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February 13, 2015

William Beck
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18000 72nd Avenue South, Suite 217
Kent, WA 98032

Re: 1,4-dioxane Remediation Approach Focused Feasibility Study memorandum
PSC-Georgetown Facility
Ecology/EPA # WAD 00081 2909

Dear Mr. Beck:

On January 16, 2015, the Washington State Department of Ecology (Ecology) received Stericycle Environmental Solutions' (PSC's) *1,4-dioxane Remediation Approach Focused Feasibility Study* memorandum. The memorandum is a revision of an October 1, 2014, draft document entitled "1,4-dioxane Remediation Approach Technical Memorandum"[1] and was submitted in response to Ecology's October 23, 2014, comment letter. The memorandum is a required deliverable under Agreed Order DE# 7347 for the company's Georgetown facility. Thank you for submitting the document in accordance with its due date and for your efforts to address Ecology's comments on the draft Memorandum.

The January 16 Focused FS memorandum states that PSC's preferred alternative for reducing 1,4-dioxane mass in site groundwater is Alternative 1. This alternative includes several cleanup action elements. These include:

- continued reliance on the subsurface barrier wall to minimize downgradient migration of contaminated groundwater below the PSC property;
- implementation of in situ chemical oxidation (ISCO) in two targeted plume areas east of 4th Ave. S. (near well 122; and, along 6th Ave. S., between Orcas and Findlay Streets);and,
- reliance on monitored natural attenuation, following the ISCO actions noted above, to attain site cleanup standards.

Prior to implementing ISCO, Alternative 1 proposes bench-scale and treatability studies to optimize the effectiveness (and minimize any drawbacks) of oxidant injection. It also proposes a

[1] Cover page dated "September 2014."

1,4-dioxane biodegradation study to "verify biodegradation is occurring" in contaminated site groundwater.

Alternative 1 is similar to the ISCO Alternative 1 described in PSC's October 2014 draft Memorandum. However, in that earlier document it was not the company's preferred alternative. Instead, Alternative 3 was identified as the preferred alternative. Alternative 3 was a combination of ISCO and follow-up remediation via enhanced in situ bioremediation (ISB). It was, in most respects, the same remedial action option identified as Alternative 2 in the January 16 memorandum. In Ecology's October 2014 comment letter we stated that:

> *The Memorandum is persuasive that this alternative* [i.e., Alternative 3] *is more likely to meet our remediation goals than the 2010 Cleanup Action Plan's contingent remedy. Ecology therefore favors utilization of these four cleanup action elements, if the preliminary biodegradation study PSC is proposing concludes that enhanced ISB (with or without bioaugmentation) should be an effective action for site groundwater contaminated with 1,4-dioxane.*

We were therefore surprised to receive a revised document that abandoned PSC's, as well as the Ecology site manager's, stated preference for a combined ISCO and enhanced ISB action.

The January 16 Focused FS memorandum notes that Alternative 1 (ISCO-only) is significantly less expensive than Alternative 2 (ISCO and enhanced ISB). The cost difference appears to be about $250,000. While Ecology agrees that Alternative 2 will be more expensive than Alternative 1 if enhanced ISB appears promising and is implemented following the oxidant injections, the added cost was apparent prior to submittal of the October 1 Memorandum. Despite the added expense, at that time PSC advocated a combination ISCO and enhanced ISB.

The January 16 memorandum supports the company's preference of Alternative 1 by judging it to be as "permanent" as Alternative 2, while more easily and quickly implementable and more likely to address site or action-related community concerns. Below, Ecology discusses these determinations and provides our perspective on the two alternatives.

The MTCA FS evaluation process and selection of a preferred alternative is based on performing a disproportionate cost analysis (per WAC 173-340-360). The most practicable permanent solution is identified as the baseline alternative, against which the other alternatives are compared. Costs are deemed disproportionate to the alternative's benefits if "the incremental costs of the alternative over that of a lower cost alternative exceed the incremental degree of benefits achieved by the alternative over that of the other lower cost alternative."

Both Alternative 1 and Alternative 2, as proposed in the January 16 memorandum, include a $200,000 biodegradation study utilizing samples of site media. If, following this study, it does not appear that 1,4-dioxane biodegradation can be initiated or improved by substrate enhancements and/or via bioaugmentation, enhanced ISB will not be implemented. Alternative 2 only differs from Alternative 1 if the study concludes that 1,4-dioxane biodegradation *can* be initiated or improved by substrate enhancements and/or via bioaugmentation; otherwise the alternatives appear to be identical. Should the biodegradation study conclude it will be

effective/beneficial, Alternative 2 will implement some form of enhanced ISB following ISCO; Alternative 1 will not.

In our view a $200,000 microcosm study should only be conducted as part of the cleanup action if there is a commitment to take follow-up actions to implement the study's recommendations -- should the study conclude that significant dioxane biodegradation can be safely initiated or improved by bioaugmentation and/or substrate enhancements. Obviously, if the study's results indicate that enhanced ISB is unlikely to be effective, or will be accompanied by undesirable side-effects that cannot be confidently mitigated, the technology should not be implemented.

With this in mind, Ecology agrees that Alternatives 1 and 2 are equally permanent if enhanced ISB is not ultimately implemented. But if enhanced ISB is implemented as part of Alternative 2, it will only be implemented if the parties conclude – based on the Sentinel study – that it is likely to improve the reduction of dioxane mass at the site. This added degree of reduction, including the potential ability of bioremediation to extend mass reduction into finer-grained units, makes Alternative 2 a potentially more permanent cleanup action than actions (such as Alternative 1) that only applying oxidant to groundwater at the site.[2]

Likewise, Alternatives 1 and 2 are equally "implementable" if enhanced ISB is not ultimately implemented. They are only different alternatives if enhanced ISB is implemented (as part of Alternative 2). In this event, "more" (field mobilizations, injections, monitoring, etc.) will need to be implemented than just ISCO. And completing the field-related aspects of the action will therefore take longer. But unless the enhancement substrate chosen for Alternative 2's ISB action contains a substance that is potentially hazardous, or has other attributes that will slow approval of its use, Ecology does not believe there is a significant difference between the two alternatives in terms of their WAC 173-340-360(3)(f)(vi) "implementability."

PSC is correct that if enhanced ISB is implemented as part of Alternative 2, there will be more field activity at the site and along street right-of-ways than if only the ISCO injections are performed. The more activity there is in the neighborhood, the greater the potential that someone may be inconvenienced. Nevertheless, as the memorandum states, a traffic control plan will be developed prior implementing either Alternative 1 or 2 to minimize disruptive local impacts. Both Alternative 1 and Alternative 2 can (and will, if chosen) be designed to satisfactorily address community concerns.

It is also important to note that community concerns expressed to Ecology in the past go beyond those stated in the memorandum. They include concerns associated with the speed of the cleanup and continued migration of contaminants to the west. They include the perspectives of multiple members of the community that whatever can be cost-effectively done to address the contamination should be done. So unless the enhancement substrate chosen for ISB contains a substance that is potentially hazardous, or otherwise worrisome to the community, Ecology believes that much of the public will welcome the more "aggressive" action of Alternative 2.

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[2] "Permanence" is defined generally in WAC 173-340 as a cleanup action in which cleanup standards of WAC 173-340-700 through 173-340-760 can be met without further action being required at the site…"

For the reasons described above, Ecology prefers the Focused FS memorandum's Alternative 2. We have also provided comments and clarifications in Enclosure A to support our preference and better communicate Ecology's positions on certain statements made in the memorandum. Several comments (1, 3, 6, 9, 10, 19, and 20) require the submittal of supplemental information that can be used by the parties to develop a draft AO/CAP Amendment.

No revision of the January 16 Focused FS memorandum is requested. Following receipt of today's letter, please submit the information requested in the seven comments identified above within twenty-one (21) days. The parties can then use this information to finalize a draft Agreed Order/Cleanup Action plan Amendment. Ecology's first draft of this Amendment will be forwarded to PSC via Email shortly.

If you have any questions, or would like to schedule a meeting or call to discuss this letter, please contact me at (425) 649-4449 or ejon461@ecy.wa.gov.

Sincerely,

EJones

Ed Jones
Environmental Engineer
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ENCLOSURE A

1,4-dioxane Remediation Approach Focused Feasibility Study memorandum, received January 16, 2015

Ecology comments and clarifications

COMMENTS

1. Page 5, Section 3.0. In our comments on the draft (October 1) Memorandum Ecology asked that the language in this section (Remedial Action Objectives) be supplemented with more specific objectives for the 1,4-dioxane cleanup action. Specifically, we asked that Section 3.0:
    - provide the 1,4-dioxane cleanup standard for the site, including the cleanup level concentration, the exposure pathway this cleanup level is intended to protect (i.e., ingestion of contaminated fish/shellfish, harvested from the Duwamish River), and the Point(s) of Compliance where dioxane groundwater cleanup levels must be met;
    - identify the restoration timeframe goal (or goals, if goals differ per area/depth) for those groundwater areas and depths where dioxane currently exceeds cleanup levels east and west of 4th Ave. S; and,
    - describe any dioxane "remediation levels" (or other short-term indicators of successful remediation progress) that PSC expects the action to attain. This would include shorter-term goals the action needs to attain to ultimately achieve the desired restoration timeframe.

    This information remains absent in the January 16 version of Section 3.0. The information will certainly be needed to develop the AO Amendment and during preparation of future Design documents. But Ecology asked that it also be included in the revised memorandum to communicate PSC's long-term restoration and short-term concentration reduction goals. Without presentation of this information, how does the company expect reviewers of the document (both at Ecology and among the public) to concur that the mass reduction alternatives the memorandum has developed and evaluated are likely to achieve the site's cleanup goals?

    For example, the company has chosen to target mass reduction in the vicinity of well 127 because this is the area "containing the highest [1,4-dioxane] mass density." From Ecology's perspective, the reason for the new dioxane action is to hasten attainment of cleanup standards and improve our confidence that this attainment will occur within a reasonable timeframe. We agree with PSC that the most cost-effective approach for doing this is to reduce dioxane mass in the most contaminated areas of the groundwater plume. We also agree that the 127 area is likely to contain the highest density of contaminant mass. But by not identifying the company's long-term restoration or short-term concentration reduction goals and their associated timeframes, it is unclear: a) why the targeted area for mass reduction should be limited to the well 127 vicinity, and b)

how much mass reduction needs to occur (in the well 127 vicinity or in other parts of the plume) for the action to be successful.

As part of the near-future process of developing a draft AO Amendment (which includes revisions to the 2010 CAP), please submit the following information: a) the restoration timeframe goal PSC proposes for site groundwater contaminated with 1,4-dioxane; and b) supporting rationale for why, based on this goal, the targeted area for full-scale ISCO mass reduction should be limited to the well 127 vicinity.

2. Page 11, Section 5.1. Ecology agrees that a technology's "development status" and its "performance record" in achieving similar remedial objectives under similar site conditions are good criteria for use in evaluating its likely effectiveness. It should be noted, however, that although PSC has used these criteria for "screening purposes," the retained ISB portion of Alternative 2 has not, to our knowledge, been successfully implemented at full-scale for 1,4-dioxane remediation (much less, "in a variety of environmental and geologic settings…").

3. Pages 15 and 16, Section 5.2.2. In our comments on the draft (October 1) Memorandum Ecology asked that the document be improved by referencing the applicable site literature, and – for those sites where conditions are similar to those in the East of 4th area – discussing: the amounts of oxidant used; the remediation goals of the ISCO treatments at those sites; whether repeat injections (into the same locations) were deemed necessary, and if so, why, how many re-injections were needed, and and how much time was considered optimum between injections; and, any unwanted side effects associated with oxidant introduction.

   Although Section 8.0 of the revised Focused FS memorandum includes five more references (only two or three of which are devoted primarily to ISCO), the discussions in Sections 5.2.2, 6.2.1, and 6.4 remain deficient in providing the information Ecology requested three months ago. This information will certainly be needed during preparation of ISCO treatability study and full-scale implementation Design documents. The consequence of not providing the information in the memorandum is that reviewers, both at Ecology and among the public, are unable to determine why PSC has proposed the particular conceptual-level injection design shown on Figure 4, what post-injection monitoring schemes are likely to be needed, and whether the estimated ISCO costs in Tables B1 and B2 are likely to adequately represent the costs associated with the cleanup action eventually described in the approved Design document.

   As part of the process of developing a draft AO Amendment, please submit the following information associated with those successful ISCO applications at other sites that PSC has drawn upon to propose ISCO at the Georgetown site: a) the remediation goals of the ISCO treatments at those sites; b) the amounts of persulfate used at those sites to meet these goals; c) any unwanted side effects that occurred subsequent to persulfate injection at the sites, and d) any actions applied at the sites to either prevent unwanted side effects or mitigate the effects once they were apparent.

4. Page 19, Section 6.0, and page 21, Section 6.2. Ecology agrees that the part of the current plume where dioxane mass appears to be largest is near well 127. We also agree that remedial efforts to reduce dioxane mass must, at least, target shallow and intermediate zone contamination at this location. To be clear, though, the objective of the site cleanup action required by AO DE# 7347 is to attain 1,4-dioxane groundwater cleanup standards within a reasonable restoration timeframe. Actions to reduce dioxane mass near well 127 have the shorter-term goal of quickly reducing dioxane groundwater concentrations so that the objective of ultimately achieving cleanup levels at and downgradient of the Point of Compliance can be realized within a reasonable timeframe.

5. Page 20, Section 6.1. In the last bullet PSC has provided a number of examples of "[p]otential public concerns." As noted in our cover letter, Ecology believes that concerns related to the site, and the action chosen to reduce 1,4-dioxane mass, go beyond these examples. Over the past 15 years members of the local community have urged Ecology to speed-up the cleanup of the Georgetown site, prevent the migration of groundwater contaminants into areas west of 4th Ave. S. and approaching the Duwamish Waterway, and generally manage the cleanup as aggressively and cost-effectively as we can. These concerns should also be factored into the evaluation of new 1,4-dioxane cleanup alternatives.

6. Page 21, Section 6.2, and pages 22, 24, and 29. On these pages the memorandum discusses groundwater monitoring associated with Alternatives 1 and 2. In our comments on the draft (October 1) Memorandum Ecology requested that the revised document:

   > *describe the type of groundwater monitoring the company intends to employ. The description can be conceptual at this point, but should provide the reader enough information so that it is clear how PSC intends to monitor treatment effectiveness as well as post-injection groundwater quality and geochemistry changes.*

   However, while the revised memorandum states that monitoring will be performed during both treatability testing and full-scale implementation of ISCO and (for Alternative 2) enhanced ISB, and generally notes the objectives of this monitoring, there is no description of the types of monitoring points (wells or direct push) or the monitoring networks envisaged for collecting the necessary data. Detailed monitoring information will certainly be needed during preparation of Design documents, but the consequence of not providing additional "conceptual-level" information in the memorandum is that it is not then clear to reviewers, both at Ecology and among the public, *how* treatment effectiveness or post-injection groundwater quality and geochemistry changes will be monitored. Nor is it clear what the estimated monitoring costs in Tables B1 and B2 are based on and whether they are likely to adequately represent the costs associated with the selected action's approved Design.

   Often, the monitoring associated with pilot or treatability studies is rigorous and includes monitoring points located both proximate to and distant from the injection locations. It

also typically includes monitoring points located at depths bracketing the injection intervals, located in multiple lateral directions (within the general downgradient area) from the injection points. Among the monitoring wells installed near well 122-60 (where the ISCO treatability study will target the 50' to 60' bgs zone):

- 128-70 is about 325' downgradient (but is not screened between 50-60')
- 161-60 is about 400' down/cross-gradient
- 160-65 is about 725' downgradient
- 135-50 is about 975' due west (but is not screened between 50-60')
- BDC10-60 is about 1200' downgradient
- CI8-60 is about 1400' downgradient

It is not obvious to Ecology how the monitoring objectives associated with the ISCO treatability study can be met by only using existing monitoring wells when so few of these wells, screened across the same interval as the injection interval, are located close to well 122.

For full-scale implementation of ISCO the 35-45' bgs and 65-75' bgs zones will be targeted in the vicinity of well cluster 127. For the shallower zone:

- Well 131-40 is about 350' downgradient
- Well 160-45 is about 400' cross-gradient (to the W-NW)
- Well 159-45 is about 600' downgradient
- Well 134-40 is about 650' downgradient
- BDC10-40 is about 750' downgradient
- CI8-40 is about 900' downgradient

For the 65-75' intermediate zone:

- Well 162-80 is about 300' cross-gradient (to the S)
- Well 160-65 is about 400' cross-gradient (to the W-NW)
- Well 134-80 is about 700' downgradient
- BDC10-60 is about 750' downgradient (but is not screened between 65-75')

Here again, it is not obvious to Ecology how the monitoring objectives associated with implementing ISCO can be met by only using existing monitoring wells, especially for those depths of interests corresponding to intermediate-zone injections.

We realize that even if the monitoring costs presented in Tables B1 and B2 are significantly underestimated, this is unlikely to affect the Alternative 1/Alternative 2 cost comparison. Both alternatives will need to similarly monitor ISCO performance and Alternative 1 – which only includes the ISCO component – will still be cheaper. But the draft AO Amendment must clearly describe how PSC intends to monitor treatment effectiveness and post-injection groundwater quality. We consider the availability of this "conceptual-level" information crucial to gaining public and Ecology acceptance of the proposed action. It should therefore be submitted as part of the near-future process of developing a draft AO Amendment.

7. Page 22, Section 6.2.1. PSC's Alternative 1 is described on these pages. In the second full paragraph on the page the memorandum states that "samples will be collected adjacent to CG-127, CG-122, and upgradient to be sent to The Sentinel Environmental Group to verify biodegradation is occurring." No further discussion appears to be provided (in this section) regarding the purpose of this activity, why it is included in Alternative 1, or why the costs associated with the sampling and *verification* determination are justified (as opposed to not conducting the activity or conducting it differently).

   In a PSC email received by Ecology after submittal of the revised memorandum (January 29) the company's project coordinator stated that "we are willing to conduct the ISB research concurrently while planning and initial pilot testing of the FFS Preferred Alternative (ISCO). So we didn't include ISB in the FFS preferred alternative in order to reduce the uncertainty in the weighted evaluation while selecting a proven and cost effective remedy that meets the requirements of the FS process. If at the end of the study we can demonstrate that natural biodegradation of 1,4-Dioxane is occurring and/or can be augmented then we will have demonstrated that natural attenuation is occurring for 1,4-dioxane, a significant finding in our remedy planning."

   As noted in our cover letter, Ecology is not opposed to a study that is designed to determine if 1,4-dioxane biodegradation can be initiated/improved by substrate enhancements and/or via bioaugmentation. We do not agree, however, that a costly microcosm study should be conducted as part of the cleanup action for the sole purpose of determining whether dioxane biodegradation may or may not be occurring in site groundwater. According to Table B1, the cost of this study represents more than 38% of the total cost of Alternative 1.

8. Page 22, Section 6.2.1.[3] In the last paragraph the memorandum states that Phase III includes the injection of oxidant at approximately 30 points near well 127. However, no mention is made as to how many injection events are planned per point. Nor is it clear from Table B-1 whether the costs associated with Alternative 1 assume one or multiple injection events. In PSC's draft (October 1) Memorandum, the company proposed follow-up injections 30 days after the first injection event to address secondary sources and thereby more effectively reduce dioxane mass. However, in a January 29 email from PSC the project coordinator verified that the company's preferred action includes only a single injection event. This sole event would "inject the full dose of oxidant (that was previously spread over two rounds). Multiple rounds of injections are usually performed at sites where concentrations are on the higher end of the spectrum. After re-evaluating the data, since concentrations are very low at PSC GT, it was decided that having multiple rounds provided very little benefit- and one large dose was more likely to be effective at immediate mass removal."

[3] This comment also applies to the discussion of oxidant injection during implementation of Alternative 2 (page 24) and implementation of PSC's preferred alternative (page 29).

Ecology agreed with the follow-up injection proposal in PSC's October 1 Memorandum and continues to believe that a second round of ISCO injections is prudent. It should therefore be assumed that a second round of oxidant will be injected after a suitable waiting period (long enough for oxidant levels to diminish and dioxane to back-diffuse from finer-grained units).[4]

9. Page 24, Section 6.2.2. The second bullet on the page describes a bench-scale study performed by The Sentinel Environmental Group to select enhanced ISB substrate and "bioagugmentation requirements." This appears to be consistent with the goals of the bench-scale microcosm project proposed by Sentinel in the November 25, 2014, "Project Proposal," forwarded to Ecology on January 21. However, the Sentinel Project Proposal also includes a "pilot-scale" bioaugmentation "test" or "trial," where bacterial cells would be injected into two monitoring wells (one "near-source" and one "control"). It is unclear to Ecology if this part of the Project Proposal is also a component of Alternative 2.

   It is also unclear why the cost of the "evaluation of enhanced biodegradation/ bioaugmentation" work proposed for Alternative 2 (in Table B2) is the same as the cost estimated under Alternative 1 "to verify biodegradation is occurring." Sentinel's bench-scale study proposal includes a number of activities beyond determining whether dioxane is biodegrading naturally (and if so, at what rate(s)); for example, it also includes:
   - the preparation of bioaugmented microcosms with groundwater collected from various parts of the plume/site;
   - the preparation of bioaugmented microcosms with water not from the site, but spiked with dioxane to the same levels contained in groundwater samples (to assess co-contaminant inhibition and the effects of bioaugmentation on CVOCs vs dioxane); and,
   - the preparation of "background microcosms to benchmark biodegradation patterns…"

   As part of the upcoming process of developing a draft AO Amendment, please inform Ecology whether the Sentinel "pilot-scale" bioaugmentation "test" or "trial" proposal, which includes injections into two monitoring wells, is a component of PSC's Alternative 2.

10. Page 24, Section 6.2.2. In the last paragraph PSC states that substrate and microorganisms (if required) would be injected via approximately 36 direct push points near wells 122 and 161. However, there is no corresponding figure depicting the proposed locations for these three dozen points. Such a figure was provided in the draft October 1 Memorandum (for that document's Alternative 3), but it is not clear if Alternative 2 is proposing the same, or different, locations. A new figure should be submitted that corresponds to the revised memorandum's Alternative 2.

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[4] If, during the action's design phase, PSC continues to strongly believe that a second injection round will provide "very little benefit," the company may submit information from the site literature that supports this contention. Ecology will then review the information. Should we concur with PSC that a second round of injections is unlikely to reduce dioxane mass significantly, the ISCO Design may be limited to a single injection event.

11. Page 25, Section 6.2.2. The memorandum states that a disadvantage to Alternative 2 is that it would take longer to implement (than Alternative 1) and would be preceded by ISB bench scale testing. Ecology agrees, but both alternatives appear to include study of site groundwater's biodegradation potential. As we noted in Comment 9 above, it is unclear how the "evaluation of enhanced biodegradation/bioaugmentation" work proposed for both Alternative 1 and Alternative 2 differs. The estimated cost is the same for each alternative's "study," but the study objectives and uses of the study data appear different.

12. Page 27, Section 6.3. In the first paragraph PSC states that ISCO is the most permanent remedy/solution. The memorandum therefore concludes that Alternatives 1 and 2 are similarly permanent, and more permanent than Alternative 3 (pump and treat). Ecology believes it is debatable whether the permanence of the three alternatives is significantly different – if dioxane biodegradation cannot be cost-effectively enhanced. If dioxane biodegradation *can* be cost-effectively enhanced, Alternative 2 is the only remedial option proposing to act on this finding. For this reason it should be considered the most permanent of the three alternatives.

13. Page 27, Section 6.3. While the memorandum is correct in identifying Alternative 1 as the alternative with PSC's highest score, Ecology does not concur with the scoring results. Nor do we believe that the scoring methodology employed in the memorandum necessarily results in a preferred alternative which provides more permanence than options at the same or lower cost, or ensures that any remedial options more permanent than the preferred alternative are disproportionately costly. Our comments related to the scoring of Alternatives 1 and 2 are provided below in the discussion of Table 3 (Comment 18).

    In our comments on the draft (October 1) Memorandum Ecology requested that the revised document propose a groundwater restoration timeframe to replace the 1,4-dioxane timeframe (2015) currently established in the 2010 CAP. We realize it is difficult to predict an accurate dioxane restoration (cleanup level attainment) date, as the memorandum acknowledges, but Ecology cannot approve the selection of a remedy that is incapable of attaining cleanup levels within a "reasonable" timeframe goal. Moreover, without such a goal in mind it is hard to justify how much dioxane mass the action should be designed to reduce, at which locations, and over what periods of time.

    The January 2015 revised memorandum does not contain a proposed Reasonable Restoration Timeframe goal for 1,4-dioxane cleanup level attainment. Nor does it state how much dioxane mass should be removed by the new cleanup action. This lack of clarity on cleanup "targets" weakens the memorandum's evaluation of alternatives, since there is no obvious linkage between the mass-reduction expectations of the technologies (ISCO, pump-and-treat, and enhanced ISB) being evaluated and ultimate cleanup goals. If the amount of dioxane mass reduction the action should achieve is so unknown that even a target amount cannot be established, there is little certainty that any of the three

alternatives – all of which attempt to only reduce mass in a limited part of the plume -- will be successful in reducing dioxane concentrations to cleanup levels within a reasonable timeframe. Consequently, Ecology has reached the following conclusions about the preferred cleanup action we will propose in the amended AO:

a) the action's Reasonable Restoration Timeframe goal for attaining 1,4-dioxane cleanup levels (CULs) should be 2032, consistent with the cleanup timeframe for other contaminants in site groundwater. With current groundwater concentrations of dioxane only about one order of magnitude greater than CULs and the closest CUL exceedance approximately 1200 feet from the Waterway, 2032 seems to us a reasonable as well as attainable goal;

b) because there is considerable uncertainty about how much dioxane mass *should be* removed by the new cleanup action, as well as how much *can be* removed by PSC's three alternatives, the preferred alternative should be selected and designed to reduce as much dioxane mass as is practicably possible at the targeted locations proposed for injections. For this and other reasons, Ecology prefers Alternative 2 and repeated ISCO injection events; and,

c) because PSC is uncertain about how efficacious either ISCO or enhanced ISB will be in significantly reducing dioxane concentrations at the site, and since attainment of dioxane CULs throughout the plume is likely to take some time, the amended AO will also include:

(1) requirements for groundwater monitoring to be continued throughout the restoration period at key locations and depths east and west of 4th Ave. S;

(2) requirements for the continued tracking of 1,4-dioxane concentrations throughout the restoration period to ensure that surface water quality in the Duwamish Waterway is protected and that concentration reductions are consistent with attainment of CULs throughout the plume at the close of the period;

(3) a requirement to implement follow-up actions if in the future it appears that groundwater levels of 1,4-dioxane, discharging to the Waterway, may approach or exceed the surface water-based CUL; and,

(4) a requirement to implement follow-up actions if in the future it appears that tracked reductions in groundwater concentrations of 1,4-dioxane are inconsistent with attainment of the CUL at the close of the restoration period.

14. Pages 27 and 28, Section 6.3. At the bottom of page 27 and continuing onto page 28 the memorandum discusses the scoring of the three alternatives. As noted in the comment above, Ecology does not concur with some of the scoring results and our scoring-related comments are provided below, in discussions of Table B2.

    In addition, Ecology does not agree with the logic of lowering Alternative 2's permanence score because "ISB for 1,4-dioxane has not been proven in the field." If Alternative 2 only included enhanced ISB it would be proper to account for the uncertainty in its effectiveness in the scoring of the "Effectiveness over the long term" and perhaps even the "Permanence" criteria. But Alternative 2 includes the same ISCO action as Alternative 1, and the enhanced ISB component of the alternative would only be implemented if – following the microcosm study – it was likely the technology would be effective/beneficial.

15. Page 28, Section 6.4. As discussed above, Ecology does not agree that the memorandum has shown that Alternative 1 should be the preferred alternative. Nor is it clear, as noted in comments above, why Alternative 1 includes Sentinel's evaluation of ISB (repeated at the bottom of this page) if the alternative does not intend to implement enhanced ISB should the evaluation indicate this technology is likely to be effective/beneficial.

16. Page 31, Section 7.0. The first paragraph of the Schedule discussion appears to be inconsistent with the Figure 5 timeline. On page 31 the first mention of a public comment period is associated with the RD/RA Work Plan (revision of the EDR). Figure 5 correctly presents the sequence of events as:
    (1) preparation of a draft AO Amendment (which describes revisions to the 2010 CAP);
    (2) public comment on the draft AO Amendment and its associated SEPA threshold determination;
    (3) finalization of the AO Amendment; and,
    (4) preparation and submittal of a draft RD/RA Work Plan (describing revisions to the approved EDR).

17. Table 2. In our comments on the draft (October 1) Memorandum's Table 2 Ecology stated that:

    In Ecology's opinion, the draft Memorandum gives the impression that significant 1,4-dioxane biodegradation is occurring and that the proposed study will identify enhancements (nutrients, augmented microorganisms, etc.) that will improve the rate of this degradation...PSC may be correct that significant 1,4-dioxane biodegradation is and has been occurring in site groundwater, but Ecology has not reached the same conclusion and has not been provided persuasive evidence this is the case...We are hopeful, however, that the attenuation of dioxane levels we have observed at the Georgetown site – though proceeding at a slower rate than we anticipated five years ago – is due in some part to biodegradation...If PSC believes there is compelling evidence that biodegradation has been significantly reducing dioxane plume concentrations, this evidence should be

presented. Dioxane levels have attenuated; this is obvious. But the degree to which that attenuation is due to biodegradation has not, in Ecology's opinion, been demonstrated.

The January 16 memorandum does not provide persuasive evidence that significant 1,4-dioxane biodegradation is naturally occurring at the Georgetown site. Ecology therefore disagrees with repeated statements in the "Site-specific Issues Affecting Technology or Implementation" column that dioxane appears to be degrading or natural biodegradation is occurring.

18. Table 3. Please see Comment 8 above concerning the number of ISCO injection events (during full-scale implementation near well 127). In addition, it is unclear why:
    a) the table states, as part of the Alternative 1 "Implementation Method" discussion, that this alternative "[a]ssumes ISB bench-scale results are poor." The memorandum states that PSC will not implement enhanced ISB as part of Alternative 1 in any case. That is, whether the Alternative 1 biodegradation study concludes the technology could be implemented effectively/beneficially, or not, it will not be implemented ; and,

    b) the same statement concerning ISB assumption is made in describing Alternative 3. Again, the memorandum provides no "alternative path" for implementing enhanced ISB as part of Alternative 3, should the biodegradation study conclude it merits inclusion as part of the cleanup action.

Ecology's cover letter discusses our perspectives about Alternatives 1 and 2 in regard to several of the FS evaluation criteria. Below, we have continued that discussion in the context of Table 3's assessment of the three alternatives.

Protectiveness: Ecology agrees that if all three alternatives are likely to result in future 1,4-dioxane groundwater concentrations sustainably lower than cleanup levels at points immediately upgradient of the Waterway, they are equally "protective."[5] Since there is uncertainty as to whether this will be the case, those alternatives which will result in the scenario being (relatively) more likely should be considered somewhat more protective.

Permanence: Ecology agrees that Alternatives 1 and 2 may be more permanent than Alternative 3. However, we disagree that Alternatives 1 and 2 are equally permanent – if enhanced ISB is shown to be effective during the proposed study and then implemented. By enhancing biodegradation the 1,4-dioxane mass reduction rate should increase and reductions in contaminant mass contained in finer-grained units will be more certain. For these reasons Alternative 2 should be considered the most permanent of the three alternatives.

[5] This assumes that within the Restoration Timeframe no contaminated site groundwater is pumped to the surface and used for drinking water purposes.

Cost: Ecology agrees that Alternative 2 will be more costly than Alternative 1. Even if enhanced ISB is not ultimately implemented, costs associated with Alternative 2's biodegradation study may be higher (despite the memorandum's estimate of equal costs, it will depend on whether the Alternative 2 study includes tasks that are not deemed necessary to meet Alternative 1's objectives ; please see Comments 7, 9, and 11 above).

Long-term Effectiveness: the memorandum ranks all three alternatives equally low for this criterion. Ecology has a different perspective. The ultimate cleanup objective is to attain 1,4-dioxane cleanup levels at and downgradient of the point of compliance within a reasonable timeframe. There is no technology that can practicably meet this goal if the timeframe is very short. But if the timeframe is extended – which is reasonable to do if receptors will be protected during the restoration period – each of the three alternatives are likely to be effective. It depends on what the timeframe is.[6]

Ecology believes that Alternatives 1 and 2 should be considered equally effective if results from the biodegradation study indicate that enhanced ISB should not be implemented. If, however, the study concludes that enhanced ISB is likely to be effective, and any side-effects mitigatable, implementation of the technology should coincide with a more effective cleanup action. Alternative 2 should therefore be "scored' higher for long-term effectiveness.

Implementability: Ecology agrees that Alternatives 1 and 2 would probably be easier to implement than Alternative 3. Alternatives 1 and 2 are basically the same alternative, and would therefore be equally implementable, if actions to enhance/initiate ISB are not conducted. If, however, the Alternative 2 biodegradation study concludes that enhanced ISB *is* likely to be effective, and is then implemented, it is true that "more" will need to be implemented than just ISCO. However, we do not believe that the extra administrative and regulatory requirements, monitoring requirements, or scheduling and access considerations associated with the enhanced ISB action necessarily merit a lower implementability score. Ecology assumes that implementability considerations would be factored into the decisions – following the biodegradation study – as to: a) whether enhanced ISB should be performed at the site, and b) how enhanced ISB could best be implemented in a cost-effective manner.

Consideration of Public Concerns: PSC scores Alternative 1 higher under this criterion than Alternatives 2 and 3. Ecology disagrees, though PSC's discussion of traffic and other inconveniences is apt. We believe that actions can be taken under both Alternatives 1 and 2 to minimize traffic-related disturbances and other "nuisances." We also believe that local community concerns about site contamination and our responses to that contamination go beyond the tabled bullets (please see Comment 5 above). Alternatives 1 and 2 are basically the same alternative if actions to enhance/initiate ISB are not conducted. If, however, enhanced ISB is implemented, it will be because Alternative 2's

[6] And whether the 1,4-dioxane cleanup levels established in the 2010 CAP remain adequately protective (i.e., do not need to be adjusted significantly downward in the future due to new toxicity information or changes to the types of exposed receptors at the site).

biodegradation study indicates such action will be effective/beneficial. In this event, Ecology believes the public will support our decision to go forward with post-ISCO remediation.

19. Table B1. It is unclear to Ecology:

- what monitoring activities are being assumed during Alternative 1's (and 2's) ISCO treatability study (near well 122). A number of Phase II tasks are identified on page 29 (and page 22), and include injection-related and monitoring-related activities. The table estimates $2000 for these activities and refers to the monitoring as "monthly sampling." It is difficult to understand how the Phase II objectives will be met if the total monitoring-related outlay is limited to $2000. As discussed in Comments 3 and 6 above, PSC needs to provide more monitoring-related information for Alternatives 1 and 2 before the parties complete amendment/revision of the 2010 AO/CAP.

- why the Phase III persulate cost is only four times the Phase II persulate cost.

- why, under costs for Alternative 1's biodegradation study, there is a reference to "Pilot Study Costs" and "Substrate Costs." Sentinel's November 2014 "Project Proposal" includes a bench-scale microcosm project followed by a "pilot-scale" bioaugmentation "test" or "trial." As discussed in comments above, if the sole objective of Alternative 1's biodegradation study is to "verify biodegradation is occurring," the memorandum should have clarified which Sentinel bench-scale and "pilot-scale bioaugmentation trial" tasks would and would not be undertaken as part of Alternative 1.

20. Table B2. Please see our comments above concerning ISCO and biodegradation study costs. In addition, the table estimates $10,000 for enhanced ISB monitoring costs and refers to the monitoring as "semi-annual." It is unclear what short and long-term monitoring activities are being assumed in the derivation of this estimate. As discussed in several comments above, before the parties revise the 2010 AO/CAP PSC needs to provide more monitoring-related information for Alternative 2, including the monitoring devoted specifically to assessing enhanced ISB performance.