil and 10 feet for ground water), and the possibility of contaminant entrance into the food chain through animal consumption of plant material."
- **House Street does not meet any of the EPA criteria for phytoremediation. HSP has high levels of deep contamination in the soil and groundwater and potential for wildlife exposure.**

EPA 1999. Phytoremediation Resource Guide. (EPA 542-B-99-003)

Wolverine's Phyto-Cap

- GZA makes numerous statements that phytoremediation will reduce and/or control infiltration.
- Given the site is heavily wooded, there may be minimal difference between current infiltration in the existing forest vs tearing out live, mature, trees and planting new ones.
- Tree roots improve infiltration (Xie et al., 2020).
- Infiltration could be much higher after existing tree removal and the first 10+ years while the phytoremediation trees are growing.
- "Reduced infiltration of precipitation through waste during growing season."



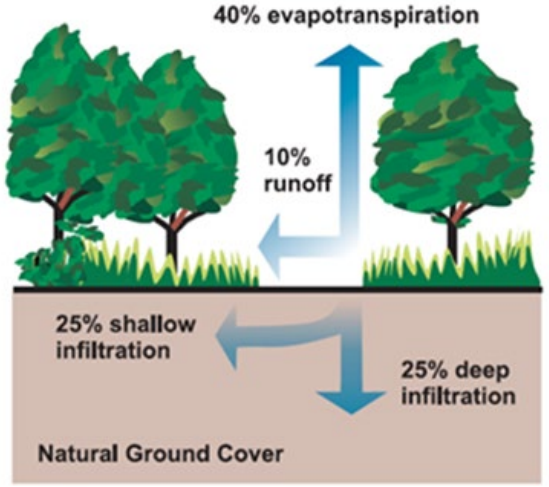


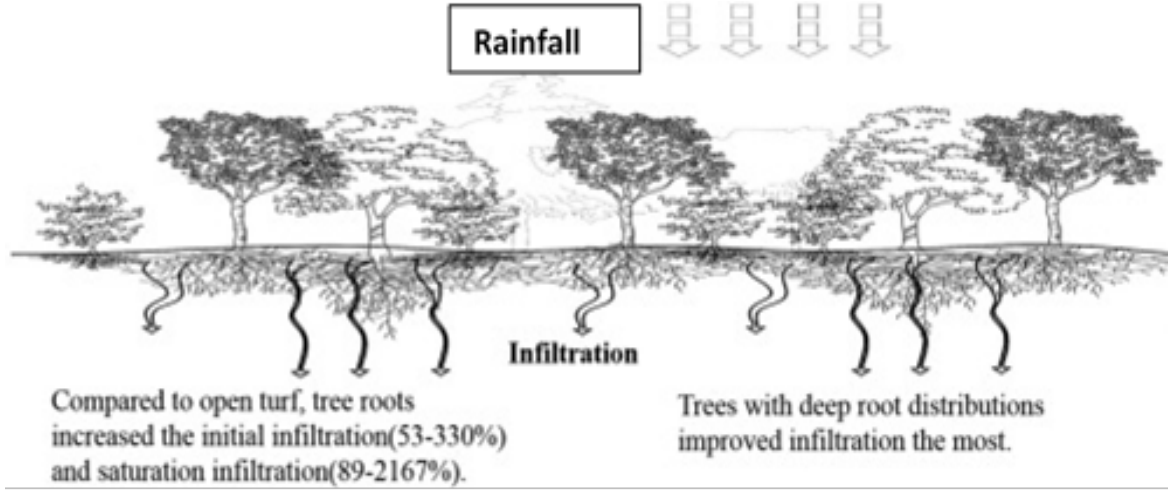
FISRWG 1998. Stream Corridor Restoration: Principles, Processes, Practices. Federal Stream Corridor Restoration Handbook (NEH-653)

Xie, C.; Cai, S.; Yu, B.; Yan, L.; Liang, A.; Che, S. The effects of tree root density on water infiltration in urban soil based on a Ground Penetrating Radar in Shanghai, China. Urban For. Urban Green. 2020, 50, 126648.

Wolverine's Phyto-Cap

- Limited infiltration benefit similar to the No Action Alternative.
- "Existing vegetation will continue to uptake at least some amount of PFAS from beneath the surface, thereby preventing at least some PFAS from migrating to groundwater and ultimately to surface water. Residual concentrations of PFAS at the HSP will slowly attenuate over hundreds of years."
- Why has the existing mature forest not effectively removed PFAS and reduced infiltration? (bioavailability, root depth, limited to the growing season, the natural 25% infiltration??)





FISRWG 1998. Stream Corridor Restoration: Principles, Processes, Practices. Federal Stream Corridor Restoration Handbook (NEH-653)

Xie, C.; Cai, S.; Yu, B.; Yan, L.; Liang, A.; Che, S. The effects of tree root density on water infiltration in urban soil based on a Ground Penetrating Radar in Shanghai, China. Urban For. Urban Green. 2020, 50, 126648.

Unsubstantiated claims of PFAS uptake

- GZA makes the following statement “For example, spruce trees growing in soil containing 220,000 µg/kg PFOS and 50 µg/kg PFOA can extract approximately 2,000,000 µg/kg PFOS and 800 µg/kg PFOA. Growing in the same soil, willows can extract approximately 1,100,000 µg/kg PFOS and 1,200 µg/kg PFOA, birch can extract approximately 3,100,000 µg/kg PFOS and 1,800 µg/kg PFOA, and grasses can extract approximately 2,400,000 µg/kg PFOS and 1,300 µg/kg PFOA. Grown in soil containing 10,000 µg/kg PFOS and 10 µg/kg PFOA, spruce can extract approximately 96,000 µg/kg PFOS and 200 µg/kg PFOA, while willow can extract approximately 52,000 µg/kg PFOS and 300 µg/kg PFOA.”
- No source for these high levels of accumulation was provided.
- If true, the effect of wildlife and insects consuming vegetation with 2,000,000-3,100,000 µg/kg PFOS needs to be seriously evaluated. The projected PFAS accumulation rates would result in Spruce tree concentrations exceeding 0.3% PFOS and Wolverine recognizes special waste management procedures may be necessary to deal with fallen trees. Will deer be impacted by feeding on the trees? What about PFAS in fallen foliage?

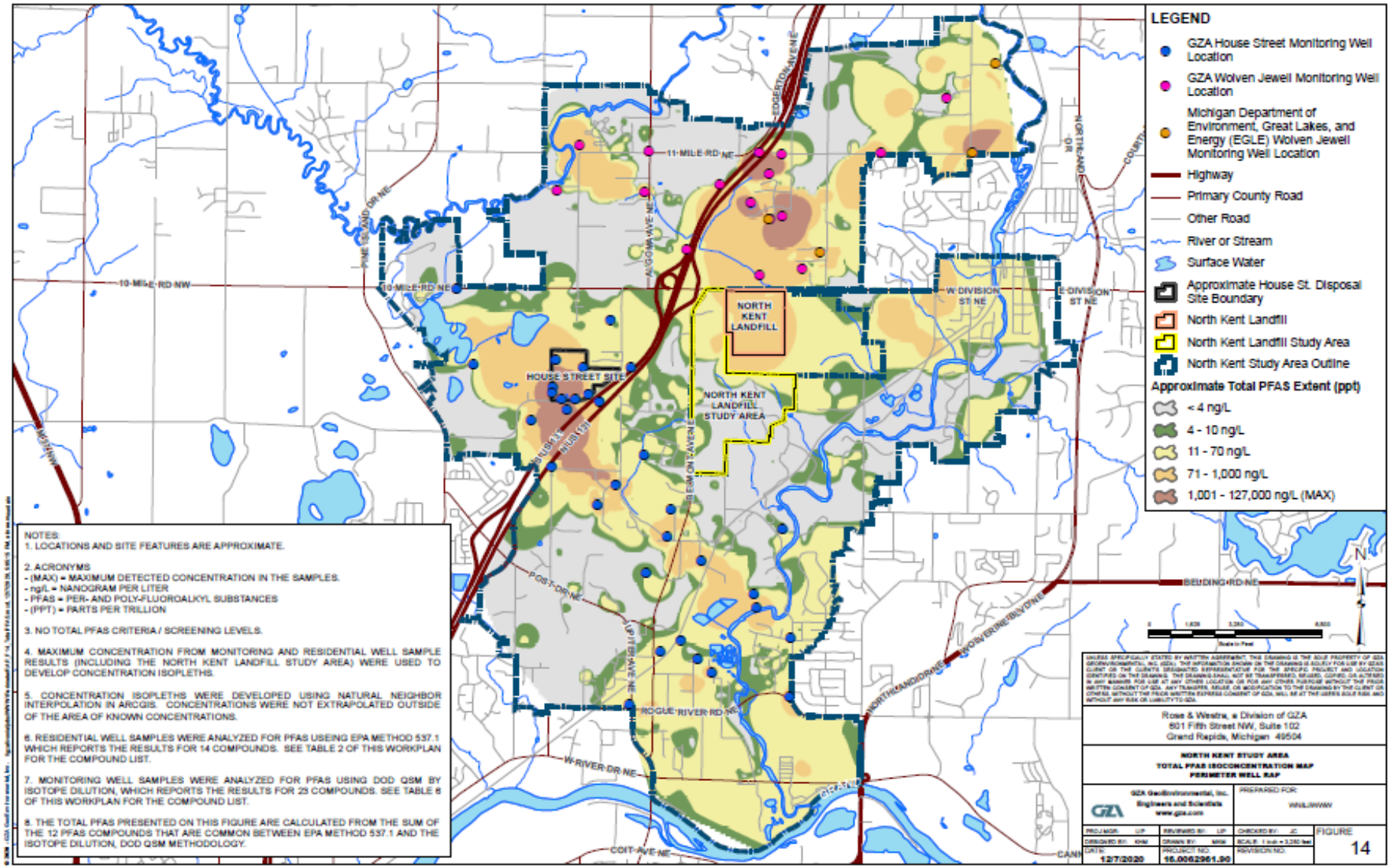
GZA's literature citations do not support the use of phytoremediation at House Street

- The study by Huff et al. (2020) was conducted in a greenhouse using sand and PFAS laden irrigation water. It was specifically designed to not include any effects of soil/PFAS interactions or pore water concentrations. This study has limited relevance to the conditions at House Street.
- The paper by Wang et al (2020) correctly identified that organic carbon and soil conditions can influence the ability of plants to absorbed PFAS. GZA made no effort to quantify the soil/PFAS conditions at the House Street Site with respect to sorption and plant availability. Given the application history of highly organic, PFAS-laden tannery sludges and the significant retention of PFAS in the waste material, the feasibility of phytoremediation cannot be evaluated without this information. **The bioavailability of PFAS needs to be assessed with respect to the effects of soil adsorption.**

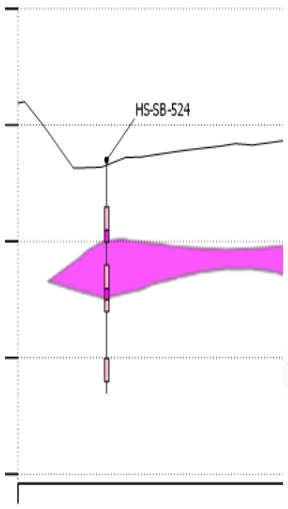
GZA's literature citations do not support the use of phytoremediation at House Street

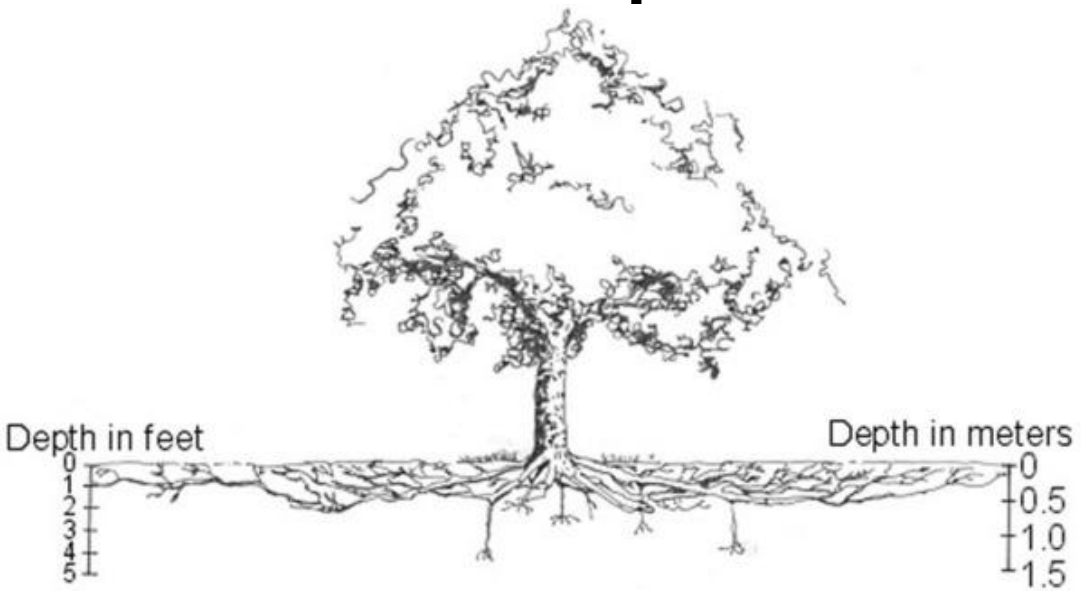
- Contrary to the discussion provided by GZA, phytoremediation of PFAS is a very experimental approach with only one study using the technique at an actual PFAS site has been reported. Most if the plant studies were conducted on vegetables and grains to check consumption hazards.
- Gobelius et al., 2017 evaluated the use of Phytoremediation at the Stockholm airport where levels of 26 PFAS compounds in soil were detected in soil at concentrations ranging from 16 to 160 ng/g (16-160 ug/kg) dry weight. House Street Disposal Area soils contain PFOS levels ranging 4-81,000 ug/kg so the study site was significantly less contaminated than the location the results were applied to. Based on the study results, the phytoremediation process will require thousands of years to treat PFAS contamination.
- Based on the current status of the plume and the high level of PFAS in the source area, remedial solutions with this timeline are unacceptable unless a pilot study or other relevant data are presented showing better performance.

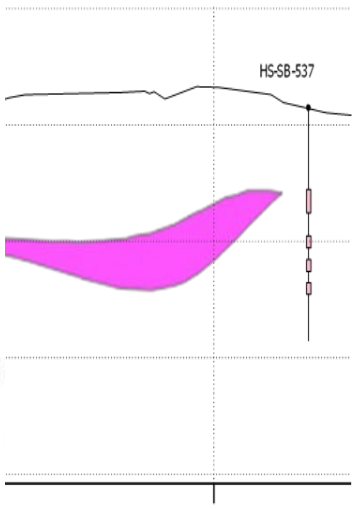
What will the plume look like after 100s of years?

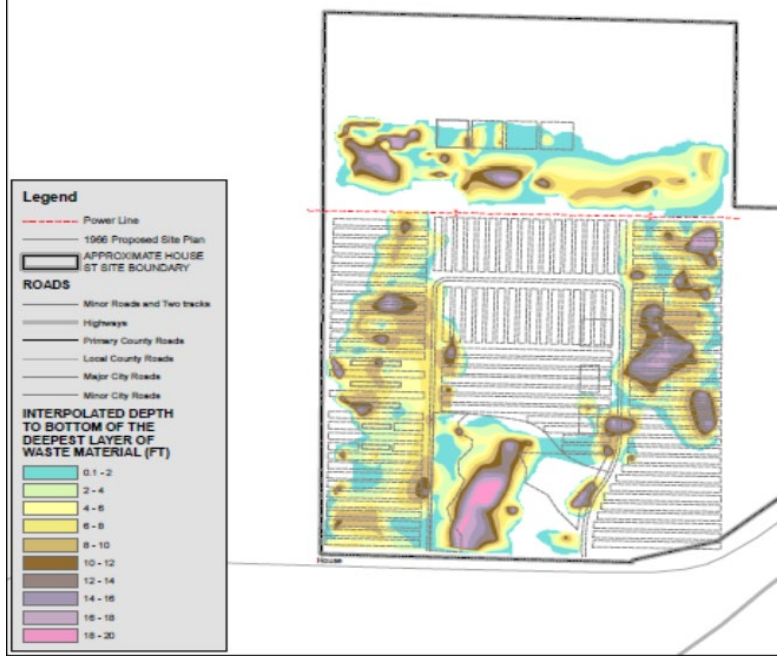


Contaminant Depth Issues









- Cross sections of the waste included in the FS and Summary Report for the implementation of the Extent of Contamination Study Removal Work Plan (RWP) dated May 29, 2018 show PFAS wastes are buried 3-20 feet deep. GZA also proposes to increase cover over near-surface waste to a minimum of 2 feet throughout the site.
- How will GZE implement phytoremediation to remove PFAS from waste buried below 3 ft?
- How will GZA monitor root depth and phytoextraction amounts/rates?

Implementation Issues

- No information on maintenance or monitoring is provided.
- GZA will remove fallen trees off site.
- Certain PFAS compounds like PFOS may accumulate more in the roots due to the higher partition coefficient. Removing the tree trunk will not prevent the roots from decaying and recycling PFOS back to the water table.

Comparison of Alternatives

Cap Option

- Manages the waste by covering the material with an impermeable barrier that will immediately limit leaching and infiltration to groundwater.

Pump and Treat

- Treats contamination at the source and reduces groundwater migration.

Phyto-Cap

- Continues to allow infiltration and leaching
- Slow uptake over millennia

Next Steps

- FS Public Hearing: **March 31.**
- FS Comments due: **April 17.**
- Tannery Meeting: **Wed May 5th**
- Tannery Comment Period: **April 22nd through May 22nd**