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BY E-MAIL

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Re: Request Pursuant to 40 CFR §300.825(c) to Alter Response Action for the Northern Impoundment, San Jacinto River Waste Pits Superfund Site, Harris County, Texas ("Site")

Administrative Settlement Agreement and Order on Consent for Remedial Design, United States Environmental Protection Agency Region 6, CERCLA Docket No. 06 02 18 ("AOC")

Dear Dr. Nance and Ms. Price:

This letter is submitted by International Paper Company and McGinnes Industrial Maintenance Corporation (collectively, "Respondents"), with respect to the Northern Impoundment of the Site, located adjoining the San Jacinto River and immediately north of the Interstate 10 ("I-10") bridge in Channelview, Texas. The Respondents are developing the remedial design ("RD") of the response action for the Northern Impoundment, selected in a record of decision ("ROD") issued on October 11, 2017.[1] Under the AOC, the Respondents are to submit a pre-final 90% RD for the Northern Impoundment ("90% RD") to the United States Environmental Protection Agency ("USEPA") by June 26, 2022.

The purpose of this letter is to request, pursuant to section 300.825 of the National Oil and Hazardous Substances Pollution Contingency Plan Contingency Plan, 40 CFR § 300.1 *et seq.* ("NCP"), that USEPA reconsider and alter the response action for the Northern Impoundment. This request is based on significant new information

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[1] The AOC references both the Northern and Southern Impoundments. The RD for the Southern Impoundment was completed and approved in April 2021.

that has been developed since the remedy was selected that involves the type of changes and circumstances that require USEPA to either amend the ROD or modify it through an Explanation of Significant Differences ("ESD"). As described in this letter and presented in greater detail in Appendix B, the changes, in light of the new information, include: significant increases in the volume (50%), lateral extent and total average depth (62%) of impacted materials required to be excavated; significantly increased complexity, risk, duration and cost as a result of the increased volume and depth; implementability issues with the required best management practices ("BMP"); an inability to meet the ROD's requirement to excavate the waste material in certain areas "in the dry" or to satisfy the ROD's requirement for "no discharges"; and implementability issues and design changes necessitated by the Texas Department of Transportation ("TxDOT") plans to replace and widen the I-10 bridge.

Each of these changes represents a significant if not fundamental change with respect the remedy; collectively, these multiple changes will unequivocally result in modifications to the ROD that the USEPA must address.[2] These changes therefore require USEPA under the NCP to evaluate the new information and modify the remedy, as appropriate, by either amending the ROD or issuing an ESD. In the short-term, the new information demonstrates the need for a pause in the schedule for development of the RD, as it is apparent due to concerns raised by TxDOT that significant changes will be required in the 90% RD that is due June 26, 2022. TxDOT's plans call into question fundamental assumptions underlying the RD related to access, the design of the BMP and schedule; they are not ones that can simply be addressed through later changes to the 90% RD or a subsequent 100% RD.

The Respondents request a meeting with USEPA to discuss the impact of the new information and an appropriate mechanism to address the changes to the remedy necessitated by the new information. That meeting needs to take place promptly considering the upcoming deadline for submission of the 90% RD.

SUMMARY OF THE NEW INFORMATION AND ITS IMPACT ON THE SELECTED REMEDY

The selected remedy requires the excavation and off-site disposal of dioxin-impacted waste material from beneath a time-critical removal action armored cap constructed by the Respondents over a former waste pit ("TCRA Cap"). It requires excavation of all material exceeding a cleanup standard of 30 nanograms per kilogram Toxicity Equivalence ("30 ng/kg TEQ"), regardless of depth, with the excavation to be performed over a two year period, "in the dry" from within a BMP, and without any discharges exceeding the Texas Surface Water Quality Standards ("TSWQS") of dioxins or other chemicals of concern from the former waste pit to the San Jacinto

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[2] That new information is described in a summary prepared by the Respondents' RD contractor GHD Services Inc. ("GHD") that is attached as Appendix B.

River.[3] When it was selected, the remedy was conceptual in nature, and deferred to the RD phase additional waste sampling to determine the depth and lateral extent of the waste and engineering evaluations related to the design and location of the BMP.

The new information about conditions at the Northern Impoundment and other developments which have occurred since the remedy was selected is summarized below. Additional details regarding the basis for selection of the remedy and the new information and developments is provided in the section of this letter below headed "Detailed Description of New Information and Post-ROD Developments."

<u>TxDOT's Bridge Replacement and Widening Project</u>

The following summarizes the impact of TxDOT's current bridge replacement and widening plans on the RD:

- The TxDOT right of way ("ROW") located along the northern boundary of I-10 adjoining the Northern Impoundment provides the only land access to the Northern Impoundment, which is partially submerged in the San Jacinto River.

- TxDOT's plans are to replace the decades-old I-10 bridge with wider and higher spans, although the design process is ongoing. TxDOT has stated that it could begin using the ROW for its project as soon as 2024 or 2025, and that the project may take three to five years to construct (depending on the design selected). At this point, TxDOT has not yet defined when and which portions of the ROW, if any, it may allow be used for the remedy, or identified where structures on the ROW to support the bridge will be located. TxDOT has raised a number of concerns about the impact of the BMP design in the 90% RD on its replacement project and on its bridge structures, including changes the BMP may cause to river flow due to its location near the main channel of the river.[4]

- Even if access to the ROW were to be made available, the coordination of work with the concurrent bridge construction project (and the associated restrictions on freeway access and traffic delays during the project) will extend the time needed to complete the work. Rather than seven years (already five years longer than the two-year period assumed in the ROD), it could take several more years to complete the work.

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[3] ROD at 80, 86 and 87.

[4] These issues are detailed in the section below regarding the TxDOT bridge replacement project.

Additional Site Investigations and Engineering Evaluations

Three separate field investigations and other evaluations of conditions in the Northern Impoundment have occurred since the remedy was selected. The investigations conducted by the Respondents gathered more than ten times more analytical data regarding conditions within the Northern Impoundment than was available when the remedy was selected and three times more geotechnical data about the subsurface conditions. That investigation and evaluation has identified critical newly-discovered information that:

- The extent and depth of the material to be excavated is significantly greater than was assumed in the ROD (a 50% increase in volume, a 62% increase on average in the depth of the material to be excavated and an increase in the maximum depth of excavation of six feet to -28.40 feet);
- Excavation "in the dry" to the depths required to meet the cleanup standard throughout the Northern Impoundment[5] is not implementable, given the risk of catastrophic failure of the excavation bottom in multiple areas due to hydraulic heave and the potential for undermining the structural integrity of the BMP;
- The remedy also cannot be implemented without the potential for discharges of dioxins that exceed the TSWQS, though the ROD states that the remedy must be implemented without discharges of dioxins exceeding these standards;
- A minimum of seven years (even assuming unrestricted use of the TxDOT ROW) will be required to implement the remedy; and
- Driven by changes required by the deeper depth and volume of material to be excavated, the BMP and other aspects of the RD involve significantly increased complexity and much greater risk and higher cost than was contemplated in the ROD.[6]

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5 As addressed below, as part of the RD process, EPA has rejected use of average concentrations to determine if the cleanup standard has been met on the basis that the ROD does not authorize the use of an average concentration. Appendix C includes an analysis showing the use of average concentrations is consistent with the ROD remedy.

6 For purposes of this submission, and given the current uncertainty regarding RD, the Respondents have not undertaken to identify the impact of the increased volume and depth of excavation on overall remedy costs. Given the nature of the new information (showing there is more and deeper material that must be removed), the increased costs above the EPA estimate are anticipated to be significant and would provide another basis on which the EPA should further evaluate the ROD and reconsider the selected remedy.

As noted above, the Respondents have a June 26, 2022, deadline to submit the 90% RD. To date, USEPA has taken conflicting positions regarding strict adherence to the ROD in developing the 90% RD, stating that use of a surface-weighted average concentration ("SWAC") is inconsistent with the ROD, while at the same time directing the Respondents to submit as part of the 90% RD a design that arguably deviates in a number of respects from the express requirements in the ROD (*e.g.*, describing mechanical dredging through a water column as an "approved approach" for excavation in areas of deeper impacts, even though by definition mechanical dredging cannot be conducted in the dry and would leave residuals above the 30 ng/kg threshold in place).[7] Accordingly, the EPA has already acknowledged that some deviations from the ROD will be necessary based on the new information developed since the remedy was selected. This underscores the need for USEPA, consistent with the NCP, to undertake a re-examination of the remedy.

WHY USEPA IS OBLIGATED TO CONSIDER THE NEW INFORMATION

The NCP requires USEPA to consider significant information that was not available during the public comment period, and which substantially supports the need to significantly alter the selected response action.[8] The NCP also requires USEPA to propose an amendment to a ROD if it determines that the differences since the ROD was issued fundamentally alter the remedial action. If those differences are considered "significant" (as opposed to "fundamental"), the NCP requires EPA to publish an ESD.[9]

Where potentially responsible parties (such as the Respondents) submit such information after a ROD is signed, the USEPA is required by the NCP to consider and respond to it (and to place such comments and its responses in the administrative record file for the selection of the ROD) if the comments contain information that is significant and the new information: (1) is not contained elsewhere in the administrative record, (2) could not have been submitted during the public comment period, and (3) substantially supports the need to significantly alter the response action.[10] EPA also

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[7] It is inconsistent for USEPA to, on the one hand, reject the use of a SWAC as a means of determining whether removal of material above 30 ng/kg TEQ has been accomplished (something that has been proposed by the Respondents) on the basis that the use of a SWAC is not called out in the ROD, and at the same time characterize mechanical dredging as being consistent with the ROD's requirement for excavation in the dry. There are also other elements of the RD that are inconsistent with the ROD, but that USEPA has identified as being acceptable elements of the RD (and critical to development of an implementable RD but not consistent with the ROD).

[8] 40 CFR §300.825(c).

[9] 40 CFR §300.435.

[10] NCP §300.825(c); *see also* EPA's "A Guide to Preparing Superfund Proposed Plans, Records of Decision, and Other Remedy Selection Decision Documents, 7.0 Documenting Post ROD Changes: Minor Changes, Explanations of Significant Differences, and ROD Amendments (EPA 540 R 98 031, Oswer 9200.1 23p, Pb98 963241, July 1999" ("ROD Guidance"), Section 7.1.

has the authority to evaluate whether a remedy change is warranted on its own merits, irrespective of whether a review has been triggered under NCP §300.825(c).

In evaluating new information, the new information can be categorized as requiring fundamental, significant, or non-significant or minor changes to the response action.[11] A "fundamental change" is one involving "an appreciable change or changes in the scope, performance, and/or cost or may be several significant changes that together have the effect of a fundamental change." A "significant change" generally involves a change to a component of a remedy that does not fundamentally alter the overall clean-up approach, while a "nonsignificant or minor change" typically involves modifications made during construction to functional specifications of the remedy to address issues, such as performance optimization, new technical information, support agency/community concerns and/or cost minimization (*e.g.*, value engineering process), and affects details such as the type or cost of materials, equipment, facilities, services, and supplies used to implement the remedy, but does not have a significant impact on the scope, performance, or cost of the remedy.

Against these metrics, the new information, none of it known to EPA at the time it adopted the conceptual ROD, either represents "fundamental" changes[12] that require a ROD amendment or, at the very least, represents "significant" changes which require an ESD. The new information demonstrates that an implementable design that meets all of the express requirements in the ROD for no discharges above the TSWQS, excavation in the dry, and the removal of all material above 30 ng/kg TEQ and is consistent with the ROD's emphasis on worker safety, cannot be implemented. In addition, the selected remedy may no longer be implementable given the recently disclosed plans by TxDOT which may result in the placement of permanent structures to support the I-10 bridge on the ROW that provides the only land access to the Northern Impoundment.

Attached to this letter (Appendix A) is a summary that identifies other Superfund sites at which EPA has issued either an ESD or a ROD amendment, in many instances under circumstances much less compelling than those with respect to the Northern Impoundment remedy. Changes to the remedies at some of these sites were the result of internal remedy optimization reviews conducted by USEPA. USEPA Region 6 has a long history of utilizing optimization reviews triggered by newly discovered information, which have resulted in important changes to the originally selected remedies.

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[11] ROD Guidance, Section 7.2.

[12] As noted above, a number of "significant" changes can together have the effect of a fundamental change.

DETAILED DESCRIPTION OF THE NEW INFORMATION AND POST-ROD DEVELOPMENTS

Below and in the attached summary prepared by the Respondents' consulting engineer for the RD (Appendix B) is a more detailed description of the selected remedy and of the new information and post-ROD developments that are the basis for the Respondents' request that USEPA reconsider and alter the response action for the Northern Impoundment.

Remedy Selected the ROD

As noted above, the remedy for the Northern Impoundment in the ROD requires excavation and off-site disposal of dioxin-impacted material with a concentration greater than 30 ng/kg TEQ. The material to be excavated is located beneath the TCRA Cap that was constructed by the Respondents over the Northern Impoundment, and that cap is to be removed in connection with the excavation. At the time of the ROD, it was understood that the waste material throughout much of the Northern Impoundment extended to a depth of -8 feet NAVD88 on average, with some deeper impacts in the area known as the "northwest corner" ("Northwest Corner"). As stated in the ROD, the volume of the material required to be excavated was estimated to be 162,000 cubic yards ("CY").[13]

The ROD specified that excavation was to be conducted "in the dry" behind a BMP structure that would allow work areas to be isolated from the river. The ROD stated that the RD would determine the design and placement of the BMP and the specifics of how the excavation (given that portions of the Northern Impoundment, particularly in the Northwest Corner, are submerged) might be accomplished "in the dry" and without any discharges that exceed the TSWQS. The remedy adopted in the ROD therefore was essentially conceptual in nature.

In the ROD, USEPA concluded that this remedy could be completed in two years and at an estimated cost of $105 million (even though the nature of the BMP and excavation methods to meet the cleanup standard had yet to be defined).[14] The selected remedy is described as meeting requirements for remedial actions, including being protective of human health and the environment, in both the short term and long term, implementable and cost-effective.[15] The ROD contains multiple statements that

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[13] ROD at 87.

[14] *Id.* at 92.

[15] *Id.*

protecting public health and on-site worker safety were critical considerations with respect to the remedy being selected.[16]

<u>TxDOT's Bridge Replacement Project</u>

Plans by TxDOT to replace and widen the I-10 bridge were not addressed in the ROD, although the ROD recognized that the ROW provides the only land access to the Northern Impoundment. TxDOT's current bridge replacement plans were likely accelerated in the wake of Tropical Storm Imelda, during which the I-10 bridge was struck by six barges and closed for a time for emergency repairs. The bridge replacement project is an important infrastructure project for the Houston region, and it now appears it is planned to take place during the same time period when USEPA anticipates the Northern Impoundment remedy will take place.

Any construction project by TxDOT related to the I-10 bridge would create logistical issues for the remedy, due to changes in access routes to I-10, closures of I-10 and the like.[17] Concurrent implementation of the two projects would require extensive coordination and changes to current plans for the implementation of the remedy.[18] The 90% RD being developed is premised on a production rate of approximately 600 CY per day; that production rate is in turn the basis for the 90% RD's identification of the size of the seasonal cell that can be excavated in a given construction season (a season that it is to be limited to the period from November to April to reduce risk of storm events that could result in overtopping of the BMP). It assumes access using the TxDOT ROW to the Northern Impoundment, and no significant impacts from any concurrent work on the TxDOT bridge widening project.[19] Until TxDOT's plans are further developed, there is an element of speculation in any production rate on which the 90% RD is based.

What TxDOT has recently disclosed about its plans for the bridge replacement project means that the issues now extend well beyond the need for coordination with TxDOT. In fact, during a recent meeting with TxDOT about the proposed 90% RD and the new information developed since the remedy was selected prompted a comment from a TxDOT representative that a ROD amendment was needed.[20] The issues now include:

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[16] *Id.* at 80, 81.

[17] Appendix B, § 4.2

[18] *Id.*

[19] *Id.*

[20] The meeting was a March 10, 2022 Technical Working Group ("TWG") meeting attended by USEPA, the Respondents and others. The Statement of Work attached to the AOC provides for TWG

- TxDOT intends to place structures in the ROW that depending on their location, may preclude or severely limit use of the ROW in implementing the Northern Impoundment remedy.[21]

- Even if TxDOT were to provide alternative access (from the south and under I-10), it is not clear that access would allow for a ramp to be constructed that would allow trucks to travel up and across the BMP (constructed at an elevation of +9 NAVD88) to enter the Northern Impoundment. In addition, cutting off the access provided by the current ROW from the north would cutoff land access to the areas where water treatment facilities and staging areas are planned to be located.[22]

- TxDOT has indicated it will not allow the southern extent of the BMP (as it is being designed for purposes of the 90% RD) to be anchored on its ROW. This will require extensive consultation with TxDOT as to what structure, if any, it might allow to be placed on the ROW and the redesign of that portion of the BMP. That redesign process cannot proceed until TxDOT's plans for the bridge structures on the ROW have been further defined.[23]

- TxDOT has raised specific concerns about: the size and placement of the BMP extending into the river channel and creating a risk of barge strikes; increases in river velocity resulting from the BMP's presence that could impact the stability of structures associated with the bridge; and the impact of the deep area in the river once the excavation work is complete that could create conditions that could undermine the stability of those structures.[24] The depth of the excavation along the southern side of the Northern Impoundment is now understood to be approximately -20 ft NAVD88 (compared to -5 ft NAVD88 assumed in the ROD).[25]

Additional Sampling Data and Other New Information

Three separate post-ROD investigations were conducted by the Respondents under the AOC. During these investigations, the Respondents collected 618 additional analytical samples (**ten times** the number that had been collected prior to the ROD) and

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meetings to take place as part of the RD process. TxDOT was invited to that TWG meeting specifically to discuss its bridge replacement and widening project.

21 Appendix B, § 2.

22 *Id.* at § 4.2.

23 *Id.*

24 *Id.*

25 *Id*. at § 3.1.4.

more than 40 geotechnical borings (**three times** the number collected prior to the ROD). In addition, a number of technical assessments have been performed post-ROD and under the AOC that touch on various aspects of the remedy.

The new information resulting from these investigations and assessments is detailed in Appendix B. It shows the following:

- Volume of Material to be Excavated. The volume of material that must be excavated is significantly (50%) greater than the volume estimated for purposes of the ROD.[26] Among other things, this increase in volume alone means an increase of 50% in truck trips will be required to dispose of the material off-site and a longer implementation period and increased costs.

- Depth of Excavations. Not only is there 50% more impacted material to be excavated, but the impacted material extends nearly five feet deeper on average than was understood at the time the ROD was selected. The post-ROD investigation concluded that the impacted material extends on average to -12.88 feet NAVD88 (62% deeper than the eight feet average depth that USEPA relied upon in selecting the remedy), and as deep as -28 NAVD88 in some locations, in particular, in the Northwest Corner.[27] The depth of the excavation required in specific locations could extend deeper as a result of confirmation sampling in order to remove any material that exceeds the cleanup standard of 30 ng/kg TEQ).[28] Along the southern boundary of the Northern Impoundment, the depth of impacted material increased from -5 feet NAVD88 to -20 feet NAVD88.

  TxDOT has also raised concerns about the depth of excavations, post-implementation, on flows in the river that could impact its bridge structures.[29] The increased depth of the excavation along the southern side of the Northern Impoundment (four times deeper than the depth assumed in the ROD, -20 feet NAVD88 compared with -5 feet NAVD88) has direct implications on the BMP type and alignment along that side and the end-state restoration that will be necessary to protect the bank.

- BMP Design and Placement. The greater volume and depth of the material to be excavated will require that the BMP (in the form of a more than 3,000 foot

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[26] Appendix B, §3.1.

[27] *Id.*

[28] As detailed in Appendix C, EPA staff has rejected use of a SWSAC to demonstrate compliance.

[29] Appendix B, §§ 3.1.4 and 4.2.

long double-walled cofferdam braced on the interior with 30-feet of soil) be constructed outside the perimeter of the Northern Impoundment.

- Based on post-ROD analytical data, the alignment of the BMP has had to be extended further east closer to the main channel of the San Jacinto River.[30]
- That alignment of the BMP in turn creates increased potential for events such as barge strikes that could impact the integrity of the cofferdam. Such an event is not a theoretical risk, given the barge strike on the I-10 bridge during Tropical Storm Imelda in September 2019 (a storm event that seemingly accelerated TxDOT plans to replace that bridge).[31] TxDOT has specifically raised this as a concern.

- Risk of Hydraulic Heave. Because of the need for much deeper excavations, a technical analysis was conducted by GHD regarding the potential for hydraulic heave to occur during excavation.[32] That technical analysis, a copy of which is attached to Appendix B, concluded that significant portions of the Northern Impoundment would be at an unacceptable risk of hydraulic heave – in which the bottom of an excavation could suddenly fail and the excavation would fill with water and flowing sands, putting at risk the health and safety of those working in the excavation.[33]
  - Once hydraulic heave occurs, no further excavation can take place in that location. Any impacted material greater than 30 ng/kg TEQ in that location or dispersed as a result of the hydraulic heave event could not be excavated and would have to be left in place.[34] In that instance, it would not be possible to meet the ROD's requirement that all material greater than 30 ng/kg TEQ be removed.
  - If a hydraulic heave event were to take place in a location near or adjoining the BMP, the uncontrolled nature of the heave event would have the potential to impact the stability of the BMP.
  - GHD's analysis showed that the risk of hydraulic heave in the Northwest Corner is so significant that even dewatering the area to the elevation of the river bottom could result in a heave scenario. Excavation of the

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30 Appendix B, §§3.1.1, 3.1.2 and 4.1.

31 One barge also struck the TCRA Cap as part of that same event. *See* Appendix B, § 4.1

32 Appendix B, § 3.1.2.

33 *Id.* at § 3.1.3.

34 *Id.*

Northwest Corner will not be possible "in the dry". As such, a different remedial approach will be required. [35]

- Areas with Hydraulic Heave Impacts. In addition to the Northwest Corner, GHD's analysis showed that there are a number of locations in the remaining portions of the Northern Impoundment (illustrated in the figure in Section 3.1.3 of Appendix B) which either are or could be at risk for hydraulic heave if the excavation is required, based on the results of confirmation sampling, to extend as little as one or two feet deeper.[36]

- Impact of Point Exposure Driven Remedial Goal. The risks associated with hydraulic heave are made much more significant because of USEPA's insistence that the ROD requires that all material exceeding 30 kg/mg TEQ without relying on a SWAC.

    - The Respondents have demonstrated that the use of a SWAC would be the appropriate way to implement the cleanup standard (*see,* Appendix C). Excavating to elevations that would result in a SWAC below 30 ng/kg TEQ (while maintaining a not-to-exceed level for anything remaining subsurface), would help to alleviate the risk of hydraulic heave in the majority of the Northern Impoundment (with the exception of the Northwest Corner). USEPA, however, has rejected the use of a SWAC on the basis that the ROD does not expressly allow (nor does it expressly prohibit) for averaging in determining whether that standard has been met.[37]

    - Surface-weighted averaging should also be utilized post-excavation to demonstrate compliance with the 30 ng/kg TEQ. Without the use of averaging, additional and arguably unnecessary excavation based on confirmation sampling will be required to take place. But it may not be possible to conduct the sampling the USEPA asserts that the ROD requires to demonstrate that the cleanup standard has been met.

        - In the field, based on confirmation sampling, additional excavation to even deeper levels may be required in specific locations.

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[35] Appendix B, §3.1.3. While the USACE has suggested that additional data and analysis might show a reduced risk of heave in those areas, it has never defined what data and analysis might be required. That process would also require a year to complete, so the analysis of other options could not be accomplished under the current 90% RD schedule absent a year or more extension of the deadline for submitting 90% RD for the Northwest Corner. *Id.*

[36] *Id.*

[37] Appendix C, § 2.

  - Those locations may be ones in which additional excavation (of as little as one additional foot of material) could trigger hydraulic heave.[38]

  - Post-confirmation sampling, unless it utilizes some form of averaging (which the ROD on its face does not allow), increases the risk that the excavation at a given location might extend to depths beyond the design limits of the BMP.

 - The cleanup standard itself was derived by USEPA in a manner that misapplied a key factor (the Biota-Sediment Accumulation Factor, or "BSAF"). The inability to rely on a SWAC to meet the cleanup standard magnifies the impact of the misapplied BSAF, and in and of itself justifies a reexamination of that standard.[39]

- <u>Excavation in the Northwest Corner Cannot be Conducted Consistent with the ROD</u>. USEPA has told the Respondents that, for the Northwest Corner, other excavation methods can be considered, including mechanical dredging (excavation through a water column), describing it as a method that would satisfy the the ROD, even though it would not be "in the dry" and would necessarily leave material above the cleanup standard in place.[40] In fact, there may be no implementable excavation method that can be employed in the Northwest Corner that will meet both the ROD's requirement that the work be performed in the dry and also remove all material greater than 30 ng/kg TEQ.

- <u>The Remedy Cannot Be Implemented on the Basis of No Discharges</u>. The Respondents conducted a post-ROD analysis of historical storm events and river levels, after which EPA agreed that excavation activity should be limited to the period from November to April.[41] While limiting construction activities to this period may reduce the potential for hurricanes and high water events in which there is a risk of flooding of open excavations and overtopping of the outer BMP, it does not eliminate that risk.[42]

  This risk will be exacerbated by the number of years required to complete the remedy, as well as uncertainty about the magnitude of future storm and high

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38 Appendix B, §3.1.3.

39 Appendix C, § 2.2.

40 Letter from Ashley Howard, USEPA Remedial Project Manager to Charles Munce, GHD dated January 12, 2022.

41 This risk is addressed in detail in the *Preliminary 30% Remedial Design - Northern Impoundment* dated May 28, 2020 ("30% RD").

42 *Id.*

water events. It also could be impacted by the Coastal Water Authority's plans – initiated after the September 2019 storm event referenced above – to construct additional gates on the upriver Lake Houston dam structure. These gates will be used to release water downstream during high water events and could increase the risk of overtopping events and associated releases.[43]

In addition, during installation and removal of the BMP, resuspension of sediments located outside the TCRA Cap during construction cannot be avoided,[44] and arguably would result in releases exceeding the TSWQS.

- The ROD May Not Be Implementable Given TxDOT's I-10 Bridge Construction Plans. TxDOT's recently disclosed plans to construct permanent structures to support the new I-10 bridge throughout the ROW and the timing for of I-10 bridge replacement project may mean that there is no available land access to the Northern Impoundment for the RA. The bridge replacement project was anticipated to delay implementation of the remedy, due to closure of on-ramps and exits to I-10 and the need to coordinate with TxDOT on use of the ROW.[45] TxDOT's newly-disclosed plans, however, are to start the three to five year bridge replacement project as soon as the end of 2024 or 2025 and at some point during implementation, would not be able to provide access to the ROW. During the project, TxDOT plans to place large permanent structures on the ROW that may prevent land access to the Northern Impoundment even after the bridge replacement project is completed. The remedy, as it is being designed, will require more than 20,000 truck trips to transport excavated material for disposal off-site. In the absence of land access, it would not be possible to implement the excavation remedy adopted in the ROD. In addition, TxDOT may not permit any design that involves constructing any part of the BMP on its ROW, which will necessarily result in the need to extensively redesign the BMP as it is being developed for purposes of the 90% RD.

- Even with Unimpeded Land Access, the Remedy Cannot be Implemented in Less than Seven Years and Given TxDOT's Bridge Construction Plans, Could Take Years Longer. The added scope and complexity of the remedy and the limited work season will significantly expand (to at least seven years) the time required to perform the remedy, far longer than the two-year estimate in the conceptual ROD. The seven-year

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43 Appendix B, §3.2.2.

44 Appendix B, §4.1.

45 These impacts were addressed in the 30% RD.

implementation period assumes access to the ROW and no delays associated with TxDOT's bridge replacement project.

CONCLUSION

In conclusion, the new information described and summarized above and included in detail in the appendices to this letter and in the administrative record for the RD, compels EPA to re-visit the remedy. The Respondents reserve the right to supplement this submission with additional information as it becomes available or is recognized as being relevant.

As noted above, the Respondents request a meeting with USEPA to discuss the impact of the new information and an appropriate mechanism to address the changes to the remedy necessitated by the new information. The Respondents view it as critical that the meeting take place as promptly as is possible in light of the current schedule for the RD.

Sincerely,

INTERNATIONAL PAPER COMPANY

By: Chris F. Kotara

Chris F. Kotara
Director, Global Environment Services & Remediation

MCGINNES INDUSTRIAL MAINTENANCE CORPORATION

By: Stephen T. Joyce

Steve Joyce
Senior Director,
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Attachments

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Appendices

Appendix A

Examples of Relevant Explanations of Significant Differences and ROD Amendments

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Examples of Relevant Explanations of Significant Differences and ROD Amendments

1. Introduction

Sections 117(c) and (d) of the Comprehensive Environmental Response, Compensation, and Liability Act (“CERCLA”) contain provisions for addressing and documenting changes to a remedial alternative selected in a Record of Decision (“ROD”).

This appendix provides examples of sites on the National Priorities List (“NPL”) at which U.S. Environmental Protection Agency (USEPA) issued an Explanation of Significant Difference (“ESD”) or a ROD Amendment due to new information, changed circumstances, determinations as to technical impracticability or implementability or other factors.

2. Examples of ESDs

Bayou Bonfouca Superfund Site, St. Tammany Parish, Slidell, Louisiana

ESD based on newly discovered contamination depth and area.

The 55-acre site was previously home to an abandoned creosote works facility.

USEPA changed the remedy from dredging, excavation, and dewatering to dredging portions of the site where feasibly possible and then capping the remaining contaminated portion with clean materials.[1] The basis for this change was the discovery that the contaminated area was longer and deeper than originally believed at the time of the original ROD, and that certain excavation and dredging practices presented stability concerns.

During analysis of design investigations, it was discovered that: 1) the length of the contaminated area was found to be 4,000 feet and not 2,000 feet as previously believed; 2) the contamination extended to a depth of approximately 17 feet and not 5 feet as previously believed; 3) the total volume of contaminated sediments was 150,000 cubic yards and not 46,500 cubic yards as previously believed; 4) the increase in volume of contaminated soils would have increased cleanup costs from approximately $55M to $150M; and 5) the increased depth of contamination presented stability concerns associated with dredging. USEPA determined that the clean fill cap would provide adequate protection with remaining contaminants.

Scovill Industrial Landfill Superfund Site, Waterbury, Connecticut

ESD due to discovery of increased volume of contaminated soil.

The site is approximately 25 acres and was previously home to metal manufacturing operations and was also used a landfill up until the mid-1970s.

[1] Available at https://semspub.epa.gov/work/06/1000432.pdf.

USEPA changed its approach for certain soil areas from excavation and off-site disposal to consolidation and relocation under an on-site cap elsewhere on the site.[2] The basis for this change was the discovery of approximately 3,700 additional cubic yards of contaminated soil and a finding by USEPA that the change in remedy would result in about $970,000 in cost savings.

At the time of the original ROD, approximately 3,720 cubic yards of contaminated soil was expected, but additional site investigation revealed approximately 7,400 cubic yards of contaminated soil. The increased volume led USEPA to reevaluate off-site disposal as a permanent solution, and it instead determined that consolidating and relocating like-contaminated soils from certain areas under a consolidated cap was more cost-effective. USEPA also noted that this approach would reduce heavy-haul trucking mileage, resulting in a reduction of “wear and tear” on roadways and related emissions.

USEPA determined that an ESD, instead of a ROD Amendment, was appropriate because the remedial action differed significantly from the original remedy, but the changes did not fundamentally alter the overall remedy with respect to scope, performance, or cost.

Allied Chemical and Ironton Coke Superfund Site, Ironton, Ohio

ESD based on newly discovered contamination depth and area.

The site contains former sand and gravel pits that were used for disposal of tar plant wastes and foundry sand.

The original ROD estimated 3,300-5,100 cubic yards of contaminated soil would need to be removed and assumed a dredge depth of less than 5 feet with an approximately 0.7-acre area requiring capping. However, subsequent studies demonstrated 50,000 to 60,000 cubic yards of contaminated soils, expanding the relevant area to 2.3 acres requiring dredge depths of 28 feet in some sections. USEPA determined that dredging to such depths could cause water quality and slope stabilization issues. Additionally, dredging costs were previously expected to be approximately $2.8M-$4.5M, but revised estimates showed these costs would rise to $15M-$30M. USEPA instead determined that a capping-only remedy, which still was estimated to cost $4.4M (the higher range of the original cost estimates) was appropriate. USEPA determined that this approach remained protective of human health and the environment.

USEPA determined that changes were significant but did not fundamentally alter the overall remedial action with respect to scope, performance, or cost. Therefore, USEPA determined that the use of an ESD to effectuate those changes was appropriate.

A such, the USEPA issued an ESD to change the selected remedy from dredging and off-site disposal and in-situ capping to only requiring a sediment cap.[3] The change was based on the discovery that approximately 10 times more contaminated soil was present on the site and that: 1) dredging would create water quality impacts downstream; 2) dredging to the required depths would create significant slope failure risks along the river bank; and 3) the modified remedy resulted in significant cost savings of as much as approximately $25M.

Outboard Marine Corporation Superfund Site, OMC Plant 2 Site (Operable Unit 4), Waukegan, Illinois

ESD based on discovery of saturated soils.

The OMC Plant 2 site is the fourth of four designated OUs in the area. From 1984-2000, Outboard Marine Corporation operated several vapor degreasers at its Plant 2 and used TCE during this process.

[2] Available at https://semspub.epa.gov/work/01/593606.pdf.

[3] Available at https://semspub.epa.gov/work/05/921748.pdf.

The original ROD contemplated completely removing all contaminated soils above action levels, but after encountering a shallow groundwater table, USEPA determined that this was no longer appropriate. Over 350,000 cubic yards of contaminated soil were already excavated, significantly exceeding an initial estimate of 40,000 cubic yards, and USEPA explained that it would be very difficult and costly to continue removing contaminated soils below the groundwater surface because of the significant costs associated with dewatering such a large area. USEPA determined that a modified approach would still prevent any unacceptable exposures.

USEPA changed the original remedy of excavation and off-site disposal for all site soil with contamination at certain levels to a new remedy of partial excavation and off-site disposal of unsaturated soil and placement of a clean fill cap over the remaining soil, which was previously intended to be excavated.[4] Institutional controls were also implemented to prevent unacceptable exposures to soil contamination at lower depths. The basis for this change was the discovery of saturated soils, the excavation of which would have resulted in a significant increase in effort and cost not originally anticipated in the ROD.

USEPA determined that an ESD, instead of a ROD Amendment, was appropriate because the remedial action differed significantly from the original remedy, but the changes did not fundamentally alter the overall remedy with respect to scope, performance, or cost.

Laboratory Energy-Related Health Research / Old Campus Landfill Superfund Site, Davis, California

ESD due to new analysis of capping option.

The University of California and the U.S. Department of Energy are responsible for different parts of the site.

USEPA eliminated a remedy of excavation and off-site removal of VOC hot spots where capping adequately mitigated the risk of potential migration.[5] The basis for this change was that VOC hot spot areas represented only a small portion of the VOC contamination and that a cap would effectively mitigate risks associated with VOC migration, at a reduction in cost of approximately $1.6M.

The original ROD called for the excavation and off-site disposal of VOC hot-spot areas totaling approximately 2,420 cubic yards and going as deep as 20 feet bgs. The rationale for this remedy was that it reduced potential migration to groundwater and minimized the potential for vapor intrusion into buildings. However, the impacts of a cap were not evaluated at that time, and these potential impacts were subsequently evaluated. USEPA determined that: 1) utilizing a cap would not decrease the protection to human health and the environment; 2) the long-term effectiveness and permanence of the remedy would be minimally affected; 3) the short-term effectiveness of the remedy would be improved because there would be no risk from excavation equipment and waste transport; 4) the remedy would be more implementable; and 5) costs would be reduced by $1.6M.

USEPA determined that an ESD, instead of a ROD Amendment, was appropriate because the remedial action differed significantly from the original remedy, but the changes did not fundamentally alter the selected remedy with respect to scope, performance, or cost.

Former Naval Air Station, Brunswick, Maine

ESD due to discovery of new areas of contamination.

The site is a former U.S. Navy air station.

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[4] Available at https://semspub.epa.gov/work/05/494194.pdf.

[5] Available at https://semspub.epa.gov/work/09/100006735.pdf.

The original ROD included land use controls and monitoring to assess the progress of natural attenuation. However, subsequent investigations demonstrated that two areas could be acting as continuing sources of groundwater contamination and excavating these areas would accelerate the restoration of groundwater. USEPA explained that the long-term monitoring and land use control components of the remedy would not change, and the remedy would remain protective of human health and the environment.

USEPA changed the remedy to provide for the excavation of soil from newly defined areas for transport to different parts of site for placement under a cap extension.[6] The basis for this change was the discovery of contamination in these newly defined areas of the site and the need to adequately address these contaminated soils.

AT&SF Albuquerque Superfund Site, Albuquerque, New Mexico

ESD due to newly discovered contamination depth and area.

The site consists of approximately 42 acres of a former 89-acre facility that used creosote and other compounds in wood preservation operations.

USEPA changed the remedy to reduce the depth of contaminated soil to be excavated from three (3) feet to two (2) feet.[7] The basis for this change was the discovery that the extent of contamination was 50 percent greater than was known or assumed at the time of the ROD.

The original ROD called for soils exceeding remediation goals to be excavated down to three feet. Subsequent investigations found that contamination extended farther than originally thought, increasing the volume of soil to be excavated by over 50 percent. In order to keep the excavated soil volumes at a manageable level for *in-situ* treatment and capping, USEPA decided to reduce the depth of excavation for contaminated soils to two feet. USEPA determined that this approach would remain protective of human health and the environment.

Oklahoma Refining Company Superfund Site, Cyril, Oklahoma

ESD due to lack of viable recycling options.

The site was home to a large refinery from 1920 through 1984.

USEPA changed the remedy for addressing certain pitch pits from excavation and recycling of asphaltic materials to capping the pits.[8] The basis for this change was saving approximately $1.28M while simplifying the remedy to account for a lack of recycling options.

The original ROD contemplated excavating and recycling approximately 2,640 cubic yards of asphalt and 8,200 cubic yards of asphaltic pitch. However, no viable recycling option was identified during the remedial design phase, and USEPA determined that it was appropriate to stabilize the asphalt and place it on top of the pitch pits and then place a cap on top of the stabilized asphalt and pitch pits. USEPA determined that the pitch material was not mobile and had a low migration potential and that capping the pits would be equally as protective as recycling. USEPA also determined this approach would simplify the remedy by eliminating excavation, handling, and disposal risks, and that the approach would reduce remediation costs by $1.28M. USEPA determined that this approach would still be protective of human health and the environment.

USEPA noted that there were no fundamental changes to the original remedy selected in the ROD, but that if the groundwater remedy (separate from the changes described above) was not implemented as set forth in the ROD, a ROD Amendment would be required.

[6] Available at https://semspub.epa.gov/work/01/564524.pdf.

[7] Available at https://semspub.epa.gov/work/06/883322.pdf.

[8] Available at https://semspub.epa.gov/work/06/143214.pdf.

3. Examples of ROD Amendments

Popile, Inc. Superfund Site, El Dorado (Union County), Arkansas

ROD Amendment based on post-ROD site characterization data and the technical impracticability of achieving objectives.

The site was a wood treating facility from 1947 to 1982 that used a surface impoundment and three sludge pits as part of its waste treatment process. The primary contaminants found at the site include PCP and creosote compounds associated with wood treatment.

A ROD issued in 1993 included the excavation and on-site biological treatment of contaminated soils and sludges in a land treatment unit, *in-situ* bioremediation of deep subsurface soils, and a pump-and-treat groundwater system for hydraulic containment as the remedy.

A pilot study of the on-site biological treatment process demonstrated that the performance standards set forth in the 1993 ROD could not be achieved in a reasonable timeframe. It was also determined that the Remedial Investigation/Feasibility Study (RI/FS) completed in 1992 did not sufficiently characterize the subsurface conditions, in that it failed to define the contaminant source and its associated groundwater plume.

A more detailed site investigation was performed in 1997 and demonstrated that the NAPL contamination extended vertically from the soils beneath the impoundments to a depth of 30 feet or more. The 1997 investigation identified an additional area of surface soil contamination and other previously unknown issues.

In response to the new understanding of site conditions, the on-site biological treatment was changed to stabilization only, and the additional area of surface soil contamination was covered with a cap.

In September 2001, a ROD amendment[9] was issued to document the change in the overall site cleanup strategy including a change in the RAOs. The ROD amendment's soil cleanup strategy is to maintain the land treatment unit and engineered barriers and implement institutional controls to prevent exposure to the soil contaminants.

The previous goals of the groundwater cleanup strategy were to prevent migration of the contaminant plume and restore the aquifer to drinking water standards. The goal to restore the aquifer to drinking water standards was determined to be technically impracticable. The 2001 ROD Amendment included a TI waiver and changed the groundwater remedy from pump-and-treat containment to long-term monitoring only.

Installation Restoration Site 1, Alameda, Contra Costa County, California

ROD Amendment to address new information about extent of contamination (larger and deeper impacts).

A portion of the site known as the "Burn Area" was home to open-air burning as a disposal method by the U.S. Navy Public Works Department in the 1950s.

A ROD issued in 2009 called for the excavation and off-site disposal of exhumed wastes. This remedy was based on limited data available at the time. The subsequent data gathered provided a significantly better model and understanding of the nature and extent of the burn residue, demonstrating that the relevant Burn Area was much deeper and larger than anticipated.

[9] Available at: https://semspub.epa.gov/work/06/904926.pdf.

USEPA issued a ROD Amendment[10] in 2013 that incorporated the use of a steel waste isolation bulkhead and placement of a soil cover over portions of the Burn Area soils. Full excavation in accordance with the ROD was estimated to cost approximately $40.1M, but the amended remedy was only expected to cost approximately $13.1M, resulting in a much more cost-effective approach. USEPA determined that the approach selected in the ROD Amendment, was still protective of human health and the environment.

Salford Quarry Superfund Site, Lower Salford Township (Montgomery County), Pennsylvania

ROD Amendment issued because original remedy was impracticable and could not be constructed due to lack of staging area.

The site was used as a shale quarry from the early 1900s through the 1930s. A ROD issued in 2013 required the construction of an engineered onsite cell to contain contaminated waste, soil and sediment. However, during the RD phase, USEPA determined that the original remedy was impracticable and could not be constructed due to insufficient staging area on and adjacent to the quarry property.

In light of this new information, USEPA issued a ROD Amendment in 2021[11] which replaced the prior engineered cell approach with the construction of a subsurface perimeter wall and a RCRA Subtitled C cap. The estimated cost for the modified approach was approximately $5.9M, which involved many of the same components and was nearly $20M less than the alternative engineered cell approach included in the original 2013 remedy.

Bailey Waste Disposal Superfund Site, Orange County, Texas

ROD Amendment issued to address increased waste volume and inability to meet performance criteria using the selected remedial technology

The site was originally part of a tidal marsh near the confluence of the Neches River and Sabine Lake. In the early 1950s, two ponds were constructed by dredging the marsh and piling the marsh sediments to form dikes. Between the time of the pond's construction in the 1950s and the spring of 1971, a variety of wastes including industrial waste (primarily organics including tar-like wastes), municipal solid waste, and debris were used as fill material to improve the dikes. The site was placed on the NPL in 1986.

In June 1988 a ROD was issued which selected *in-situ* solidification of the onsite waste and construction of a clay cap over the waste as the remedy for the site. During the Remedial Design ("RD") phase, investigations were performed to better define the extent and volume of site wastes by boring and trenching the waste areas. As a result of this activity, the estimated volume of site waste increased from approximately 100,000 cubic yards to 156,000 cubic yards.

As the remedy was implemented, it was discovered that the *in-situ* waste stabilization inject-and-mix systems were unable to consistently meet the stabilization requirements. A Focused Feasibility Study was performed to evaluate these conditions and concluded that successful implementation of the original remedy would, if possible at all, be significantly more difficult, more time consuming, and more costly to implement than was contemplated at the time the original ROD was issued.

The ROD was amended as a result of the difficulties associated with the implementation of the original remedy. The amended ROD[12] selected consolidation of the waste and construction of a light-weight cap as the new basis for the remediation.

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[10] Available at: https://semspub.epa.gov/work/09/1147183.pdf.

[11] Available at: https://semspub.epa.gov/work/01/548958.pdf.

[12] Available at: https://semspub.epa.gov/work/06/100044.pdf.

French Limited Superfund Site, Harris County, Texas

ROD Amendment due to technical impracticability (TI) of achieving Remedial Action Objectives ("RAOs") in a reasonable time frame

The site is located approximately two miles southwest of Crosby, Texas, near the San Jacinto River. The site was used as a sand quarry in the 1950s and 1960s, which resulted in the formation of an approximately 8-acre sand pit. The site was permitted to accept industrial waste material from 1966 until 1971 and received an estimated 90 million gallons of chemical waste, the majority of which was deposited into the former sand pit and transformed the sand pit into a waste lagoon.

In 1988 a ROD was issued which selected a remedy that included *in-situ* biodegradation of sludges and contaminated soils, aeration of lagoon waste, stabilization and on-site disposal of residues, surface water treatment and discharge to the San Jacinto River, backfilling of the lagoon to grade, contouring, pumping and treating contaminated groundwater, and groundwater monitoring for a period of 30 years.

All of the remedy components were successfully completed except for the remediation of groundwater. After 30 years of groundwater investigations and remediation, the (RAOs) for groundwater established in the 1988 ROD had not been achieved.

A Supplemental Feasibility Study was performed which concluded that the estimated timeframe to achieve the groundwater RAOs using pump-and-treat methodology was decades to hundreds of years and was not considered reasonable in the context of the NCP (40 CFR §300.430(a)(I)(iii)(F)).

A ROD Amendment[13] was issued in 2014 which waived the requirement to achieve applicable or relevant and appropriate requirements ("ARARs") within the plume boundaries (a "TI waiver") and selected monitored natural attenuation ("MNA") combined with institutional controls as the remedial technology for groundwater.

Jones Road Groundwater Plume Superfund Site, Harris County, Texas

ROD Amendment issued based on the discovery of vapor-phase contamination in a deep unsaturated zone.

The site is located outside the northwestern city limits of Houston. The source of the groundwater plume was a former dry cleaner. The hazardous substances present at the site include tetrachloroethylene ("PCE"), and daughter products trichloroethylene ("TCE"), 1,2-dichloroethylene ("DCE"), and vinyl chloride ("VC").

On September 23, 2010, a ROD was issued which selected *in-situ* chemical oxidation ("ISCO") for source zone soil and shallow groundwater remediation, bioaugmentation for deeper groundwater sources, and pump-and-treat for hydraulic containment as the remedy.

The first phase of the remedial design included an investigation to address data gaps. The investigation identified significant vapor-phase concentrations in the deep unsaturated Chicot Sand Unit at 60 to 110 feet below ground surface (bgs). This deep vapor phase contamination was not identified as part of the initial investigation and hence was not addressed in the 2010 ROD. Feasibility testing indicated that soil vapor extraction ("SVE") could effectively reduce the vapor mass in the deep unsaturated zone.

A ROD Amendment[14] was issued in September 2017 which changed the remediation technology from ISCO and bioaugmentation to SVE but did not modify other elements of the pump-and-treat hydraulic containment remedy.

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[13] Available at: https://semspub.epa.gov/work/06/713696.pdf.

[14] Available at: https://semspub.epa.gov/work/06/100003868.pdf.

Old Midland Products Superfund Site, Yell County, Arkansas

ROD Amendment due to the technical impracticability of achieving remedial objectives.

The site was a 37-acre sawmill facility and wood preserving chemical plant that operated from 1969 until 1979. The wood treating process included the use of creosote and Pentachlorophenol ("PCP") to preserve the wood from bacterial and insect degradation.

A ROD issued in 1988 included the demolition of structures, incineration or off-site disposal of soil, sludge, and sediment, and the extraction and treatment of groundwater (pump-and-treat) as the remedy. The demolition and solid waste management activities were completed in 1993.

The groundwater pump-and-treat system began operation in 1994. The treatment process included oil and water separation followed by water treatment with carbon absorption.

In 1999, the pump-and-treat system was shut down. However, monitoring identified contaminant rebound and the system was re-started in 2000.

The original remediation objective was to restore the site groundwater for use as drinking water. A determination was made that it was technically impracticable for the pump-and-treat system to meet drinking water standards, and that no other remediation technologies could reliably or logically attain site cleanup levels for the same reasons.

In April 2006, a ROD Amendment[15] was issued to change the remediation objective from the restoration of site groundwater to the minimization of migration (i.e., containment) and to waive the requirement for restoration to drinking water standards with a TI waiver applicable to the light dense non-aqueous phase liquid (LNAPL) and DNAPL source area. The amended remedy for groundwater consists of institutional controls and long-term monitoring.

South Cavalcade Street Superfund Site, Houston (Harris County), Texas

ROD Amendment due to the failure of the selected remedial technology.

The site was a former coal tar distillation and creosote wood preserving facility. The contaminants of concern in on-site soils are PAHs released from the creosote wood preservative prior to 1962, when wood treating operations ceased. A ROD issued in 1988 selected soil flushing and soil washing as remedies to remediate wood treating wastes in the soil. Through soil flushing, contaminated soil zones were to be remediated through a physical-chemical *in-situ* soil flushing process which would have continually passed an aqueous solution, containing surfactants or other chemicals, through contaminated areas to release the contaminants. As the released contaminants moved out of the contaminated zone, they were to be captured and treated by collection and treatment systems.

A pilot study was completed which determined that the selected remedy would not achieve the remedial action goals established in the ROD.

A ROD Amendment[16] issued on May 16, 1997, changed the remedy from soil flushing and soil washing to the installation of a concrete cap.

[15] Available at: https://semspub.epa.gov/work/06/202964.pdf.

[16] Available at: https://semspub.epa.gov/work/06/137011.pdf.

Texarkana Wood Preserving Company Superfund Site, Texarkana (Bowie County), Texas

ROD Amendment due to community concerns, data quality issues, and evolving industry practice.

Past operations at the site resulted in the release of PCP and creosote contaminated soils and DNAPL.

A ROD issued in September 1990 for Operable Unit 1 selected thermal desorption (i.e., incineration) of contaminated soil and DNAPL source material coupled with the extraction, treatment, and reinjection of shallow groundwater as the remedy. Due to community concerns that thermal desorption (i.e., incineration) would affect ambient air quality, the remediation was not implemented and a ROD Amendment (Amendment No. 1)[17] was issued in 1998 which selected an *in-situ* capping remedy. The *in-situ* capping remedy was not implemented.

A ROD for deeper groundwater (Operable Unit 2) issued in 1993 included groundwater extraction, treatment, and reinjection. However, this remedy was not implemented.

In September 2010, a ROD amendment[18] (Amendment No. 2) was issued which consolidated Operable Unit 2 into Operable Unit 1. Amendment No. 2 addressed soil contamination through excavation, consolidation in an on-site cell, and soil cover. The remedy selected for the DNAPL saturated mass was *in-situ* solidification and stabilization with excavation and consolidation of “swell” material. The remedy selected for deeper groundwater was monitoring to confirm that concentrations met remediation objectives. The remediation of shallow groundwater was deferred until a future ROD Amendment (i.e., Amendment No. 3).

ROD Amendment No. 3[19] was issued in September 2011. The selected remedy in this ROD Amendment for the shallow groundwater is MNA following the remediation of the DNAPL.

Standard Chlorine of Delaware Inc. Superfund Site, New Castle County, Delaware

ROD Amendment based on determination that remedy was not effective.

The site is approximately 65-acres in size and was the location of chlorobenzene manufacturing operations from 1966 through 2002.

USEPA issued a ROD in 1995 that called for the remediation of certain soils within the site’s Operable Unit 2 (OU2) via bioremediation with a contingent remedy of low temperature thermal desorption. Subsequent testing data demonstrated that bioremediation would not be effective and that the contingent remedy of low temperature thermal desorption was appropriate. USEPA estimated that the costs for such treatment would be approximately $56.5M on-site and $125.4M off-site.

In 2016, USEPA issued a ROD Amendment and determined that a more cost-effective and expeditious way to address the OU2 contaminated soils was to permanently place them under a cap being constructed at a different operable unit of the site (OU3). The estimated costs for this approach were only $300k, resulting in significant cost-savings. USEPA further noted that because the contamination in the OU2 soils was similar to the contamination of OU3 soils, consolidating these soils under the OU3 cap did not significantly alter the OU3 remedial action with respect to scope, performance, or cost.

[17] Available at: https://semspub.epa.gov/work/06/917501.pdf.

[18] Available at: https://semspub.epa.gov/work/06/900110.pdf.

[19] Available at: https://semspub.epa.gov/work/06/650346.pdf.

Anaconda Smelter, Clark Fork River Basin NPL Sites, Deer Lodge County, Montana

ROD Amendment to expand work in upland areas and waive State water quality standards.

The site is one of four contiguous NPL sites in the upper Clark Fork River Basin. From 1884-1989, milling and smelting activities were conducted at the site.

A ROD was issued in 1998 (and subsequently amended in 2011). The original remedy to address surface water contamination included: 1) the remediation of contaminated soils and engineered stormwater management options to control overland runoff into surface water; and 2) selective source removal and stream bank stabilization to minimize the transport of contaminants from fluvially deposited tailings into surface waters.

This site covers nearly 200 square miles, and as of 2020, remedial actions had been implemented on over 20,000 acres. However, surface water quality data showed that Montana standards for metals may not be achievable in certain areas. In a 2020 ROD Amendment,[20] USEPA altered the remedy by: 1) expanding the remedy to complete technically practicable work in the uplands of certain areas (i.e., selecting upland areas where remediation remained a practicable solution); 2) following completion of the remedial actions referenced in (1), undertaking a surface water monitoring period over number of years; and 3) waiving Montana water quality standards if those standards could still not be met after the technically practicable work was completed.

Silver Bow Creek / Butte Area, Clark Fork River Basin NPL Sites, Butte and Walkerville, Montana

ROD Amendment to waive State water quality standards.

The site is another one of the four contiguous NPL sites in the upper Clark Fork River Basin. The site is contaminated from historic underground, mining, milling, smelting and mineral processing operations.

A ROD was issued in 2006, but as was the case with the Anaconda Smelter Superfund Site, additional data and information collected since that time demonstrated that even with remediation efforts, it was unclear whether surface water quality data would ever come into compliance with Montana State standards. USEPA issued a ROD Amendment in 2020[21] to waive these standards and replace them with Federal water quality criteria.

Hunts Disposal Landfill Superfund Site, Caledonia (Racine County), Wisconsin

ROD Amendment due to demonstrated viability of MNA and need to modify groundwater cleanup levels.

The site is a former 35-acre landfill and was also the location of historic sand and gravel mining operations up until 1959. From 1959 through at least 1976, the site was used as a dump.

In 1990, a ROD was issued requiring numerous remedial actions, including a pump-and-treat approach to groundwater contamination. A groundwater extraction system was operated from August 1997 through September 2008. Based on testing data acquired over that time period, USEPA approved a pilot test to shut down the pump-and-treat system and subsequently approved a shutdown report.

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[20] Available at: https://semspub.epa.gov/work/08/100007981.pdf.

[21] Available at: https://semspub.epa.gov/work/08/100007291.pdf.

In 2020, USEPA issued a ROD Amendment[22] in which it determined that MNA could replace the pump-and-treat groundwater remedy and allow for the permanent shutdown of the groundwater extraction and treatment system. USEPA also modified the selected groundwater cleanup levels accordingly. Based on projected costs, the MNA approach was expected to reduce costs by about $1M.

Savage Municipal Water Supply Well Superfund Site, Milford (Hillsborough County), New Hampshire

ROD Amendment due to technical impracticability concerns.

A ROD was issued in 1991 selecting a groundwater remedy that included extraction and treatment of contaminated groundwater, natural attenuation, monitoring, and institutional controls. Data gathered since the issuance of the 1991 ROD demonstrated that it was technically impracticable to achieve cleanup goals for certain contaminants in an area that encompassed the most highly contaminated groundwater in certain overburden and bedrock aquifers.

In order to address these practicability concerns, USEPA issued a ROD Amendment[23] in 2016 that waived Federal and State groundwater standards applicable to this area and called for *in-situ* treatment to be applied in adjacent areas to try and prevent additional migration of contaminants. Institutional controls were also put in place with respect to the relevant area.

USDOE Hanford Environmental Restoration Disposal Facility, Benton County, Washington

ROD Amendment to account for changes in risk analysis.

The site is an historical U.S. nuclear site that was added to the NPL in July 1989 as four different sites (and each site was further divided into operable units).

A ROD issued in 1995 required various remedial actions and included a prohibition of the placement of any hazardous waste materials in a land disposal unit prior to completing required Resource Conservation and Recovery Act (RCRA) Land Disposal Restriction (LDR) treatment. However, subsequent data and analysis demonstrated that treatment prior to placement in land disposal units would result in greater risks to human health and the environment.

In 2015, USEPA issued a ROD amendment[24] to waive the LDR requirements and allow for certain waste items to be placed in land disposal units prior to completing LDR treatment. USEPA still required LDR treatment to be effectuated within a reasonable timeframe after placement in the land disposal units. This approach was also considered more cost effective than in-place treatment.

Sandy Beach Road Groundwater Plume Superfund Site, Pelican Bay, Texas

ROD Amendment based on recommendations from remedy optimization review.

The site is located on the western side of Eagle Mountain Lake and concerns releases of volatile organic compounds (VOCs) from a former dump site.

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22 Available at: https://semspub.epa.gov/work/05/557462.pdf.

23 Available at: https://semspub.epa.gov/work/01/592493.pdf.

24 Available at: https://semspub.epa.gov/work/10/100003686.pdf.

A ROD was issued in 2011. The site was not separated into different operable units, but the ROD consisted of three distinct remedy components: a groundwater remedy, a drinking water remedy, and a soil remedy. A ROD Amendment[25] was issued in 2018 concerning the groundwater remedy.

According to the ROD Amendment, there were concerns in 2013 about the implementation and effectiveness of the selected remedy, which consisted of a groundwater pump and treat system. The project was referred for an independent remedy optimization review. The optimization review team made several recommendations, including plugging and abandoning specific wells, prioritization of soil vapor extraction in the source area, additional characterization of the source area, additional pilot testing of in-situ bioremediation, and specific optimizations of the pump and treat system.

Under the ROD Amendment, USEPA modified the groundwater remedy by replacing groundwater extraction and treatment within situ bioremediation. USEPA noted that: (1) implementation of the pump and treat system was impractical; (2) utilizing in situ bioremediation would remain protective of human health and the environment; and (3) the in situ bioremediation option would result in considerable cost savings as the original remedy had estimated capital costs of $4.4M with operation and maintenance costs of $14.9M, while the modified remedy had estimated capital costs of $3.9M with operation and maintenance costs of $1.2M.

Marion Pressure Testing Company Superfund Site, Marion (Union Parish) Louisiana

ROD Amendment due to concerns about cost-effectiveness.

The site is a 22-acre former wood-treating facility that operated from 1964 to 1985. The primary contaminants were creosote and polycyclic aromatic hydrocarbons (“PAHs”) in soil and dense non-aqueous phase liquid (“DNAPL”) in groundwater.

A ROD issued on June 1, 2002, selected excavation and treatment using on-site low temperature thermal desorption (“LTTD”), off-site disposal of debris, a DNAPL recovery system, groundwater monitoring, and institutional controls as the remedy.

However, the remedy was not implemented due to concerns about cost-effectiveness, and additional investigations and remedial alternatives evaluations were performed.

A ROD Amendment[26] issued in September 2016 selected capping of the residual DNAPL area, deep soil mixing with solidification/stabilization in the DNAPL area, consolidation and capping of impacted soil, and limited action with long-term monitoring for an area of shallow groundwater contamination.

[25] Available at: https://semspub.epa.gov/work/06/100007654.pdf.

[26] Available at: https://semspub.epa.gov/work/06/100001150.pdf.

Appendix B

Summary of Significant New Site-Specific Information

Appendix B
Summary of Significant New Site-Specific Information

1. Introduction

GHD Services Inc. (GHD), on behalf of International Paper Company and McGinnes Industrial Maintenance Corporation (collectively Respondents), has prepared this summary of significant, new site-specific information for the Northern Impoundment of the San Jacinto River Waste Pits Superfund Site, located in Harris County, Texas (Site). This site-specific information is from investigations conducted and technical analyses performed subsequent to the issuance of the Record of Decision (ROD) on October 11, 2017 (USEPA, 2017) or relates to developments that have come to light during the remedial design (RD) process, including with respect to access necessary to perform the remedial action (RA) selected in the ROD.

2. Summary of Information Known Before and After Issuance of the ROD

This section summarizes and highlights the information known to United States Environmental Protection Agency (USEPA) at the time the ROD was issued, as compared to what is known currently, and describes how much more site-specific data is available now as compared to when the ROD was signed. The ROD relied on an extremely limited set of data that is now approximately ten years old. Since the ROD was issued, a significant amount of new data has been collected. A timeline of characterization assessments conducted at the Northern Impoundment is presented below:

As indicated above, three substantial site characterization assessments were conducted (in 2018, 2019, and 2021) after the ROD was issued and in connection with the RD of the Northern Impoundment remedy. These assessments resulted in:

– Collection and analyses of 618 additional core samples from across the Northern Impoundment analyzed for Toxicity Equivalence (TEQ) of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD). These samples represent approximately 10 times more analytical data than was available when the ROD was issued.
– Gathering of data from 41 additional geotechnical borings to evaluate soil types and strength. This provided, post-ROD, over three times as much data as was available at the time the ROD was issued to characterize the physical properties and geological and geotechnical conditions beneath the Northern Impoundment.

These sampling events provided significant, additional site-specific data that was not available to the USEPA or the Respondents when the ROD was issued regarding the vertical extent of the constituents in the subsurface and geotechnical conditions at the Northern Impoundment. Section 3 describes the nature and quantity of site-specific data available when the ROD was issued as compared to what is currently known, and also describes the impact of the additional site-specific data on the RD of the remedy selected in the ROD.

Section 4 includes a discussion of developments related to conditions in and around the Northern Impoundment and related access issues that have come to light during the RD. Those developments include plans being pursued by the Texas Department of Transportation (TxDOT) to replace the Interstate 10 (I-10) bridge adjacent to the Northern Impoundment during the time the RA would be implemented. TxDOT's current plans may preclude or significantly limit use for purposes of the RA of the TxDOT right-of-way (ROW) that provides the only land access to the Northern Impoundment. In addition, recently disclosed preliminary TxDOT plans to place structures related to the new bridge on the ROW may require a redesign of the southern span of the best management practice (BMP) enclosure (a sheet pile barrier).

3. Significant, Site-Specific Post-ROD Information

Since the issuance of the ROD, Respondents have conducted three robust field investigations to better characterize the volume and depth of impacted material and geotechnical conditions at the Northern Impoundment. The First Phase Pre-Design Investigation was conducted in 2018 and the Second Phase Pre-Design Investigation was conducted in 2019. Site-specific data from these investigations, along with extensive treatability testing can be found in the *Preliminary 30% Remedial Design for the Northern Impoundment* (Northern Impoundment 30% RD), which was submitted to the USEPA on May 28, 2020 (GHD, 2020). Based upon limitations and data gaps identified in the Northern Impoundment 30% RD, Respondents conducted a Supplemental Design Investigation (SDI) in 2021, in accordance with the USEPA-approved *Supplemental Design Investigation Sampling Plan - Revision 1*, submitted in May 2021 (GHD 2021a). This investigation concluded in September 2021.

The following are conclusions based on the new analytical and geotechnical data from the Pre-Design Investigations (PDI) and SDI:

– The volume of material increased by approximately 50 percent above what was considered in the ROD.
– At certain locations, the depth of impacted material increased from what was stated in the ROD from a maximum of -22.70 feet NAVD88 to a maximum of -28.40 feet NAVD88, an increase of almost six feet. This represents an increase in maximum excavation depth of approximately 25 percent.
– Along the southern side of the Northern Impoundment, the depth of impacted material increased from a maximum of -5 feet NAVD88, as stated in the ROD, to a maximum of -20 feet NAVD88. This represents a four-fold increase in target excavation elevation and is noteworthy due to its implications for the design of the southern extent of the BMP and how that is affected by TxDOT's plans (further detailed in Section 4.2).

- The average elevation of impacted material changed from -8 feet NAVD88, as stated in the ROD, to -12.8 feet NAVD88 across the Northern Impoundment, an increase in average depth of the material to be excavated of approximately 62 percent.
- The maximum depth of excavations could further increase based on the post-confirmation soil sampling program currently specified in the ROD to meet the cleanup level.
- Technical constraints, not originally considered in the ROD, have recently been identified associated with the geological stratigraphy, soil geotechnical properties, and the depths of excavation required by the ROD, and the resulting potential for hydraulic heave. These newly identified constraints include the potential for hydraulic heave in the northwest corner of the Northern Impoundment, the area in which deeper depths of impacted material have recently been identified (approximately -28 feet NAVD88). Other locations outside the northwest corner include sensitivity to hydraulic heave (if excavation to deeper levels is required based on post-confirmation sampling). If hydraulic heave were to occur during excavation, it would result in uncontrolled releases of water and flowing sands from the excavation. The potential for hydraulic heave while excavating to such depths therefore significantly impacts the ability to safely implement the RA as presented in the ROD.
- The increased depths to which material must be removed, combined with the unfavorable geotechnical conditions (including the hydraulic heave potential) in the northwest corner of the Northern Impoundment, reduce the factor of safety for implementation using the excavation methods required by the ROD to an unacceptable level, while significantly also impacting the following:
    - The BMP design
    - The waste material removal methodology
    - The water treatment approach, capacity, effectiveness, and cost originally presented in the ROD to contain and capture additional suspended sediments and water volume associated with horizontally larger and deeper excavations based on the new site-specific data.

Each of the above is explained in more detail below.

3.1 Significant Difference in Scope: Post ROD Sediment/Soil Volume and Depth

The assumed volume of impacted material within the Northern Impoundment to be addressed in the ROD was 162,000 in-place cubic yards (CY). The new, site-specific information indicates a significant, unanticipated increase in sediment/soil volume relative to that known and considered during development of the ROD. Implementation of the remedy in the ROD would require the removal of approximately 243,000 in-place CY of waste material, a difference of 84,000 in-place CY (a 50 percent increase) over the volume presented in the ROD.

Site-specific information obtained from the PDI and SDI, which involved advancement within the Northern Impoundment of an additional 71 soil borings (10 times the original data points), indicate an average elevation of material for potential management of approximately -12.8 feet NAVD88. Comparison of this new site-specific information to the original average depth of material addressed in the ROD of -8 feet NAVD88 results in a 62 percent increase in the average vertical depth. In addition, as described in Section 3.1.2, current knowledge of the deepest impacted material depth compared to what was known during development of the ROD indicates a 25 percent increase in thickness at certain locations (from -22 feet NAVD88 to -28 feet NAVD88).

3.1.1 Expanded Vertical and Horizontal Extent of Impacts Affecting the Engineered Barrier BMP

This new information has required the redesign of the engineered barrier BMP required by the ROD to address material 62 percent deeper on average than originally defined. Due to geotechnical conditions in the northwest corner of the Northern Impoundment, the single cantilever BMP design included in the Northern Impoundment 30% RD was deemed to be infeasible and the BMP currently being considered includes a robust double-wall system. In addition, site-specific data from the recent SDI found impacted material farther to the east than was understood at the time the ROD was issued, pushing the extent of the wall outward to the east, outside the boundaries of the Time Critical Removal Action (TCRA) armored cap and potentially encroaching into the main channel of the San Jacinto River. This expanded footprint correlates with increased volumes of water within the BMP that will have to be managed and potentially treated during the RA.

3.1.2 Material Depth for BMP Design

The existing remedy in the ROD does not pre-define excavation elevations. Rather, the remedy simply requires removal of all material exceeding the cleanup level of 30 nanogram per kilogram (ng/kg) TEQ. As previously noted, the maximum elevation of such material, as identified through the post-ROD investigations, is deeper than -28 feet NAVD88. This is 25 percent deeper than the maximum depth on which the ROD was based, and 62 percent deeper on average across the Northern Impoundment than was assumed for purposes of the ROD. This significant change in the maximum and average vertical depth of the excavation directly impacts the design of the BMP. The BMP type originally considered, as described in the Northern Impoundment 30% RD, was a single cantilever wall system. However, the significant target excavation depths would have required pile types and tip depths that were not feasible or implementable. Thus, the project team was forced to shift to a more robust double wall system with a much wider footprint. A requirement of this BMP system is that at the top of the excavation slope, an additional 30 feet bench of undisturbed ground must be maintained to support the wall system. Due to space constraints on the south side of the Northern Impoundment, the double wall system (including a slope out of the excavation, 30-feet bench, and double wall) will not be possible. The excavation along this side will extend to the vertical wall and the excavation along that wall will be deep (as deep as -20 feet NAVD88). To account for this, a more robust “combi” wall is needed. This wall will consist of a combination of five-feet diameter king piles and AZ sheets tied back to a shorter anchor wall spaced approximately 35 feet away. The ROD requirement to complete post-confirmation sampling following excavation introduces the risk that further excavation along the perimeter of the Northern Impoundment could result in a slope that moves out from the designed excavation and starts encroaching on the 30-ft bench required for the BMP system, or on the wall itself along the southern extent, which could undermine the stability of the BMP.

The significant change in the depth of impacted material prompted a detailed evaluation of the potential for hydraulic heave during excavation, detailed in a Hydraulic Heave Analysis report (GHD, 2021c), included as Attachment A and described in Section 3.1.3 below. There are also numerous locations across the Northern Impoundment in which there are several feet of clean overburden above a low-level exceedance of the cleanup level (ranging from 44 ng/kg to 369 ng/kg TEQ) and in several of these instances, excavating to the depth necessary to remove a deeper two-foot layer of material with a low-level exceedance of the cleanup level means excavating to an elevation at risk of hydraulic heave, as further described below. As shared with the USEPA, Texas Commission on Environmental Quality (TCEQ), and United States Army Corps of Engineers (USACE) during the Technical Working Group (TWG) Meeting on November 16, 2021, the Respondents calculated that such buried impacted material represents approximately 0.2 percent of the total mass of dioxins, and in order to completely remove these materials with low-level exceedances, requires excavation of 44,000 CY of material. This represents approximately 18 percent of the total volume of the 243,000 CY of material to be excavated.

3.1.3 Risk of Hydraulic Heave

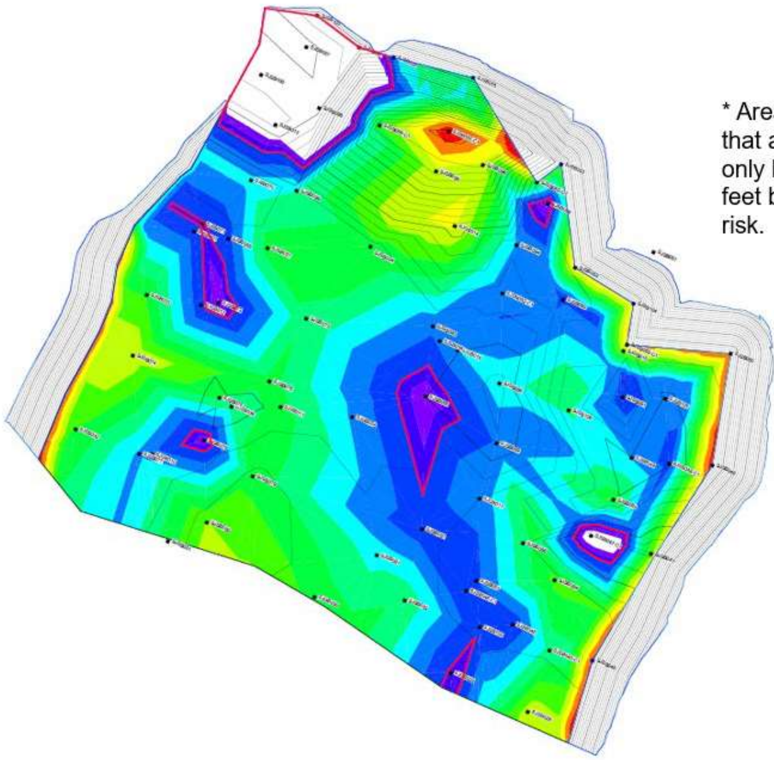
Based on data from the PDI and SDI, the RA presented in the ROD does not address nor incorporate the deeper waste and technical constraints associated with excavation to these depths. The Respondents performed significant geotechnical evaluation work to enhance characterization of the stratigraphy and geological conditions and to assess potential impacts on the RA associated with these recently discovered conditions. Following the SDI, the Respondents evaluated whether there would be a potential for hydraulic heave while excavating to target depths of known impact, specifically in the northwest corner. The Respondents’ concerns around hydraulic heave were discussed with the USEPA, USACE, and TCEQ in detail during the October 19, 2021, November 16, 2021, and December 14, 2021 TWG Meetings, and were documented in the Hydraulic Heave Analysis report submitted to the USEPA on December 9, 2021 (GHD, 2021c) and the Respondents' letter to USEPA dated December 22, 2021 (GHD, 2021d). The Hydraulic Heave Analysis has been included as Attachment A.

The concern associated with hydraulic heave is that removal of the soils and water during excavation in the deeper areas would reduce the downward forces to the extent that the upward hydraulic pressures in the underlying strata would cause a failure of the excavation bottom. During this phenomenon, water and/or "flowing sands" could rapidly fill the excavation, and, if they cannot be suppressed, cause an irreversible and catastrophic failure of the excavation, with serious risk to worker safety and potential for the release of impacted material into the environment.

The evaluation examined the thicknesses of the underlying strata beneath the Northern Impoundment including the alluvium and underlying Beaumont Clay and the interface between the Beaumont Clay and Beaumont Sand. Respondents also evaluated the pore pressures of the Beaumont Sand, as measured by deep piezometers to determine the hydraulic head level. Finally, the evaluation examined the properties of the material, including the unit weight of the clay and overlying alluvium and the presence of sand lenses in some parts of the clay layer. This evaluation was to assess whether the pore pressures within the Beaumont Sand and/or sand layers within the clay would be sufficient to overcome the weight of the overburden considering the planned excavation depths. Based on this evaluation, the Respondents determined that there are several areas across the Northern Impoundment (specifically in the northwest corner) in which there would be significant risk of hydraulic heave if material is removed to the currently known elevations presented in this document. The evaluation indicated a total stress analysis factor of safety (FS) below 1.25 for removal of material to the ROD-required depths in these areas. A total stress analysis FS of 1.25 is considered protective of hydraulic heave and is in accordance with USACE guidance. Based upon the results of this evaluation, it is not safe to excavate the material in the northwest corner to the currently known depths in the manner required by the ROD.

During the December 14, 2021 TWG Meeting, USACE representatives, who had conducted a review of the hydraulic heave evaluation at the USEPA's request, indicated that they would like to see additional analyses and data to support GHD's position on the risk of hydraulic heave, but to date, they have not provided details regarding that data and/or analyses they would need to see. USACE representatives also made reference to potential alternate approaches to manage the risk of hydraulic heave in that area, including dewatering the underlying aquifer, injection of a binding agent into the sand lenses, installation of a cutoff wall, etc, during the December 14, 2021 TWG Meeting. Any assessment of these potential alternatives would likely require data collection and analysis that would take at least six months to a year to complete and would require a significant extension of the deadline for submitting a 90% RD with respect to the northwest corner. At this time and point in the RD process, there is too much uncertainty and not enough data or time to support proceeding with the RD utilizing any of these alternatives.

In addition to the northwest corner, several areas covering large portions of the Northern Impoundment were identified that are at risk of or sensitive to hydraulic heave if excavation were to occur to the deepest elevations of impact currently known. This makes post-confirmation sampling problematic in these areas as digging deeper based upon an exceedance in a post-confirmation sample could trigger hydraulic heave and/or result in undermining the stability of the BMP which will be designed to accommodate specific, pre-defined excavation elevations. In some locations, extending the excavation even an additional one foot would put the location at risk of hydraulic heave. The figure below, which was presented to the USEPA in the November 16, 2021 TWG Meeting shows the areas across the Northern Impoundment that are at risk of hydraulic heave. The figure has been color coded to indicate how many additional feet (if any) could be excavated before hydraulic heave becomes a significant risk (FS < 1.25). Areas shown in white are at risk of hydraulic heave just by excavating to the depth of known impact. Light purple shading indicates areas in which an additional one foot of excavation (as could be required based upon post-confirmation sampling) would put the area at risk of hydraulic heave. Dark purple shading indicates areas in which excavating two additional feet would put the area at risk, and so on. As described in Appendix C, use of a surface weighted average concentration (SWAC) to demonstrate compliance with the cleanup standard might reduce but would not eliminate the risks of hydraulic heave in some of these areas.



* Areas outlined in red indicate areas that are currently at risk (white) or could only be excavated an additional 1 – 2 feet before hydraulic heave becomes a risk.

Additional Feet of Excavation			
Number	Minimum Elevation	Maximum Elevation	Color
1	−23.68	−22.00	
2	−22.00	−20.00	
3	−20.00	−18.00	
4	−18.00	−16.00	
5	−16.00	−14.00	
6	−14.00	−12.00	
7	−12.00	−10.00	
8	−10.00	−8.00	
9	−8.00	−6.00	
10	−6.00	−4.00	
11	−4.00	−2.00	
12	−2.00	−1.00	
13	−1.00	0.00	

3.1.4 End-State Restoration

As previously mentioned, the target excavation elevations along the southern extent of the Northern Impoundment are now understood to be as much as four times deeper than those anticipated at the time that the ROD was issued (maximum elevation increased from -5 feet NAVD88 to -20 feet NAVD88). Furthermore, due to space constraints, the impacted material will have to be excavated right up to the planned BMP wall on that side. Assuming full removal of the BMP upon completion of the RA, this will result in an approximately 29-foot-tall vertical face (-20 feet excavation plus +9-foot built-up ramp over the BMP to get into the excavation) along that southern bank. This face would be located approximately 75 feet from the current I-10 bridge structure, and likely closer to the alignment of the future replacement bridge. At the time the ROD was issued, the excavation elevation along that southern extent was thought to be only -5 feet NAVD88, so site restoration was not considered or specified. Given current conditions and TxDOT's recently stated preference that the southern BMP wall be removed at the completion of the RA (see Section 4.2), significant site restoration efforts will be necessary, should the final RD require removal of the wall in that location, to backfill and armour the slope along that southern bank. A preliminary evaluation indicates that approximately 25,000 CY of fill material will be needed to create a 4:1 slope along that bank to ensure there is no risk to the structural stability of the bank or the TxDOT bridge. That embankment will also need to be armored with riprap or revetment to prevent erosion and scour. Extensive hydrodynamic modelling will be needed to ensure the planned armor will be adequate. None of this was anticipated at the time of the ROD.

3.2 **Significant Differences in Performance**

3.2.1 Changes to the Originally Anticipated Schedule

The currently anticipated schedule for implementation of the RA includes seasonal construction (only performing excavation activities during the period from November - April) to avoid high water periods. Using the new knowledge of the significantly greater volumes of impacted material combined with the limitations of construction occurring only during the period defined above, the RA will take approximately seven years to complete, which is three and a half times longer than the ROD estimate of the time required to implement the selected remedy. The expanded schedule is a result of the increased volume of impacted material described in this document and the need to switch to a seasonal approach to limit excavation activities to low water seasons (as described in Section 3.2.2 below and detailed in the Northern Impoundment 30% RD). This increase in schedule duration is already substantial and may be further extended by current plans by TxDOT to replace the I-10 bridge spanning the San Jacinto River adjacent to the Northern Impoundment, further discussed in Section 4.2.

3.2.2 Significant Differences Regarding High Water Elevations During Excavation

The current BMP developed to implement the existing remedy in the ROD is based on high water levels observed in the San Jacinto River during the low water season (November through April) using hydraulic data dating back to 1994 (to establish a BMP top elevation of approximately +9 feet NAVD88). The RD and the current BMP do not account for the pending improvements to the Lake Houston flood control structure, which discharges upstream of the site into the San Jacinto River. The flood control structure currently has two radial gates with a total capacity of 10,000 cubic feet per second in addition to the spillway. The expansion project would significantly increase the current discharge to the San Jacinto River. Information regarding surface water elevation impacts to the Northern Impoundment from the planned Lake Houston flood control structure need to be evaluated and addressed in the final design of the remedy for the Northern Impoundment. To date, the Respondents have yet to receive the modeled flows associated with the flood control structure improvement project from the Coastal Water Authority and as such, the potential impact is unknown.

Adopting a seasonal construction schedule helps to mitigate the risk of storm events and high-water events overtopping the BMP, but there are no guarantees that there would not be a storm event that would occur during the “low-water season.” This is a risk that may increase due to climate change over the time period required to implement the RA. Plans will need to be in place during the RA to attempt to quickly “button up” an exposed excavation in the event that a serious storm event is predicted. Even with such procedures in place, there is an inherent risk of releases associated with such storm events and no guarantee that a storm would not occur that would cause flooding that could overtop the BMP and result in a release to the San Jacinto River.

4. Other Post-ROD Developments

4.1 BMP Alignment

As noted in Section 3.1.1, the increased depth of impacted material has required a more robust BMP design with an expanded footprint that projects further into the channel of the San Jacinto River than was contemplated with the ROD was adopted. This new alignment of the BMP will require extensive coordination with the United States Coast Guard (USCG) and will increase the risk of barge strikes that could cause BMP failure. In 2019, flooding associated with Tropical Storm Imelda caused 11 barges upstream of the Northern Impoundment to break free. Six of the barges struck the pier columns supporting the I-10 bridge resulting in over $5MM in damages. One of the barges also struck the berm on the northeast side of the Northern Impoundment. To the extent extreme weather events become more common (a concern that was expressed in the ROD), the likelihood of a barge impacting the BMP structure protruding into the river channel over the projected seven-year duration of the project is high.

The current plans for the installation of the BMP will place it outside the perimeter of the Northern Impoundment. In that location, installation and removal of the BMP is not anticipated to result in any releases of dioxin-impacted material, as defined in Remedial Action Objective (RAO) 1 from the ROD, which states that the remedy must “prevent releases of dioxins and furans above cleanup levels from the former waste impoundments to sediments and surface water of the San Jacinto River”. The Respondents’ plan to move the BMP outside the extent of the TCRA cap was prompted by the challenges encountered while deploying turbidity curtains in the northwest corner during the SDI. These challenges and the Respondents' position on the risk of a release during BMP installation and removal were outlined in a letter to the USEPA dated September 28, 2021 (GHD, 2021b). If the USEPA's position is that the "no release scenario" in the ROD is applicable to all activities required to implement the RA, and not just to releases of dioxin-impacted material located beneath the TCRA cap, studies and analyses performed by the Respondents since the ROD was issued show that resuspension of sediments containing background levels of various contaminants may occur during installation and removal of the BMP and that measures such as turbidity curtains may be ineffective to control them.

4.2 TxDOT Bridge Replacement Project

Events that have occurred since the ROD was issued related to TxDOT's plans to replace the I-10 bridge during the period during which the RA would be implemented create another significant risk to the successful design and implementation of the RA. Following the barge strike that damaged the I-10 bridge in 2019 referenced above, TxDOT has proceeded with plans to replace the I-10 bridge over the San Jacinto River, adjacent to the Northern Impoundment.

The Respondents have known about this planned project for some time – it was identified as a risk in the Northern Impoundment 30% RD and the progress of the project has been tracked through routine engagements between the Respondents, the USEPA, and TxDOT. Until the February 23, 2022 call discussed below, those discussions had focused on timing of the TxDOT project and how it may overlap with the planned RA.

During a call on February 23, 2022 between GHD, TxDOT, and its design contractor, LJA Engineering (LJA), LJA disclosed that the current preliminary bridge design includes full use of the TxDOT access road just north of the existing I-10 bridge, which is the only route to access the Northern Impoundment and is also needed for placement of a portion of the southern stretch of the BMP. TxDOT's preliminary plan is to utilize the ROW for bridge supports for the new westbound lanes, which will include installation of foundations and pilings approximately every 120 feet along the entire length of the current site access road, up to the southern berm of the Northern Impoundment. Based on these plans, TxDOT representatives at the meeting indicated that TxDOT likely would not be prepared to provide access to the ROW for purposes of implementing the RA. During the call, TxDOT representatives stated that the bridge replacement work could begin as early as the end of 2024 or the beginning of 2025. Representatives from TxDOT and LJA participated in a TWG Meeting on March 10, 2022 to further discuss the issues identified during the February 23, 2022 call.

As discussed in Section 3.1.2, the design of the BMP along the south side of the Northern Impoundment had already been optimized to the extent possible to account for limited space due to the TxDOT ROW abutting the southern berm of the impoundment. Even with the more robust wall design to allow for excavation right up to the wall, a portion of the required anchor wall along the southern BMP will need to extend onto TxDOT's ROW. TxDOT's current plans are problematic as they are expected to eliminate the ability to place any structures, even temporary structures, on the ROW. Given these constraints from TxDOT, there are two options. The current southern wall alignment could be moved to the north off the TxDOT ROW. This would result in potentially leaving impacted material in place or installing the wall through impacted material, neither of which are consistent with the express requirements of the ROD. Alternately, a different wall type with a thinner profile will need to be designed. Due to the deeper excavation depths along that southern wall (which are over four times deeper than had originally been anticipated in the ROD), a single cantilever wall would need to include very robust pile types extending to significantly deep elevations. This type of wall was originally considered and included in the Northern Impoundment 30% RD package, but due to concerns with the ability to install (or remove) the wall without releases and concerns around the proximity of such deep tip depths (approximately -93 feet NAVD88) to the ExxonMobil pipeline that runs adjacent to the Northern Impoundment in that area, the single cantilever option was discarded. In addition, the Northern Impoundment 30% RD analyzed vibration and noise impacts associated with driving piles to that depth, and those considerations - in particular with respect to the impact of vibrations on bridge structures - would have to be addressed in connection with any alternative design of the wall. Deviating from the current design at this point to design a wall that does not rely on the TxDOT ROW will be problematic in general and it will certainly not be possible to redesign the wall to include in the Northern Impoundment 90% RD which is due in June 2022.

The planned TxDOT bridge alignment will also effectively cut off all access via ground transportation to the Northern Impoundment, which is problematic because over the course of the RA, an estimated 20,000 haul trucks will be required to drive onto the Northern Impoundment to transport the waste material off-site for disposal. The TxDOT project is still at a preliminary phase but given that the work is planned to begin as soon as the end of 2024 or beginning of 2025, it will most certainly overlap with the planned seven-year duration of the Northern Impoundment RA. Not only will access to the Northern Impoundment be impacted, but access to and from the assumed staging and water storage and treatment area located on the property to the west of the Northern Impoundment will be effectively cut off. The Northern Impoundment 90% RD currently includes water conveyance from the Northern Impoundment to a neighboring property to the west of the impoundment for water storage and treatment. That property would also be used for office trailers, parking, truck scales, and materials storage. The only way to access that property from the Northern Impoundment is via the current TxDOT ROW road. Even if TxDOT were to secure an alternate route for trucks to reach the Northern Impoundment, conceivably from south of the bridge, access to the neighboring property that is essential for efficient site operations, would be eliminated.

There will also undoubtedly be a loss of efficiency in RA activities associated with both congestion and simultaneous operations of the two major projects being conducted in tandem, and with the increased traffic and detours that will result from the bridge replacement project. This will be especially pronounced if and when TxDOT agrees to provide access to the Northern Impoundment that is rerouted under the bridge structure that will then be under construction. An anticipated 40 haul trucks each day would be required to traverse a congested construction site to get to and from the Northern Impoundment and to and from the landfill. Traffic on the I-10 bridge itself and on all surrounding roadways will be significantly impacted and slowed throughout the duration of the project. The Northern Impoundment 90% RD assumes a certain daily production rate (approximately 600 CY per day) that is the basis for the size of the seasonal cells and the anticipated number of years to complete the RA. This production rate does not account for a loss of efficiency from either on-site congestion or constant heavy traffic on the roads to and from the landfills. This loss of efficiency may result in additional working seasons to complete the RA. There are also significant health and safety concerns associated with working in close proximity to another large-scale construction project which will have multiple contractors, marine and land-based heavy equipment operations, and construction occurring overhead. The added safety risks associated with the simultaneous operations and with the congested and irregular traffic patterns on the adjacent elevated bridge structure could result in increased rates of property damage and safety incidents.

During the March 10, 2022 TWG Meeting, TxDOT also voiced concerns regarding how the RD would affect the planned I-10 bridge replacement project as well as the existing bridge structure. In addition to TxDOT's objections to having a structure installed on its property, TxDOT representatives also had concerns related to increased river velocities that could be caused by the BMP structure in the river and how those velocities might affect the current bridge and dolphin/fender system protecting the bridge. They also expressed concerns about the location of the BMP in the river and the likelihood that it would be struck by a barge at some point during the RA. They also raised concerns, discussed above, regarding the end-state of the project and how a deep hole in the river right beside the south bank might affect the structural stability of the existing and new bridge structures. They requested that modeling be performed to evaluate increased velocities caused by the BMP and potential scour that could occur along the end-state south bank once the material and BMP are removed.

5. Conclusion

As detailed in the preceding sections, significant site-specific data collected after the issuance of the ROD and developments that have occurred during the RD process have greatly changed the Respondents' knowledge and understanding of site conditions at the Northern Impoundment. This new information calls into question the ability to design and safely implement, in a manner that protects human health and the environment, a RA that meets the requirements of the ROD.

6. References

GHD, 2020. Preliminary 30% Remedial Design - Northern Impoundment, San Jacinto River Waste Pits Superfund Site. Prepared for McGinnes Industrial Maintenance Corporation, International Paper Company, and the U.S. Environmental Protection Agency, Region 6. May 28, 2020.

GHD, 2021a. Supplemental Design Investigation Sampling Plan - Revision 1, San Jacinto River Waste Pits Superfund Site. Prepared for McGinnes Industrial Maintenance Corporation, International Paper Company, and the U.S. Environmental Protection Agency, Region 6. May 21, 2021.

GHD, 2021b. Turbidity Curtain Deployment During the Supplemental Design Investigation. Prepared for McGinnes Industrial Maintenance Corporation, International Paper Company, and the U.S. Environmental Protection Agency, Region 6. September 28, 2021.

GHD, 2021c. Hydraulic Heave Analysis, San Jacinto River Waste Pits Superfund Site. Prepared for McGinnes Industrial Maintenance Corporation, International Paper Company, and the U.S. Environmental Protection Agency, Region 6. December 10, 2021.

GHD, 2021d. Concerns Regarding Hydraulic Heave, San Jacinto River Waste Pits Superfund Site. Prepared for McGinnes Industrial Maintenance Corporation, International Paper Company, and the U.S. Environmental Protection Agency, Region 6. December 22, 2021.

USEPA. 2017. Record of Decision. San Jacinto River Waste Pits. Harris County, Texas. USEPA ID TXN000606611. USEPA Region 6. Dallas TX. October 2017.

Enclosed:

Attachment A   Hydraulic Heave Analysis Report

Attachment A

Hydraulic Heave Analysis Report

5551 Corporate Boulevard, Suite 200
Baton Rouge, Louisiana 70808
United States
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Our Ref.: 11215702-Howard-16

December 9, 2021

Ms. Ashley Howard
Environmental Protection Agency Remedial Project Manager
1201 Elm Street, Suite 500
Dallas, Texas 75270

Hydraulic Heave Analysis

Dear Ms. Howard:

GHD Services Inc. (GHD), on behalf of International Paper Company (IPC) and McGinnes Industrial Maintenance Corporation (MIMC; collectively referred to as the Respondents), hereby submits to the United States Environmental Protection Agency (EPA) a Hydraulic Heave Analysis report. The report provides details on the geological and geotechnical context, methodology, and results of a hydraulic heave analysis performed by GHD on data collected at the Northern Impoundment of the San Jacinto River Waste Pits Superfund Site.

GHD conducted a Supplemental Design Investigation (SDI) at the Northern Impoundment from June 28 through September 16, 2021, in accordance with the *Supplemental Design Investigation Sampling Plan - Revised*, approved by the EPA on June 4, 2021. The SDI included the installation of 25 analytical soil borings and 15 geotechnical soil borings, including 11 cone penetration test (CPT) borings and four piezometers. As preliminary data was received, GHD began evaluating and updating the understanding of the depths of impact (dioxins/furans concentrations above 30 nanograms per kilogram [ng/kg] TEQ) and the geological/geotechnical conditions at the Northern Impoundment. All preliminary (unvalidated) data was received by October 1, 2021. Data from the SDI indicated that exceedances of the clean-up level were present at deeper elevations than previously understood (as deep as -28.4 feet North American Vertical Datum of 1988 [NAVD88]) which raised concerns about the potential for hydraulic heave during excavation activities.

A preliminary evaluation of hydraulic heave was performed and presented at a Technical Working Group (TWG) meeting on October 19, 2021. Following that meeting, a more focused, detailed evaluation was performed. The results of this more detailed evaluation were presented during the November 16, 2021, TWG meeting. During this meeting the EPA indicated that the United States Army Corps of Engineers (USACE) would be performing a detailed review of GHD’s hydraulic heave analysis and requested that the data and calculations used in the analysis be provided to them. GHD provided the requested raw data and analyses that had been completed at that time to the EPA and USACE on November 19, 2021. Following the Thanksgiving holiday on November 30, 2021, GHD participated in a call with the EPA, USACE, and the Texas Commission on Environmental Quality (TCEQ) to discuss the data provided and answer questions. Several additional documents were requested during that meeting. GHD provided those documents to the EPA and USACE on December 7, 2021.

The enclosed report includes a wholistic summary of the hydraulic heave evaluation performed, including data reviewed, methodology utilized, and the results and conclusions of the evaluation. This report is intended to provide context, clarity, and interpretation of the data that has already been provided to the EPA and USACE.

It is the Respondents’ understanding that the EPA prefers to withhold approval of the Respondents’ October 1, 2021, Request for Extension of the *Pre-Final 90% Remedial Design - Northern Impoundment* (Northern Impoundment 90% RD) until the USACE has completed its evaluation of the hydraulic heave analysis. While the enclosed report should help facilitate the timely completion of that review, the currently pending January 2022 deadline for the Northern Impoundment 90% RD is weeks away and the Respondents need to have written approval of an extension of that deadline issued without further delay. As detailed in the October 1, 2021, Request for Extension, the extension was necessitated by the need to collect, analyze, and incorporate the SDI data in the Northern Impoundment 90% RD, a process that was recognized months ago could not be completed by the current January 2022 deadline. The hydraulic heave issue is independent of the issues necessitating the extension and a review of the hydraulic heave analysis is not necessary, in order for the EPA to approve the extension. The Respondents request that the EPA proceed to approve the extension request without further delay.

Should you have any questions or require additional information regarding this submittal, please contact GHD at (225) 292-9007.

Regards,

GHD

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KJ/jlf/16

Encl.: Hydraulic Heave Analysis

cc: Lauren Poulos, EPA
Katie Delbecq, TCEQ
Phil Slowiak, IPC
Brent Sasser, IPC
Judy Armour, MIMC

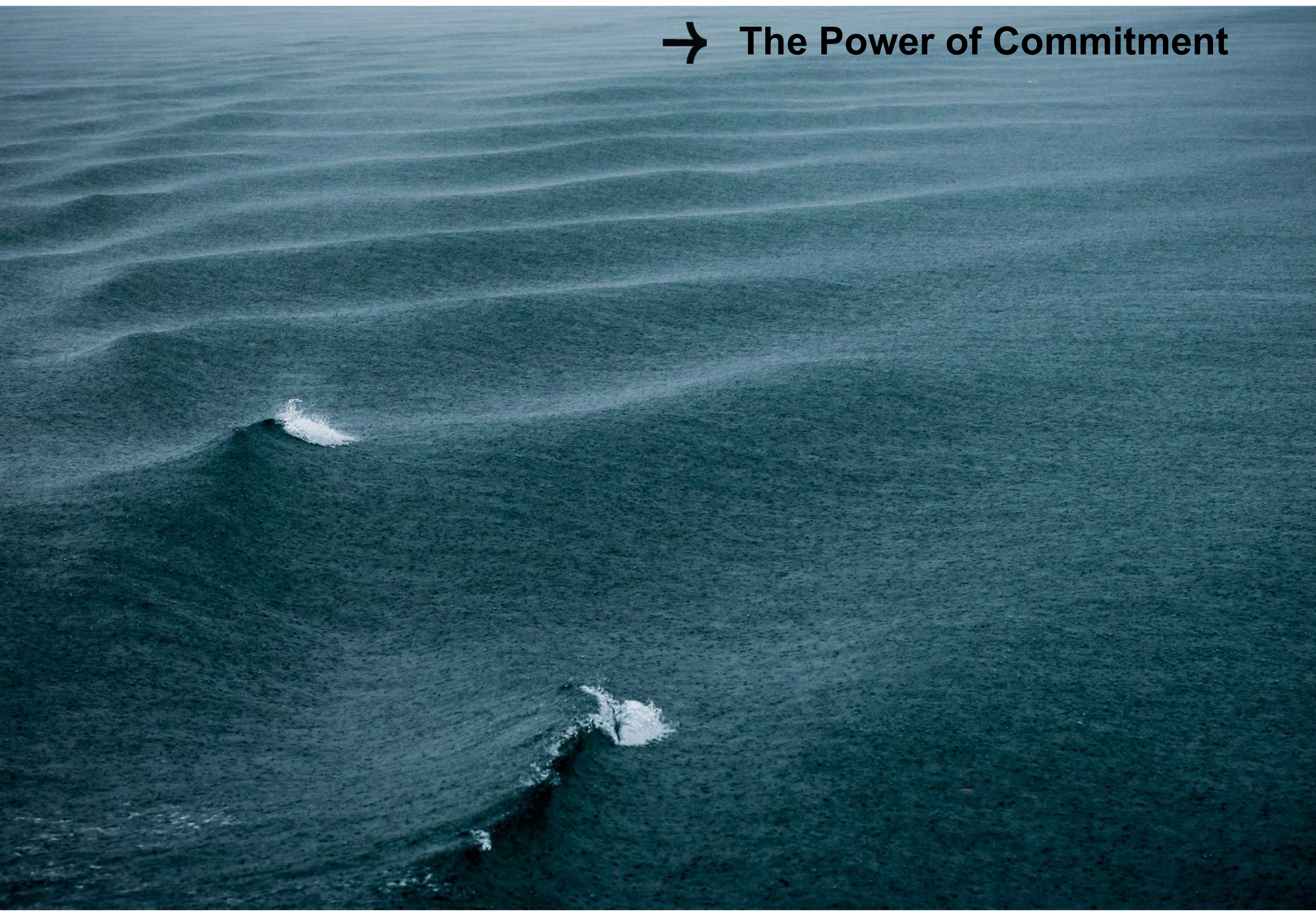
GHD

Hydraulic Heave Analysis

Northern Impoundment
San Jacinto River Waste Pits Superfund Site
Harris County, Texas

International Paper Company and McGinnes Industrial Maintenance Corporation

December 9, 2021



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Appendices

1. Introduction

GHD Services Inc. (GHD), on behalf of the International Paper Company and McGinnes Industrial Maintenance Corporation (collectively referred to as the Respondents), submits to the United States Environmental Protection Agency (EPA) this *Hydraulic Heave Analysis* performed for the Northern Impoundment of the San Jacinto River Waste Pits Superfund Site in Harris County, Texas.

Following completion and receipt of data from the Supplemental Design Investigation (SDI) in September and October 2021, GHD performed a hydraulic heave analysis to evaluate the geological and geotechnical conditions of the Northern Impoundment with respect to the Northern Impoundment 90% Remedial Design (RD). The Northern Impoundment 90% RD is being developed based on the 2017 EPA Record of Decision (ROD) which specifies that the selected remedy for the Northern Impoundment is the full removal of all waste material in the dry that exceeds the clean-up level of 30 nanograms per kilogram (ng/kg) for dioxins/furans. Data from the SDI found impacts above the clean-up level at deeper elevations than had been previously understood, prompting concern around the risk of hydraulic heave associated with the resulting excavation work. The geological and geotechnical context, methodology, and results of this analysis are described hereafter in this report.

2. Brief Geological Conditions Description

The San Jacinto River Waste Pits Site is located in Harris County, Texas, east of the City of Houston. The Northern Impoundment is located immediately north of the Interstate Highway 10 (I-10) bridge over the San Jacinto River.

The geology in the vicinity of the Northern Impoundment is somewhat variable given the natural meander of the San Jacinto River over time. Based on the Geologic Atlas of Texas, Houston (1982), the near surface of the western bank of the San Jacinto River is comprised predominantly by Holocene Alluvium, which is comprised of clay, silt, and sand, and can include organic matter. These alluvium deposits can be comprised of point-bar, natural levee, stream channel, back-swamp, and coastal marsh deposits. The near surface of the eastern bank of the San Jacinto River is comprised predominantly of the Pleistocene Beaumont Formation, which is made up of mostly clay, silt, and sand.

Historical topographic maps of the area from the United States Geological Survey (USGS) indicate that the near surface in the vicinity of the Northern Impoundment may have been comprised of backswamp and/or swamp deposits. It is unclear the extent to which these were scoured out and/or eroded over time, as well as how much was physically removed due to industrialization.

3. Geotechnical Conditions

3.1 Geotechnical Soundings

In order to define the geotechnical conditions of the Northern Impoundment, four geotechnical investigation events were carried out and are listed below:

- Remediation investigation (RI) in 2011.
- First Phase Pre-Design Investigation (PDI-1) in 2018.
- Second Phase Pre-Design Investigation (PDI-2) in 2019.
- SDI in 2021.

During these four investigations, a total of 43 geotechnical boreholes were drilled. During the recent SDI, four piezometers were installed and cone penetrations tests (CPT) were also performed at 13 locations in the Northern Impoundment. Figure 1 shows the locations of the geotechnical soundings.

Table 3.1 below presents the list of the deepest geotechnical soundings in which the Beaumont sand formation was reached. These soundings were used for the hydraulic heave assessment.

Table 3.1 Geotechnical Soundings Considered in the Hydraulic Heave Analysis

Geotechnical Investigation	Sounding ID	Termination Depth (feet below ground surface [ft bgs])	Coordinates (NAD83)		Ground Surface Elevation (ft NAVD88)
			Easting	Northing	
RI (2011)	SJGB-001	60	3216751.135	13857514.92	3.50
	SJGB-002	59.5	3216860.608	13857743.81	0.75
	SJGB-003	119.5	3217161.011	13857865.43	-10.67
	SJGB-004	59.5	3217397.812	13857774.85	-3.25
	SJGB-005	61.5	3217542.386	13857614.08	-4.50
	SJGB-007	119.5	3217417.804	13857330.12	-3.25
	SJGB-008	59.5	3217332.707	13857191.39	-3.0
PDI-1 (2018)	SJGB-018	52	3216809.986	13857802.24	-13.43
	SJGB-019	59	3216887.243	13857986.27	-14.82
	SJGB-020	62	3217105.993	13858004.5	-8.17
	SJGB-021	56	3217609.928	13857456.24	-5.15
	SJGB-022	47	3217485.032	13857183.95	-9.39
	SJGB-023	60	3216651.132	13857586.97	-1.86
PDI-2 (2019)	SJGB-047	100	3217421.371	13857278.32	-3.40
	SJGB-053	100	3217301.198	13857799.52	-9.70
	SJGB-057	100	3216960.196	13857956.45	-17.1
SDI (2021)	SJMW-16	70	3216869.538	13857581.37	5.0
	SJMW-17	72	3217204.371	13857083.84	5.0
	SJCPT-11	76	3216891.118	13857566.47	3.0

3.2 Subsurface Conditions

According to information provided by the various geotechnical investigations, the general subsurface stratigraphy noted within the Northern Impoundment is as follows:

– ***Surficial Alluvium Sediments:*** fairly heterogenous, consisting of silty sands, sands silts, lean clays, and sandy clays. When cohesive, the sediments are typically very soft to firm. When granular (cohesionless), these sediments are loose-to-compact.

– ***Beaumont Clay Formation:*** generally encountered at elevations ranging between -20 to -30 feet (ft) North American Vertical Datum of 1988 (NAVD88), this formation is composed of a stiff-to-very-stiff high plasticity clay (fat clay). Interspersed within this deposit are seams/lenses of sandy materials, as evidenced in the boring logs and photographs from three different borings, all in the vicinity of the northwest corner of the Northern Impoundment. The lateral extents of these particular features remain unknown.

– ***Beaumont Sand Formation:*** encountered at elevations ranging between -50 to -70 ft NAVD88, this formation is essentially composed of compact-to-dense silty sand to clayey sand.

Subsurface geological conditions are shown in two cross-sections included as Figures 2 and 3. The interpolated thickness of the Beaumont clay is shown on the attached Figure 4.

3.3 Hydraulic Conditions

During the SDI, piezometers were installed in boreholes SJMW-16 and SJMW-17 and the water levels were logged in these piezometers at regular time intervals. Figure 3.1 below shows the variation of the piezometric level (red line) in the piezometer (SJMW-16) installed in the Beaumont sand for the period between August 13 and September 13, 2021. The water level in the San Jacinto River (blue line) is also shown in this figure for the same period.

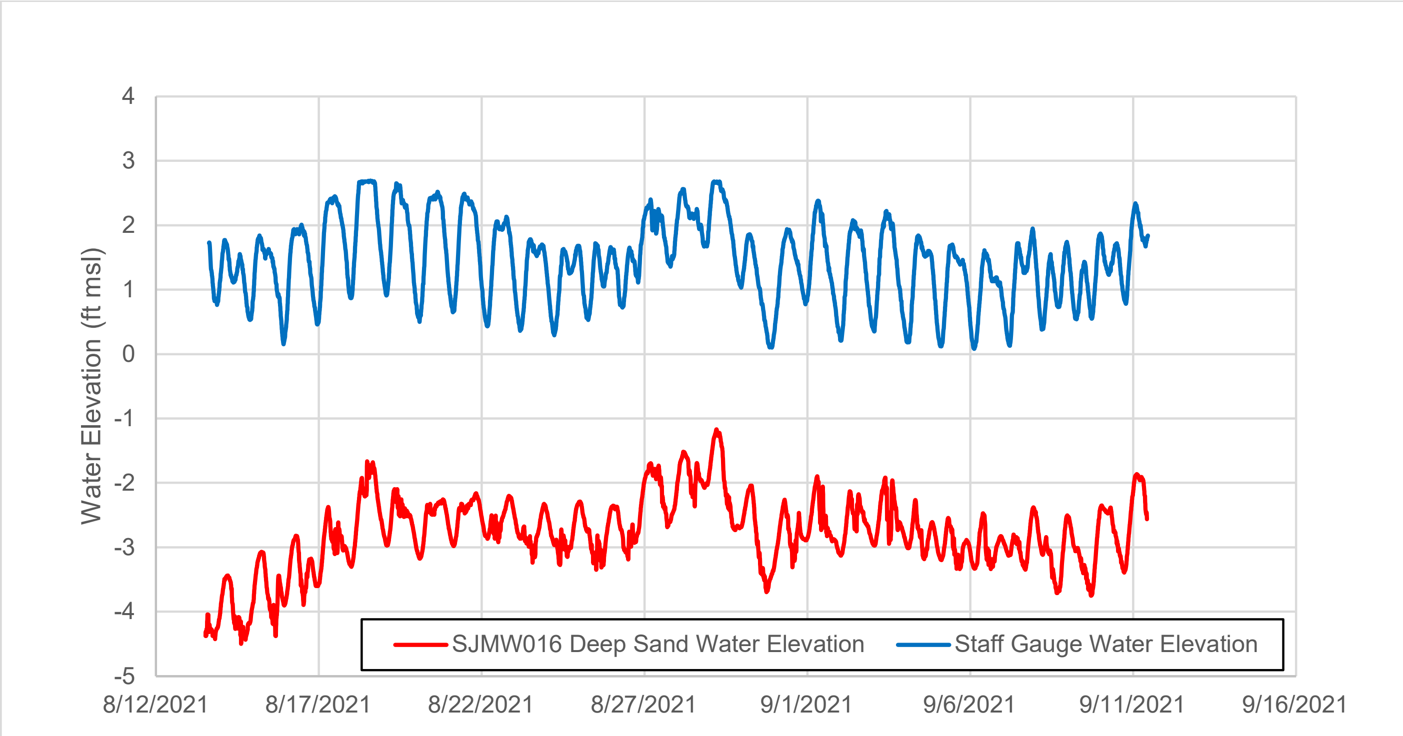


Figure 3.1 ***Variation of the Water Levels in the Beaumont Sand Formation and the San Jacinto River***

Water level readings shown on Figure 3.1 suggest that:

– The water level in the river fluctuates with the tides between 0 to 3 ft (with an average elevation of 1.5 ft).

– The piezometric level in the Beaumont sand fluctuates between -4 to -1 ft (with an average value of about -2.5 ft) and seems to be tidally connected.

The piezometer was removed from SJMW-16 on September 13, 2021, at the direction of the EPA in advance of an approaching hurricane.

4. Required Excavation Depths

The compiled analytical results show the presence of exceedances of the clean-up level at various depths in the surficial alluvium in the Northern Impoundment. Based on these results, the deepest exceedances have been detected at elevations close to -28.4 ft NAVD88 within the northwest corner of the Northern Impoundment.

A complete removal of the impacted material, as specified in the ROD would thus require excavation down to elevations of -28.4 ft NAVD88, and potentially to lower elevations depending on the results of post-confirmation testing to be done during excavation.

An assessment of the hydraulic heave risk assuming a complete removal of the impacted alluvions has been performed. The calculated factor of safety (FS) values at the location of each analytical borehole are presented in the attached Tables 1A and 1B. These tables present results that are based on Assumptions 1 and 2, respectively. Details on these assumptions are presented in Section 5.2.1.2.

5. Hydraulic Heave Assessment

5.1 Principle of Hydraulic Heave

5.1.1 Hydraulic Heave Mechanism

When an excavation is dug into a clay deposit underlain by a pervious stratum under artesian pressure, pressure and seepage may result, leading to instability of the excavation.

The above-mentioned conditions are illustrated for the Northern Impoundment case on Figure 5.1. The hydrostatic head in the deep Beaumont sand below the impervious Beaumont clay layer is higher than the bottom of the excavation. If the effective stress at point A approaches zero, the situation becomes unstable. Therefore, if the pore pressure at point A exceeds the total vertical stress at this point., heave may occur in the bottom of the excavation.

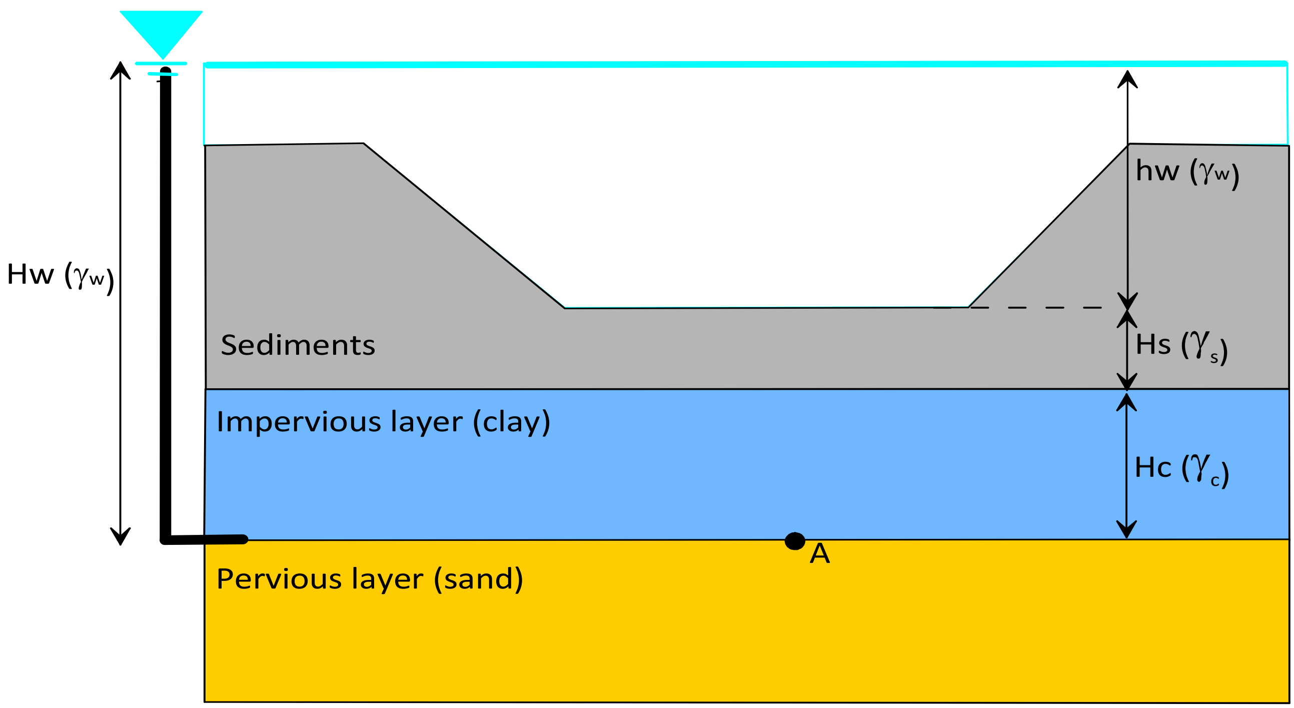


Figure 5.1 Artesian Groundwater Conditions Below Excavation

There are two accepted methods to evaluate uplift pressures which could result in a heave situation: the total stress approach and the effective stress approach. GHD initially limited this evaluation to the total stress approach as it is more appropriate evaluation for this application. At the request of the United States Army Corps of Engineers (USACE), GHD also performed the analysis using the effective stress approach to serve as a validation step. The results of both evaluations are included in Tables 1A, 1B, 2A, and 2B.

5.1.2 Total Stress Approach

For the total stress approach, the heave assessment is solely based on the ratio of total stresses and uplift pore pressures.

For this approach, the FS protective of hydraulic heave is expressed using the following equation:

$$FS_{Total} = (Hs.\ \gamma_s + Hc.\ \gamma_c)/\ Hw.\ \gamma_w \qquad [1]$$

In this equation, Hs and Hc are the thicknesses of the sediments and the clay layers, respectively and Hw is the water head in the pervious layer. γ_s and γ_c are the total unit weights of the sediments and the clay respectively. γ_w corresponds to the water unit weight.

In order to prevent hydraulic heave with a sufficient security margin, pore pressure at point A should not exceed 80 percent of the total vertical stress at this point, corresponding to a factor of safety (FS_{Total}) of 1.25.

5.1.3 Effective Stress Approach

When the difference in water heads between the bottom of the excavation and the surrounding soils outside the excavation reaches a critical value, hydraulic heave (potentially piping) may occur. In relation with Figure 5.1, the effective stress factor of safety ($FS_{Effective}$) is expressed by the following equation:

$$FS_{Effective} = (Hs.\ \gamma'_s + Hc.\ \gamma'_c) / (h_w.\ \gamma_w) \qquad [2]$$

In this equation, hw is the water head between the free water surface (river) and the bottom of the excavation while γ'_s and γ'_c are the buoyant unit weights of the sediments and the clay, respectively. For the effective stress approach, a FS of 1.5 was targeted.

5.2 Assessment Methodology

To assess the risk of hydraulic heave, the FS to protect against hydraulic heave was determined at the location of 77 boreholes (both geotechnical and analytical).

The evaluation of hydraulic heave FS requires the knowledge of (1) the thickness and unit weight of each stratigraphic units and (2) uplift pore pressures (water head) in the underlaying pervious sandy formation (Beaumont sand).

The methodology and the assumptions used for the determination of the required parameters are described in the following sections.

5.2.1 Stratigraphic Unit Thicknesses

5.2.1.1 Surficial Sediments Layer

The sediment layer thickness was defined and is known for all boreholes considered for the hydraulic heave FS assessment.

5.2.1.2 Beaumont Clay

The Beaumont clay thickness was only determined in the geotechnical boreholes listed in Table 3.1. At the location of the analytical boreholes, two assumptions were considered to define the interface elevation between the Beaumont Clay and the Beaumont Sand as shown on Figure 5.2:

– ***Assumption 1:*** Hs(A) + Hc(A) equals the thickness of the Beaumont clay measured in the closest geotechnical borehole.
– ***Assumption 2:*** The Clay/Sand interface (at the base of Hc(A)) was defined assuming that the elevation of the Beaumont sand for the considered analytical borehole is equal to the one measured in the closest geotechnical borehole.

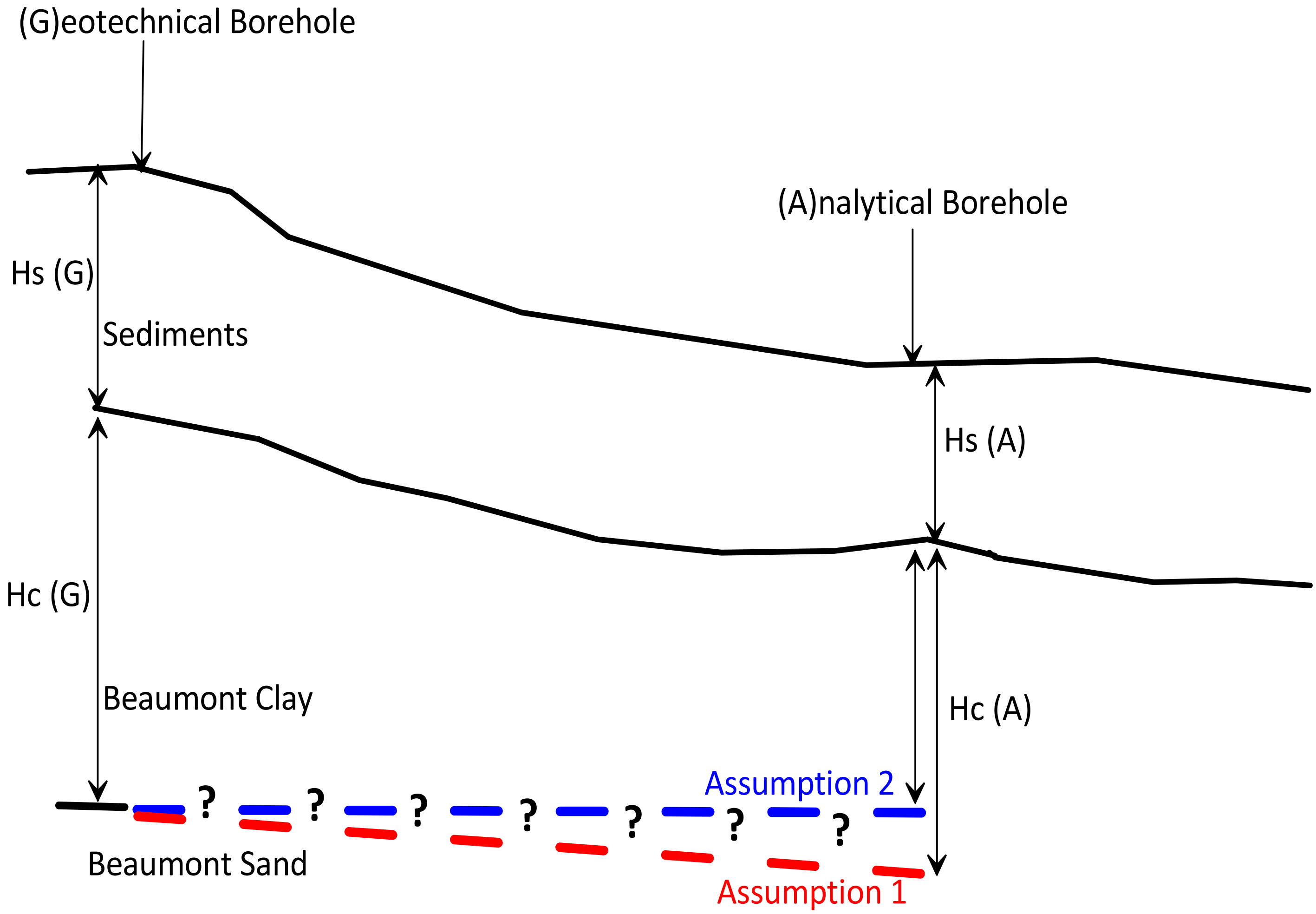


Figure 5.2 Assumptions 1 and 2 Considered to Estimate the Beaumont Clay Thickness

The data was evaluated using both assumptions and the results of each are included in Tables 1A, 1B, 2A, and 2B (the "A" tables correspond to Assumption 1 and the "B" tables correspond to Assumption 2).

As previously mentioned in Section 3.2, sand seams/lenses ranging from a few inches to few feet thick were encountered in the Beaumont clay layer at depths ranging between 35 to 60 feet below ground surface (ft bgs) corresponding to an elevation close to -50 to -70 ft. These lenses were found in boreholes SJGB-018, SJGB-019, SJGB-020, and SJGB-057 all drilled in the northwest corner of the Northern Impoundment. Photographs of these features are presented in Appendix A.

To calculate a FS at each analytical boring location, stratigraphic data from the closest geotechnical boring(s) was assumed for each analytical boring. In some instances, as shown in Tables 1A and 1B, the conditions at two geotechnical borings were applied to the target excavation elevations at a particular analytical boring to calculate the FS. In these situations, it is necessary to assume the more conservative conditions of the two to ensure that the design is sufficiently protective of hydraulic heave.

5.2.2 Geotechnical/Hydraulic Parameters

5.2.2.1 Unit Weights

The unit weights were evaluated based on the natural moisture content (w) and specific gravity (G) of samples recovered from the sediments and native clay deposit, and assuming that these soils are saturated. Figure 5.3 shows unit weight values for both deposits based on laboratory testing.

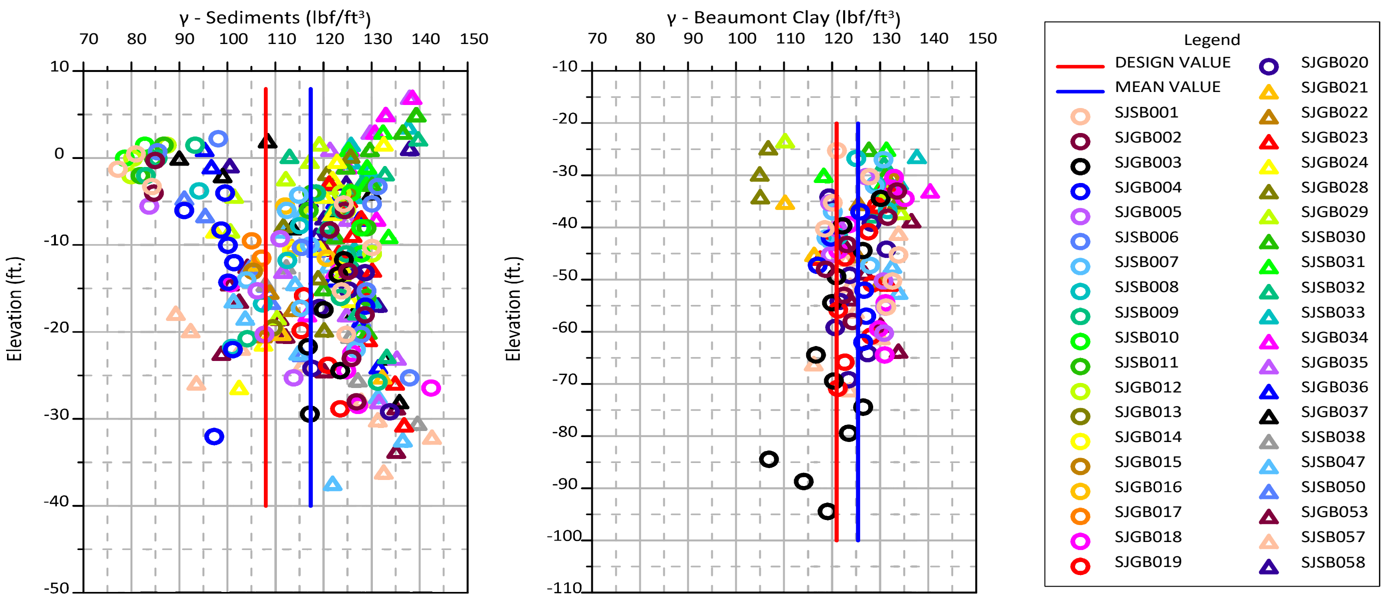


Figure 5.3 Variation of Unit Weights with Elevation

Table 5.1 below summarizes the mean and design values considered for the hydraulic heave assessment.

Table 5.1 Mean and Design Unit Weights

Stratigraphic Unit	Total Unit Weight, γ (pounds per cubic feet [pcf])	
	Mean Value	Design Value
Surficial alluvium	117	108
Beaumont clay formation	125	121

5.2.3 Uplift Pore Pressures

The uplift pore pressures were evaluated based on a piezometric level at elevation -2 ft (water level in the river - see Section 3.3). These uplift pore pressures were considered acting at the interface between the Beaumont clay and the underlaying sand. At the location of the analytical boreholes, where this interface was not defined, the interface elevation was estimated for both Assumptions 1 and 2 as described in Section 5.2.1.2.

In locations where sand lenses were encountered in the Beaumont clay, the top elevation of those sand lenses was assumed to be the interface elevation for uplift pore pressures.

Note, that the water conditions considered for the hydraulic heave assessment exclude water level variations induced by hurricane season, since excavation activities would not be conducted during that time.

5.3 Assessment Results

5.3.1 For a Complete Removal of Impacted Material

The FS values for an excavation surface down to the deepest elevations of impacted material are presented in the attached Tables 1A and 1B. The FS values show that for both assumptions for uplift pore pressures, the total and effective stress approach FS are larger than the target values in the majority of the Northern Impoundment. In the northwest corner, where sand lenses are present, FS values were lower than 1.0 for both the total and effective stress approaches (SJSB-057 and SJSB-098). Such values indicate that hydraulic heave will occur in this area if excavation activities are conducted to the deepest elevations of known impact.

While the majority of the area outside the northwest corner does not show calculated FS below the target values, much of this area is approaching elevations that would be at risk of heave. This is important to note, given that excavation depths could increase based upon post-confirmation sampling. The calculated FS values shown in the attached Tables 1A and 1B correspond to the minimum required depth of the excavation required to remove the impacted materials. If the results of confirmation testing indicate that deeper excavation is required, the currently assumed FS will be reduced.

5.3.2 Safe Hydraulic Heave Excavation Surface

A surface excavation for which both total and effective FS are higher than 1.25 and 1.5, respectively, was established. Tables 2A and 2B present the minimum excavation elevation at the location of each borehole that is protective of hydraulic heave. The two tables show the results of the assessments considering the two different assumptions for the clay thickness. Table 3 provides a consolidated set of values in which the more conservative elevation (shallower) was selected for each boring location.

Table 4 provides a summary of the data, including the excavation limits protective of hydraulic heave, the target excavation depth based on an approach to excavate everything above the clean-up level, and the delta (in feet) between the two elevations.

6. Conclusions

The hydraulic heave analysis indicates that there are areas of the Northern Impoundment in which excavation to the target elevations under a full removal scenario will result in an unacceptable risk of hydraulic heave. The presence of sand lenses is evident in logs and photographs from four geotechnical borings in the northwest corner so this reality must be taken into account when developing a design that is sufficiently protective of hydraulic heave risks.

While there are multiple areas across the Northern Impoundment that show FS values below the target values, the risk is most pronounced in the northwest corner where FS values are less than 1.0 for both the total and effective stress approaches. In this area, approximately 10 to 14 ft of waste material could not be removed based upon the elevations calculated to be protective against hydraulic heave, as shown in Table 4.

While the northwest corner presents the most pronounced risk of hydraulic heave, a significant portion of the rest of the Northern Impoundment is on the threshold of triggering the risk of hydraulic heave. Table 4 depicts the delta between the calculated excavation limit needed to maintain a FS of 1.25 and the target excavation elevations based on exceedances of the clean-up level. Values highlighted in red indicate the existence of hydraulic heave risk and valued highlighted in yellow indicate a high sensitivity (0 to 5 ft) to hydraulic heave. This will need to be taken into consideration when developing the approach to post-confirmation sampling.

7. Scope and Limitations

The recommendations made in this report are in accordance with our present understanding of the project, the ground surface elevations and current conditions at the Northern Impoundment, and are based on the work scope described in the report. The services were performed in a manner consistent with that level of care and skill ordinarily exercised by members of geotechnical engineering professions currently practicing under similar conditions in the same locality.

All details of design and construction are rarely known at the time of completion of a geotechnical study. The recommendations and comments made in this report are based on our subsurface investigation and resulting understanding of the project, as defined at the time of the study. GHD will review our recommendations when the remedial design drawings and specifications are complete.

It is important to emphasize that a soil investigation is, in fact, a random sampling of a site and the comments included in this report are based on the results obtained at the test locations only. The subsurface conditions confirmed at the test locations may vary at other locations.

Table 1A

Hydraulic Heave Safety Factors For Total Removal of Exceedances of Clean-Up Level - Assumption 1
Hydraulic Heave Analysis
Northern Impoundment - San Jacinto River Waste Pits Superfund Site

Location	Northing (NAD83)	Easting (NAD83)	Surface/Riverbed Elevation	Reference Borehole	BS Elevation in Reference Borehole (ft)	Distance From Borehole (ft)	Aquifer Piezo Elevation (ft)	BC Depth (ft)	BC Elevation (ft)	BS Depth (ft)	BS Elevation (ft)	Sediment Thickness (ft)	BC Thickness (ft)	Excavation Floor Elevation (ft)	Pressure Head (ft)	Uplift Porepressure (psf)	Remaining Sediment Thickness (ft)	Sediments Layer Total Pressure (psf)	BC Layer Total Pressure (psf)	FS (Total)	FS (Effective)
SJGB010	13857411.203	3216753.589	3.00	SJGB001	-56	107	-2	29	-26	59.5	-56.50	29	30.5	-6.3	54.5	3400	20	2132	3689	1.71	10.02
SJGB011	13857474.591	3216925.733	3.00	SJCPT-011	-53.4	83	-2	33	-30	58.4	-55.40	33	25.4	-9.6	53.4	3331	20	2208	3072	1.58	5.11
SJGB012	13857611.312	3216819.464	3.00	SJCPT-011	-53.4	93	-2	33	-30	58.4	-55.40	33	25.4	-7.6	53.4	3331	22	2424	3072	1.65	7.20
SJSB013	13857852.438	3216918.897	-12.4	SJGB018	-53.43	113	-2	30	-42.4	37.5	-49.90	30	7.5	-16	47.9	2988	26	2857	907	1.26	1.89
SJGB014	13857716.960	3217158.780	-1.50	SJGB053	-69	166	-2	15	-16.5	81	-82.50	15	66	-9.2	80.5	5022	7	790	7983	1.75	9.35
SJGB016	13857551.031	3217162.509	-0.50	SJCPT-011	-53.4	267	-2	33	-33.5	58.4	-58.90	33	25.4	-6.1	56.9	3550	27	2965	3072	1.70	10.73
SJGB017	13857352.164	3217191.717	-1.85	SJGB008	-61	207	-2	23	-24.85	58	-59.85	23	35	-17.85	57.85	3609	7	758	4233	1.38	2.40
SJSB028	13857067.126	3217256.398	1.25	SJGB008	-61	264	-2	23	-25.26	58	-56.75	23	32.8	-9.09	54.75	3416	16	1750	3967	1.67	6.02
SJSB029	13857119.314	3217153.087	2.68	SJGB008	-61	193	-2	23	-20.32	58	-55.32	23	35	2.68	53.32	3326	23	2489	4233	2.02	N/A
SJSB030	13857220.516	3216971.008	4.33	SJMW17	-60	120	-2	23	-18.67	63	-58.67	23	40	4.33	56.67	3535	23	2489	4838	2.07	N/A
SJSB031	13857295.051	3216774.912	5.12	SJMW17	-60	120	-2	23	-17.88	63	-57.88	23	40	5.12	55.88	3486	23	2489	4838	2.10	N/A
SJSB032	13857444.802	3216651.498	3.21	SJGB001	-56	120	-2	29	-25.79	59.5	-56.29	29	30.5	-8.3	54.29	3387	17	1893	3689	1.65	6.58
SJSB033	13857624.835	3216746.671	4.59	SJGB023	-61.66	100	-2	29.5	-24.91	59.8	-55.21	29.5	30.3	-8.9	53.21	3320	16	1733	3665	1.63	5.83
SJSB034	13857689.491	3217045.977	6.99	SJCPT-011	-53.4	200	-2	33	-26.01	58.4	-51.41	33	25.4	6.99	49.41	3083	33	3571	3072	2.16	N/A
SJSB035	13857460.903	3217021.623	6.64	SJCPT-011	-53.4	167	-2	33	-26.36	58.4	-51.76	33	25.4	6.64	49.76	3104	33	3571	3072	2.14	N/A
SJSB036	13857475.106	3216859.930	2.00	SJCPT-011	-53.4	97	-2	33	-31	58.4	-56.40	33	25.4	-10.75	54.4	3394	20	2191	3072	1.55	4.43
SJSB037	13857687.402	3216908.317	3.00	SJGB002	-58.75	73	-2	33.5	-30.5	59.5	-56.50	33.5	26	-9.6	54.5	3400	21	2262	3145	1.59	5.23
SJSB038	13857563.077	3217138.458	-0.50	SJCPT-011	-53.4	240	-2	33	-33.5	58.4	-58.90	33	25.4	-12.96	56.9	3550	21	2223	3072	1.49	3.55
SJSB045	13857135.810	3217343.067	-2.10	SJGB008	-61	57	-2	23	-25.1	58	-60.10	23	35	-2.1	58.1	3625	23	2489	4233	1.85	497.55
SJSB045-C1	13857149.350	3217285.350	-1.30	SJGB008	-61	63	-2	23	-24.3	58	-59.30	23	35	-13.3	57.3	3575	11	1190	4233	1.52	3.62
SJSB046	13857183.750	3217236.016	-2.00	SJGB008	-61	96	-2	23	-25	58	-60.00	23	35	-20	58	3618	5	541	4233	1.32	2.03
SJSB046-C1	13857229.000	3217174.000	-2.39	SJGB008	-61	150	-2	23	-25.39	58	-60.39	23	35	-20.4	58.39	3643	5	540	4233	1.31	1.98
SJSB047	13857278.320	3217421.371	-2.10	SJGB047	-53.4	0	-2	22	-24.1	50	-52.10	22	28	-2.1	50.1	3126	22	2381	3387	1.85	424.49
SJSB047-C1	13857302.550	3217340.988	-4.00	SJGB047	-53.4	80	-2	22	-26	50	-54.00	22	28	-20	52	3244	6	649	3387	1.24	1.71
SJSB048	13857396.530	3217503.368	-2.40	SJGB007	-67.75	107	-2	23	-25.4	64.5	-66.90	23	41.5	-2.4	64.9	4049	23	2489	5020	1.85	139.64
SJSB048-C1	13857398.780	3217445.299	-4.00	SJGB007	-67.75	67	-2	23	-27	64.5	-68.50	23	41.5	-22	66.5	4149	5	541	5020	1.34	2.13
SJSB049	13857406.390	3217395.258	-5.10	SJGB007	-67.75	77	-2	23	-28.1	64.5	-69.60	23	41.5	-19.1	67.6	4217	9	974	5020	1.42	2.66
SJSB050	13857546.330	3217527.884	-3.40	SJGB005	-65	67	-2	26	-29.4	60.5	-63.90	26	34.5	-3.4	61.9	3862	26	2814	4173	1.81	36.78
SJSB050-C1	13857558.160	3217389.116	-6.30	SJGB005	-65	120	-2	26	-32.3	60.5	-66.80	26	34.5	-6.3	64.8	4043	26	2814	4173	1.73	11.97
SJSB051	13857682.020	3217424.684	-2.70	SJGB004	-62.75	93	-2	28	-30.7	59.5	-62.20	28	31.5	-2.7	60.2	3756	28	3030	3810	1.82	71.63
SJSB052	13857661.470	3217319.770	-5.70	SJGB004	-62.75	133	-2	28	-33.7	59.5	-65.20	28	31.5	-5.7	63.2	3943	28	3030	3810	1.73	13.55
SJSB052-C1	13857626.750	3217222.469	-2.20	SJGB053	-66.7	190	-2	17	-19.2	57	-59.20	17	40	-2.2	57.2	3569	17	1840	4838	1.87	250.20
SJSB053	13857799.520	3217301.198	-9.70	SJGB053	-66.7	0	-2	17	-26.7	57	-66.70	17	40	-9.7	64.7	4036	17	1840	4838	1.65	6.50
SJSB053-C1	13857775.270	3217268.406	-7.40	SJGB053	-66.7	40	-2	17	-24.4	57	-64.40	17	40	-7.4	62.4	3893	17	1840	4838	1.72	9.27
SJSB054	13857745.960	3217282.887	-7.40	SJGB053	-66.7	57	-2	17	-24.4	57	-64.40	17	40	-23.4	62.4	3893	1	108	4838	1.27	1.79
SJSB055	13857915.360	3217183.420	-4.90	SJGB003	-95.17	60	-2	33	-37.9	84.5	-89.40	33	51.5	-13.5	87.4	5453	24	2641	6229	1.63	5.76
	13857915.360	3217183.420	-4.90	SJGB020	-48.17	113	1.5	22	-26.9	40	-44.90	22	18	-13.5	46.4	2895	13	1450	2177	1.25	1.78
SJSB055-C1	13857843.355	3217150.478	-9.54	SJGB003	-96.5	30	-2	33	-42.54	84.5	-94.04	33	51.5	-13.54	92.04	5742	29	3138	6229	1.63	6.04
SJSB056	13857942.460	3217077.154	-12.40	SJBG057	-73.1	113	-2	17	-29.4	56	-68.40	17	39	-12.4	66.4	4142	17	1840	4717	1.58	4.72
	13857942.460	3217077.154	-12.40	SJGB020	-48.17	100	1.5	22	-34.4	40	-52.40	22	18	-12.4	53.9	3363	22	2381	2177	1.36	2.38
SJSB056-C1	13857851.608	3217058.119	-4.29	SJSB003	-95.17	100	-2	33	-37.29	84.5	-88.79	33	51.5	-4.29	86.79	5415	33	3571	6229	1.81	31.70
SJSB057	13857956.449	3216960.196	-17.1	SJSB057	-73.1	0	-2	17	-34.1	56	-73.10	17	39	-26.4	71.1	4436	8	833	4717	1.25	1.73
	13857956.449	3216960.196	-17.1	SJGB019	-49.82	77	1.5	20	-37.1	35	-52.10	20	15	-26.4	53.6	3344	11	1158	1814	0.89	0.79
SJSB058	13857700.162	3216855.509	0.62	SJGB002	-58.7	43	-2	33.5	-32.88	59.5	-58.88	33.5	26	-17.4	56.88	3549	15	1675	3145	1.36	2.32
SJSB070	13857778.065	3216886.192	-1.17	SJGB002	-58.7	43	-2	33.5	-34.67	59.5	-60.67	33.5	26	-15.2	58.67	3660	19	2107	3145	1.43	2.93
SJSB071	13857719.189	3216821.133	-0.8	SJGB002	-58.7	43	-2	33.5	-34.3	59.5	-60.30	33.5	26	-18.8	58.3	3637	16	1677	3145	1.33	2.13
SJSB072	13857614.250	3216842.652	1.42	SJCPT-011	-53.4	67	-2	33	-31.58	58.4	-56.98	33.00	25.40	-20.56	54.98	3430	11	1193	3072	1.24	1.72
SJSB073	13857593.160	3216960.041	1.29	SJCPT-011	-53.4	67	-2	33	-31.71	58.4	-57.11	33.00	25.40	-10.71	55.11	3438	21	2273	3072	1.55	4.51
SJSB074	13857543.710	3216728.114	3.34	SJGB001	-56	33	-2	29	-25.66	59.5	-56.16	29.00	30.50	-4.66	54.16	3379	21	2273	3689	1.76	16.56
SJSB075	13857486.820	3216843.803	2.28	SJGB001	-56	93	-2	29	-26.72	59.5	-57.22	29.00	30.50	-9.72	55.22	3445	17	1840	3689	1.60	5.33
SJSB076	13857508.770	3216910.806	2.26	SJCPT-011	-53.4	60	-2	33	-30.74	58.4	-56.14	33.00	25.40	-9.74	54.14	3378	21	2273	3072	1.58	5.07
SJSB077	13857411.880	3216736.668	1.42	SJGB001	-56	100	-2	29	-27.58	59.5	-58.08	29.00	30.50	-14.58	56.08	3499	13	1407	3689	1.46	3.04
SJSB078	13857430.030	3216823.139	1.82	SJGB001	-56	107	-2	29	-27.18	59.5	-57.68	29.00	30.50	-20.18	55.68	3474	7	758	3689	1.28	1.86
SJSB079	13857381.900	3216888.271	1.05	SJMW17	-58	177	-2	23	-21.95	63	-61.95	23.00	40.00	-10.95	59.95	3740	11	1190	4838	1.61	5.10
SJSB080	13857320.220	3216827.045	1.77	SJMW17	-58	100	-2	23	-21.23	63	-61.23	23.00	40.00	-8.23	59.23	3695	13	1407	4838	1.69	7.56
SJSB081	13857276.460	3217054.335	-2.26	SJMW17	-58	120	-2	23	-25.26	63	-65.26	23.00	40.00	-14.26	63.26	3947	11	1190	4838	1.53	3.72
SJSB082	13857216.120	3217091.823	-1.75	SJMW17	-58	200	-2	23	-24.75	63	-64.75	23.00	40.00	-11.75	62.75	3915	13	1407	4838	1.60	4.83
SJSB083	13857242.260	3217187.497	-2.93	SJGB008	-61	153	-2	23	-25.93	58	-60.93	23.00	35.00	-14.93	58.93	3676	11	1190	4233	1.48	3.17
SJSB084	13857243.090	3217292.257	-3.86	SJGB008	-61	67	-2	23	-26.86	58	-61.86	23.00	35.00	-9.86	59.86	3734	17	1840	4233	1.63	5.77
SJSB085	13857350.670	3217370.887	-5.67	SJGB007	-67.75	53	-2	23	-28.67	64.5	-70.17	23.00	41.50	-13.67	68.17	4253	15	1623	5020	1.56	4.28
SJSB086	13857292.630	3217249.901	-2.72	SJGB008	-61	130	-2	23	-25.72	58	-60.72	23.00	35.00	-2.72	58.72	3663	23	2489	4233	1.84	69.10
SJSB087	13857311.470	3217114.943	-3.01	SJMW17	-58	240	-2	23	-26.01	63	-66.01	23.00	40.00	-19.01	64.01	3993	7	758	4838	1.40	2.51
SJSB088	13857488.390	3217119.275	-2.12	SJCPT-011	-53.4	240	-2	33	-35.12	58.4	-60.52	33.00	25.40	-20.52	58.52	3651	15	1580	3072	1.27	1.87
SJSB089	13857426.020	3217214.579	-2.88	SJGB007	-67.75	220	-2	23	-25.88	49.9	-52.78	23.00	26.90	-14.88	50.78	3168	11	1190	3254	1.40	2.59
SJSB090	13857506.130	3217218.409	-1.50	SJGB007	-67.75	267	-2	23	-24.50	49.9	-51.40	23.00	26.90	-11.50	49.40	3082	13	1407	3254	1.51	3.66
SJSB091	13857487.240	3217383.273	-3.58	SJGB007	-68.5	160	-2	23	-26.58	54.6	-58.18	23.00	31.60	-3.58	56.18	3505	23	2489	3822	1.80	29.47
SJSB092	13857618.600	3217303.607	-4.93	SJGB053	-66.7	187	-2	17	-21.93	57	-61.93	17.00	40.00	-18.93	59.93	3739	3	325	4838	1.38	2.35
SJSB093	13857582.780	3217129.479	-1.53	SJCPT-011	-66.7	200	-2	33	-34.53	58.4	-59.93	33.00	25.40	-15.53	57.93	3614	19	2056	3072	1.42	2.79
SJSB094	13857691.550	3217241.216	-4.22	SJSB053	-66.7	120	-2	17	-21.22	57	-61.22	17.00	40.00	-16.22	59.22	3695	5	541	4838	1.46	2.90
SJSB095	13857790.230	3217133.851	-2.07	SJGB003	-95.17	80	-2	33	-35.07	84.5	-86.57	33.00	51.50	-18.07	84.57	5276	17	1840	6229	1.53	3.79
SJSB096	13857798.660	3217196.291	-6.55	SJGB003	-95.17	73	-2	33	-39.55	84.5	-91.05	33.00	51.50	-18.55	89.05	5556	21	2273	6229	1.53	3.85
SJSB097	13857955.960	3217030.737	-15.64	SJSB057	-73.1	67	-2	17	-32.64	56	-71.64	17.00	39.00	-15.54	69.64	4345	17	1851	4717	1.51	3.63
	13857955.960	3217030.737	-15.64	SJGB020	-48.17	80	1.5	22	-37.64	32	-47.64	22.00	10.00	-15.54	49.14	3066	22	2392	1210	1.17	1.50
SJSB098	13857874.760	3216977.358	-14.36	SJGB019	-49.82	137	1.5	20	-34.36	35.1	-49.46	20.00	15.10	-28.36	50.96	3179	6	649	1826	0.78	0.82
	13857874.760	3216977.358	-14.36	SJSB057	-73.1	80	-2	17	-31.36	56	-70.36	17.00	39.00	-28.36	68.36	4265	3	325	4717	1.18	1.47
SJSB099	13857764.250	3216947.207	-0.61	SJGB002	-58.75	80	-2	34	-34.11	59.5	-60.11	33.50	26.00	-12.61	58.11	3625	22	2327	3145	1.51	3.79
SJSB100	13857919.310	3216899.688	-13.36	SJSB057	-73.1	67	-2	17	-30.36	56	-69.36	17.00	39.00	-15.36	67.36	4202	15	1623	4717	1.51	3.57
	13857919.310	3216899.688	-13.36	SJGB019	-48.82	67	1.5	20	-33.36	35	-48.36	20.00	15.00	-15.36	49.86	3111	18	1948	1814	1.21	1.62
SJSB101	13857709.580	3216809.881	-0.15	SJGB002	-58.75	63	-2	34	-33.65	59.5	-59.65	33.50	26.00	-12.15	57.65	3597	22	2327	3145	1.52	3.96
SJSB102	13857180.230	3217192.143	-2.05	SJGB008	-61	133	-2	23	-25.05	58	-60.05	23.00	35.00	-20.15	58.05	3622	5	530	4233	1.32	2.01
SJSB103	13857998.430	3216974.835	-15.36	SJSB057	-73.1	43	-2	17	-32.36	56	-71.36	17.00	39.00	-15.36	69.36	4327	17	1840	4717	1.52	3.68
	13857998.430	3216974.835	-15.36	SJGB020	-48.17	87	1.5	22	-37.36	32	-47.36	22.00	10.00	-15.36	48.86	3048	22	2381	1210	1.18	1.52
SJSB104	13857613.240	3217397.901	-5.49	SJBG005	-65	140	-2	26	-31.49	60.5	-65.99	26.00	34.50	-5.49	63.99	3992	26	2814	4173	1.75	14.75
SJSB105	13857485.550	3217440.440	-4.36	SJGB007	-67.75	153	-2	23	-27.36	64.5	-68.86	23.00	41.50	-20.36	66.86	4171	7	758	5020	1.39	2.40
SJSB106	13857469.990	3217311.018	-3.10	SJGB007	-67.75	173	-2	23	-26.10	64.5	-67.60	23.00	41.50	-5.10	65.60	4093	21	2273	5020	1.78	17.54

Total BC Unit Weight	19.0	kN/m^3	121.0	pcf
Total BC Unit Weight	19.5	kN/m^3	124.1	pcf
Total Sediment Unit Weight	17.0	kN/m^3	108.2	pcf
Water Unit Weight	9.8	kN/m^3	62.4	pcf
Total FS	1.25			
Effective BC Unit Weight	9.2	kN/m^3	58.6	pcf
Effective BS Unit Weight	9.7	kN/m^3	61.8	pcf
Effective Sediment Unit Weight	7.2	kN/m^3	45.8	pcf
Effective FS	1.5			
Conversion kN/m^3 to pcf	6.37			

Notes:
ft = feet
NAD83 = North American Datum of 1983
piezo = piezometer
BC = Beaumont Clay
BS = Beaumont Sand
psf = pounds per square foot
kN/m^3 = kilonewtons per cubic meter
pcf = pounds per cubic foot
FS = Factor of Safety
Orange highlighted rows indicate instances where geotechnical conditions from the closest two geotechnical borings were applied to those locations to assess hydraulic heave. The more conservative of the two assumptions will be carried forward for the basis of design.
Red highlighted rows indicate a FS that is less than the target FS protective of hydraulic heave.

Table 1B

Hydraulic Heave Safety Factors For Total Removal of Exceedances of Clean-Up Level - Assumption 2
Hydraulic Heave Analysis
Northern Impoundment - San Jacinto River Waste Pits Superfund Site

Location	Northing (NAD83)	Easting (NAD83)	Surface/Riverbed Elevation	Reference Borehole	BS Elevation in Reference Borehole (ft)	Distance From Borehole (ft)	Aquifer Piezo Elevation (ft)	BC Depth (ft)	BC Elevation (ft)	BS Depth (ft)	BS Elevation (ft)	Sediment Thickness (ft)	BC Thickness (ft)	Excavation Floor Elevation	Pressure Head (ft)	Uplift Porepressure (psf)	Remaining Sediment Thickness (ft)	Sediments Layer Total Pressure (psf)	BC Layer Total Pressure (psf)	FS (Total)	FS (Effective)
SJGB010	13857411.203	3216753.589	3.00	SJGB001	-56	107	-2	30	-27	59.5	-56	30	29	-6.3	54	3369	21	2240	3508	1.71	9.87
SJGB011	13857474.591	3216925.733	3.00	SJCPT-011	-53.4	83	-2	19.7	-16.7	58.4	-53.4	19.7	36.7	-9.6	51.4	3207	7	768	4439	1.62	5.22
SJGB012	13857611.312	3216819.464	3.00	SJCPT-011	-53.4	93	-2	19.7	-16.7	58.4	-53.4	19.7	36.7	-7.6	51.4	3207	9	985	4439	1.69	7.35
SJSB013	13857852.438	3216918.897	-12.4	SJGB018	-53.43	113	-2	19.7	-32.1	37.5	-53.43	19.7	21.33	-16	51.43	3209	16	1742	2580	1.35	2.28
SJGB014	13857716.960	3217158.780	-1.50	SJGB053	-66.7	166	-2	25.9	-27.4	81	-66.7	25.9	39.3	-9.2	64.7	4036	18	1970	4753	1.67	6.98
SJGB016	13857551.031	3217162.509	-0.50	SJCPT-011	-53.4	267	-2	19.7	-20.2	58.4	-53.4	19.7	33.2	-6.1	51.4	3207	14	1526	4016	1.73	10.13
SJGB017	13857352.164	3217191.717	-1.85	SJGB008	-61	207	-2	25	-26.85	58	-61	25	34.15	-17.85	59	3681	9	974	4131	1.39	2.44
SJSB028	13857067.126	3217256.398	1.25	SJGB008	-61	264	-2	23	-25.26	58	-61	23	32.8	-9.09	56.06	3497	16	1750	3967	1.63	6.02
SJSB029	13857119.314	3217153.087	2.68	SJGB008	-61	193	-2	23	-20.32	58	-61	23	40.68	2.68	59	3681	23	2489	4920	2.01	N/A
SJSB030	13857220.516	3216971.008	4.33	SJMW17	-60	120	-2	30	-25.67	63	-60	30	34.33	4.33	58	3618	30	3247	4152	2.04	N/A
SJSB031	13857295.051	3216774.912	5.12	SJMW17	-60	120	-2	30	-24.88	63	-60	30	35.12	5.12	58	3618	30	3247	4248	2.07	N/A
SJSB032	13857444.802	3216651.498	3.21	SJGB001	-56	120	-2	30	-26.79	59.5	-56	30	29.21	-8.3	54	3369	18	2001	3533	1.64	6.51
SJSB033	13857624.835	3216746.671	4.59	SJGB023	-61.66	100	-2	29.9	-25.31	59.8	-61.66	29.9	36.35	-8.9	59.66	3722	16	1776	4397	1.66	6.69
SJSB034	13857689.491	3217045.977	6.99	SJCPT-011	-53.4	200	-2	19.7	-12.71	58.4	-53.4	19.7	40.69	6.99	51.4	3207	20	2132	4922	2.20	N/A
SJSB035	13857460.903	3217021.623	6.64	SJCPT-011	-53.4	167	-2	19.7	-13.06	58.4	-53.4	19.7	40.34	6.64	51.4	3207	20	2132	4879	2.19	N/A
SJSB036	13857475.106	3216859.930	2.00	SJCPT-011	-53.4	97	-2	30	-10.75	58.4	-53.4	12.75	42.65	-10.75	51.4	3207	0	0	5159	1.61	4.58
SJSB037	13857687.402	3216908.317	3.00	SJGB002	-58.75	73	-2	34.4	-31.4	59.5	-58.75	34.4	27.35	-9.6	56.75	3540	22	2359	3308	1.60	5.49
SJSB038	13857563.077	3217138.458	-0.50	SJCPT-011	-53.4	240	-2	19.7	-20.2	58.4	-53.4	19.7	33.2	-12.96	51.4	3207	7	784	4016	1.50	3.33
SJSB045	13857135.810	3217343.067	-2.10	SJGB008	-61	57	-2	23	-25.1	58	-61	23	35.9	-2.1	59	3681	23	2489	4342	1.86	506.00
SJSB045-C1	13857149.350	3217285.350	-1.30	SJGB008	-61	63	-2	23	-24.3	58	-61	23	36.7	-13.3	59	3681	11	1190	4439	1.53	3.76
SJSB046	13857183.750	3217236.016	-2.00	SJGB008	-61	96	-2	23	-25	58	-61	23	36	-20	59	3681	5	541	4354	1.33	2.08
SJSB046-C1	13857229.000	3217174.000	-2.39	SJGB008	-61	150	-2	23	-25.39	58	-61	23	35.61	-20.4	59	3681	5	540	4307	1.32	2.02
SJSB047	13857278.320	3217421.371	-2.10	SJGB047	-53.4	0	-2	34	-36.1	50	-53.4	34	17.3	-2.1	51.4	3207	34	3680	2093	1.80	412.20
SJSB047-C1	13857302.550	3217340.988	-4.00	SJGB047	-53.4	80	-2	34	-38	50	-53.4	34	15.4	-20	51.4	3207	18	1948	1863	1.19	1.54
SJSB048	13857396.530	3217503.368	-2.40	SJGB007	-67.75	107	-2	25	-27.4	64.5	-67.75	25	40.35	-2.4	65.75	4102	25	2706	4880	1.85	140.62
SJSB048-C1	13857398.780	3217445.299	-4.00	SJGB007	-67.75	67	-2	25	-29	64.5	-67.75	25	38.75	-22	65.75	4102	7	758	4687	1.33	2.08
SJSB049	13857406.390	3217395.258	-5.10	SJGB007	-67.75	77	-2	25	-30.1	64.5	-67.75	25	37.65	-19.1	65.75	4102	11	1190	4554	1.40	2.54
SJSB050	13857546.330	3217527.884	-3.40	SJGB005	-65	67	-2	24.4	-27.8	60.5	-65	24.4	37.2	-3.4	63	3930	24	2641	4499	1.82	37.75
SJSB050-C1	13857558.160	3217389.116	-6.30	SJGB005	-65	120	-2	24.4	-30.7	60.5	-65	24.4	34.3	-6.3	63	3930	24	2641	4149	1.73	11.66
SJSB051	13857682.020	3217424.684	-2.70	SJGB004	-62.75	93	-2	24	-26.7	59.5	-62.75	24	36.05	-2.7	60.75	3790	24	2597	4360	1.84	73.54
SJSB052	13857661.470	3217319.770	-5.70	SJGB004	-62.75	133	-2	24	-29.7	59.5	-62.75	24	33.05	-5.7	60.75	3790	24	2597	3998	1.74	13.15
SJSB052-C1	13857626.750	3217222.469	-2.20	SJGB053	-66.7	190	-2	25.9	-28.1	57	-66.7	25.9	38.6	-2.2	64.7	4036	26	2803	4669	1.85	276.33
SJSB053	13857799.520	3217301.198	-9.70	SJGB053	-66.7	0	-2	25.9	-35.6	57	-66.7	25.9	31.1	-9.7	64.7	4036	26	2803	3762	1.63	6.26
SJSB053-C1	13857775.270	3217268.406	-7.40	SJGB053	-66.7	40	-2	25.9	-33.3	57	-66.7	25.9	33.4	-7.4	64.7	4036	26	2803	4040	1.70	9.33
SJSB054	13857745.960	3217282.887	-7.40	SJGB053	-66.7	57	-2	25.9	-33.3	57	-66.7	25.9	33.4	-23.4	64.7	4036	10	1071	4040	1.27	1.81
SJSB055	13857915.360	3217183.420	-4.90	SJGB003	-95.17	60	-2	18	-22.9	84.5	-95.17	18	72.27	-13.5	93.17	5813	9	1017	8741	1.68	6.50
	13857915.360	3217183.420	-4.90	SJGB020	-48.17	113	1.5	22	-26.9	40	-48.17	22	21.27	-13.5	49.67	3099	13	1450	2573	1.30	1.99
SJSB055-C1	13857843.355	3217150.478	-9.54	SJGB003	-96.5	30	-2	18	-27.54	84.5	-96.5	18	68.96	-13.54	94.5	5896	14	1515	8341	1.67	6.50
SJSB056	13857942.460	3217077.154	-12.40	SJBG057	-73.1	113	-2	18	-30.4	56	-73.1	18	42.7	-12.4	71.1	4436	18	1948	5165	1.60	5.13
	13857942.460	3217077.154	-12.40	SJGB020	-48.17	100	1.5	19.5	-31.9	40	-48.17	19.5	16.27	-12.4	49.67	3099	20	2110	1968	1.32	2.13
SJSB056-C1	13857851.608	3217058.119	-4.29	SJGB003	-95.17	100	-2	19.7	-23.99	84.5	-95.17	19.7	71.18	-4.29	93.17	5813	20	2132	8610	1.85	35.50
SJSB057	13857956.449	3216960.196	-17.1	SJBG057	-73.1	0	-2	19.7	-36.8	56	-73.1	19.7	36.3	-26.4	71.1	4436	10	1126	4391	1.24	1.71
	13857956.449	3216960.196	-17.1	SJGB019	-49.82	77	1.5	19.5	-36.6	35	-49.82	19.5	13.22	-26.4	51.32	3202	10	1104	1599	0.84	0.71
SJSB058	13857700.162	3216855.509	0.62	SJGB002	-58.7	43	-2	34.4	-33.78	59.5	-58.7	34.4	24.92	-17.4	56.7	3537	16	1773	3014	1.35	2.30
SJSB070	13857778.065	3216886.192	-1.17	SJGB002	-58.7	43	-2	23	-24.17	59.5	-58.7	23	34.53	-15.2	56.7	3537	9	971	4177	1.46	2.96
SJSB071	13857719.189	3216821.133	-0.8	SJGB002	-58.7	43	-2	34.4	-35.2	59.5	-58.7	34.4	23.5	-18.8	56.7	3537	16	1775	2842	1.31	2.03
SJSB072	13857614.250	3216842.652	1.42	SJCPT-011	-53.4	67	-2	19.7	-18.28	58.4	-53.40	19.70	35.12	-20.56	51.40	3207	-2	-247	4248	1.25	1.69
SJSB073	13857593.160	3216960.041	1.29	SJCPT-011	-53.4	67	-2	19.7	-18.41	58.4	-53.40	19.70	34.99	-10.71	51.40	3207	8	833	4232	1.58	4.42
SJSB074	13857543.710	3216728.114	3.34	SJGB001	-56	33	-2	29.8	-26.46	59.5	-56.00	29.80	29.54	-4.66	54.00	3369	22	2359	3573	1.76	16.45
SJSB075	13857486.820	3216843.803	2.28	SJGB001	-56	93	-2	34	-31.72	59.5	-56.00	34.00	24.28	-9.72	54.00	3369	22	2381	2937	1.58	5.05
SJSB076	13857508.770	3216910.806	2.26	SJCPT-011	-53.4	60	-2	19.7	-17.44	58.4	-53.40	19.70	35.96	-9.74	51.40	3207	8	833	4350	1.62	5.09
SJSB077	13857411.680	3216736.668	1.42	SJGB001	-56	100	-2	30.00	-28.58	59.5	-56.00	30.00	27.42	-14.58	54.00	3369	14	1515	3317	1.43	2.86
SJSB078	13857430.030	3216823.139	1.82	SJGB001	-56	107	-2	30.00	-28.18	59.5	-56.00	30.00	27.82	-20.18	54.00	3369	8	866	3365	1.26	1.76
SJSB079	13857381.900	3216888.271	1.05	SJMW17	-58	177	-2	19.7	-18.65	63	-58.00	19.70	39.35	-10.95	56.00	3494	8	833	4760	1.60	4.76
SJSB080	13857320.220	3216827.045	1.77	SJMW17	-58	100	-2	19.7	-17.93	63	-58.00	19.70	40.07	-8.23	56.00	3494	10	1050	4847	1.69	7.18
SJSB081	13857276.460	3217054.335	-2.26	SJMW17	-58	120	-2	23.00	-25.26	63	-58.00	23.00	32.74	-14.26	56.00	3494	11	1190	3960	1.47	3.17
SJSB082	13857216.120	3217091.823	-1.75	SJMW17	-58	200	-2	23.00	-24.75	63	-58.00	23.00	33.25	-11.75	56.00	3494	13	1407	4022	1.55	4.18
SJSB083	13857242.260	3217187.497	-2.93	SJGB008	-61	153	-2	23.00	-25.93	58	-61.00	23.00	35.07	-14.93	59.00	3681	11	1190	4242	1.48	3.17
SJSB084	13857243.090	3217292.257	-3.86	SJGB008	-61	67	-2	23.00	-26.86	58	-61.00	23.00	34.14	-9.86	59.00	3681	17	1840	4129	1.62	5.67
SJSB085	13857350.670	3217370.887	-5.67	SJGB007	-67.75	53	-2	25.00	-30.67	64.5	-67.75	25.00	37.08	-13.67	65.75	4102	17	1840	4485	1.54	4.05
SJSB086	13857292.630	3217249.901	-2.72	SJGB008	-61	130	-2	25.00	-27.72	58	-61.00	25.00	33.28	-2.72	59.00	3681	25	2706	4025	1.83	58.90
SJSB087	13857311.470	3217114.943	-3.01	SJMW17	-58	240	-2	19.7	-22.71	63	-58.00	19.70	35.29	-19.01	56.00	3494	4	400	4268	1.34	2.11
SJSB088	13857488.390	3217119.275	-2.12	SJCPT-011	-53.4	240	-2	19.7	-21.82	58.4	-53.40	19.70	31.58	-20.52	51.40	3207	1	141	3820	1.24	1.65
SJSB089	13857426.020	3217214.579	-2.88	SJGB007	-67.75	220	-2	25.00	-27.88	64.5	-67.75	25.00	39.87	-14.88	65.75	4102	13	1407	4822	1.52	3.65
SJSB090	13857506.130	3217218.409	-1.50	SJGB007	-67.75	267	-2	25.00	-26.50	49.9	-67.75	25.00	41.25	-11.50	65.75	4102	15	1623	4989	1.61	5.24
SJSB091	13857487.240	3217383.273	-3.58	SJGB007	-68.5	160	-2	24.40	-27.98	54.6	-68.50	24.40	40.52	-3.58	66.50	4149	24	2641	4901	1.82	35.42
SJSB092	13857618.600	3217303.607	-4.93	SJGB053	-66.7	187	-2	24.40	-29.33	57	-66.70	24.40	37.37	-18.93	64.70	4036	10	1126	4520	1.40	2.52
SJSB093	13857582.780	3217129.479	-15.53	SJCPT-011	-66.7	200	-2	19.7	-35.23	58.4	-66.70	19.70	31.47	-15.53	64.70	4036	20	2132	3806	1.47	3.25
SJSB094	13857691.550	3217241.216	-4.22	SJSB053	-66.7	120	-2	25.90	-30.12	57	-66.70	25.90	36.58	-16.22	64.70	4036	14	1504	4424	1.47	3.13
SJSB095	13857790.230	3217133.851	-2.07	SJGB003	-95.17	80	-2	18.00	-20.07	84.5	-95.17	18.00	75.10	-18.07	93.17	5813	2	216	9084	1.60	4.48
SJSB096	13857798.660	3217196.291	-6.55	SJGB003	-95.17	73	-2	21.90	-28.45	84.5	-95.17	21.90	66.72	-18.55	93.17	5813	10	1071	8070	1.57	4.22
SJSB097	13857955.960	3217030.737	-15.64	SJBG057	-73.1	67	-2	19.70	-35.34	56	-73.10	19.70	37.76	-15.54	71.10	4436	20	2143	4567	1.51	3.69
	13857955.960	3217030.737	-15.64	SJGB020	-48.17	80	1.5	22.00	-37.64	32	-48.17	22.00	10.53	-15.54	49.67	3099	22	2392	1274	1.18	1.53
SJSB098	13857874.760	3216977.358	-14.36	SJGB019	-49.82	137	1.5	19.50	-33.86	35.1	-49.82	19.50	15.96	-28.36	51.32	3202	6	595	1930	0.79	0.64
	13857874.760	3216977.358	-14.36	SJBG057	-73.1	90	-2	27.00	-41.36	56	-73.10	27.00	31.74	-28.36	71.10	4436	13	1407	3839	1.18	1.46
SJSB099	13857764.250	3216947.207	-0.61	SJGB002	-58.75	80	-2	34.40	-35.01	59.5	-58.75	34.40	23.74	-12.61	56.75	3540	22	2424	2871	1.50	3.65
SJSB100	13857919.310	3216899.688	-13.36	SJBG057	-73.1	67	-2	19.70	-33.06	56	-73.10	19.70	40.04	-15.36	71.10	4436	18	1916	4843	1.52	3.79
	13857919.310	3216899.688	-13.36	SJGB019	-49.82	67	1.5	19.70	-33.06	35	-49.82	19.70	16.76	-15.36	51.32	3202	18	1916	2027	1.20	1.70
SJSB101	13857709.580	3216809.881	-0.15	SJGB002	-58.75	63	-2	34.40	-34.55	59.5	-58.75	34.40	24.20	-12.15	56.75	3540	22	2424	2927	1.51	3.86
SJSB102	13857180.230	3217192.143	-2.05	SJGB008	-61	133	-2	23.00	-25.05	58	-61.00	23.00	35.95	-20.15	59.00	3681	5	530	4348	1.33	2.06
SJSB103	13857998.430	3216974.835	-15.36	SJBG057	-73.1	43	-2	19.70	-35.06	56	-73.10	19.70	38.04	-15.36	71.10	4436	20	2132	4601	1.52	3.76
	13857998.430	3216974.835	-15.36	SJGB020	-48.17	87	1.5	22.00	-37.36	32	-48.17	22.00	10.81	-15.36	49.67	3099	22	2381	1308	1.19	1.56
SJSB104	13857613.240	3217397.901	-5.59	SJBG005	-65	140	-2	24.40	-29.99	60.5	-65.00	24.40	35.01	-5.49	63.00	3930	25	2651	4235	1.75	14.57
SJSB105	13857485.550	3217440.440	-4.36	SJGB007	-67.75	153	-2	24.40	-28.76	64.5	-67.75	24.40	38.99	-20.36	65.75	4102	8	909	4716	1.37	2.33
SJSB106	13857469.990	3217311.018	-3.10	SJGB007	-67.75	173	-2	25.00	-28.10	64.5	-67.75	25.00	39.65	-5.10	65.75	4102	23	2489	4796	1.78	17.46

Total BC Unit Weight	19.0	kN/m3	121.0	pcf
Total BC Unit Weight	19.5	kN/m3	124.1	pcf
Total Sediment Unit Weight	17.0	kN/m3	108.2	pcf
Water Unit Weight	9.8	kN/m3	62.4	pcf
Total FS	1.25			
Effective BC Unit Weight	9.2	kN/m3	58.6	pcf
Effective BS Unit Weight	9.7	kN/m3	61.8	pcf
Effective Sediment Unit Weight	7.2	kN/m3	45.8	pcf
Effective FS	1.5			
Conversion kN/m3 to pcf	6.37			

Notes:
ft = feet
NAD83 = North American Datum of 1983
piezo = piezometer
BC = Beaumont Clay
BS = Beaumont Sand
psf = pounds per square foot
kN/m^3 = kilonewtons per cubic meter
pcf = pounds per cubic foot
FS = Factor of Safety
Orange highlighted rows indicate instances where geotechnical conditions from the closest two geotechnical borings were applied to those locations to assess hydraulic heave. The more conservative of the two assumptions will be carried forward for the basis of design.
Red highlighted rows indicate a FS that is less than the target FS protective of hydraulic heave.

Table 2A

Elevations of Excavation to Maintain Hydraulic Heave Safety Factor of 1.25 - Assumption 1
Hydraulic Heave Analysis
Northern Impoundment - San Jacinto River Waste Pits Superfund Site

Location	Northing (NAD83)	Easting (NAD83)	Surface/Riverbed Elevation (ft)	Reference Borehole	BS Elevation in Reference Borehole (ft)	Distance From Borehole (ft)	Aquifer Piezo Elevation (ft)	BC Depth (ft)	BC Elevation (Ft)	BS Depth (ft)	BS Elevation (ft)	Sediment Thickness (ft)	BC Thickness (ft)	Pressure Head (ft)	Uplift Porepressure (psf)	BC Layer Total Pressure (psf)	FS	Required Sediment Thickness (ft)	Total Analysis Required Minimum Excavation Elevation (ft)	Corresponding Effective Analysis FS
SJGB010	13857411.203	3216753.589	3.00	SJGB001	-56	107	-2	29	-26	59.5	-56.50	29	30.5	54.5	3400	3689	1.25	5.18	-20.82	1.72
SJGB011	13857474.591	3216925.733	3.00	SJCPT-011	-53.4	83	-2	33	-30	58.4	-55.40	33	25.4	53.4	3331	3072	1.25	10.09	-19.91	1.75
SJGB012	13857611.312	3216819.464	3.00	SJCPT-011	-53.4	93	-2	33	-30	58.4	-55.40	33	25.4	53.4	3331	3072	1.25	10.09	-19.91	1.75
SJGB013	13857852.438	3216918.897	-12.5	SJGB018	-53.43	113	-2	30	-42.5	37.5	-50.00	30	7.5	48	2995	907	1.25	26.21	-16.29	1.84
SJGB014	13857716.960	3217158.780	-1.50	SJGB053	-66.7	166	-2	15	-16.5	81	-82.50	15	66	80.5	5022	7983	1.25	-15.76	-32.26	1.67
SJGB016	13857551.031	3217162.509	-0.50	SJCPT-011	-53.4	267	-2	33	-33.5	58.4	-58.90	33	25.4	56.9	3550	3072	1.25	12.61	-20.89	1.75
SJGB017	13857352.164	3217191.717	-0.50	SJGB008	-61	207	-2	23	-23.5	58	-58.50	23	35	56.5	3525	4233	1.25	1.60	-21.90	1.71
SJSB028	13857067.126	3217256.398	1.25	SJGB008	-61	264	-2	23	-25.26	58	-56.75	23	32.8	56.06	3497	3967	1.25	3.74	-21.48	1.72
SJSB029	13857119.314	3217153.087	2.64	SJGB008	-61	193	-2	23	-20.36	58	-55.36	23	35	53.36	3329	4233	1.25	-0.67	-21.03	1.70
SJSB030	13857220.516	3216971.008	4.33	SJMW17	-58	120	-2	23	-18.67	63	-58.67	23	40	56.67	3535	4838	1.25	-3.87	-22.54	1.69
SJSB031	13857295.051	3216774.912	6.00	SJMW17	-58	120	-2	23	-17	63	-57.00	23	40	55	3431	4838	1.25	-5.07	-22.07	1.68
SJSB032	13857444.802	3216651.498	3.21	SJGB001	-56	120	-2	29	-25.79	59.5	-56.29	29	30.5	54.29	3387	3689	1.25	5.03	-20.76	1.72
SJSB033	13857624.835	3216746.671	4.59	SJGB023	-61.66	100	-2	29.5	-24.91	59.8	-55.21	29.5	30.3	53.21	3320	3665	1.25	4.48	-20.43	1.72
SJSB034	13857689.491	3217045.977	8.00	SJCPT-011	-53.4	200	-2	33	-25	58.4	-50.40	33	25.4	48.4	3020	3072	1.25	6.49	-18.51	1.73
SJSB035	13857460.903	3217021.623	8.00	SJCPT-011	-53.4	167	-2	33	-25	58.4	-50.40	33	25.4	48.4	3020	3072	1.25	6.49	-18.51	1.73
SJSB036	13857475.106	3216859.930	2.00	SJCPT-011	-53.4	97	-2	33	-10.75	58.4	-56.40	12.75	45.65	54.4	3394	5522	1.25	-11.82	-22.57	1.66
SJSB037	13857687.402	3216908.317	2.00	SJGB002	-58.75	73	-2	33.5	-31.5	59.5	-57.50	33.5	26	55.5	3462	3145	1.25	10.93	-20.57	1.75
SJSB038	13857563.077	3217138.458	-0.50	SJCPT-011	-53.4	240	-2	33	-33.5	58.4	-58.90	33	25.4	56.9	3550	3072	1.25	12.61	-20.89	1.75
SJSB045	13857135.810	3217343.067	-2.10	SJGB008	-61	57	-2	23	-25.1	58	-60.10	23	35	58.1	3625	4233	1.25	2.75	-22.35	1.71
SJSB045-C1	13857149.350	3217285.350	-1.30	SJGB008	-61	63	-2	23	-24.3	58	-59.30	23	35	57.3	3575	4233	1.25	2.17	-22.13	1.71
SJSB046	13857183.750	3217236.016	-2.00	SJGB008	-61	96	-2	23	-25	58	-60.00	23	35	58	3618	4233	1.25	2.68	-22.32	1.71
SJSB046-C1	13857229.000	3217174.000	-2.39	SJGB008	-61	150	-2	23	-25.39	58	-60.39	23	35	58.39	3643	4233	1.25	2.96	-22.43	1.71
SJSB047	13857278.320	3217421.371	-2.10	SJGB047	-53.4	0	-2	22	-24.1	50	-52.10	22	28	50.1	3126	3387	1.25	4.81	-19.29	1.72
SJSB047-C1	13857302.550	3217340.988	-4.00	SJGB047	-53.4	80	-2	22	-26	50	-54.00	22	28	52	3244	3387	1.25	6.18	-19.82	1.73
SJSB048	13857396.530	3217503.368	-2.40	SJGB007	-67.75	107	-2	23	-25.4	64.5	-66.90	23	41.5	64.9	4049	5020	1.25	0.38	-25.02	1.70
SJSB048-C1	13857398.780	3217445.299	-4.00	SJGB007	-67.75	67	-2	23	-27	64.5	-68.50	23	41.5	66.5	4149	5020	1.25	1.54	-25.46	1.71
SJSB049	13857406.390	3217395.258	-5.10	SJGB007	-67.75	77	-2	23	-28.1	64.5	-69.60	23	41.5	67.6	4217	5020	1.25	2.33	-25.77	1.71
SJSB050	13857546.330	3217527.884	-3.40	SJGB005	-65	67	-2	26	-29.4	60.5	-63.90	26	34.5	61.9	3862	4173	1.25	6.05	-23.35	1.72
SJSB050-C1	13857558.160	3217389.116	-6.30	SJGB005	-65	120	-2	26	-32.3	60.5	-66.80	26	34.5	64.8	4043	4173	1.25	8.14	-24.16	1.73
SJSB051	13857682.020	3217424.684	-2.70	SJGB004	-62.75	93	-2	28	-30.7	59.5	-62.20	28	31.5	60.2	3756	3810	1.25	8.17	-22.53	1.73
SJSB052	13857661.470	3217319.770	-5.70	SJGB004	-62.75	133	-2	28	-33.7	59.5	-65.20	28	31.5	63.2	3943	3810	1.25	10.34	-23.36	1.74
SJSB052-C1	13857626.750	3217222.469	-2.20	SJGB053	-66.7	190	-2	17	-19.2	57	-59.20	17	40	57.2	3569	4838	1.25	-3.49	-22.69	1.69
SJSB053	13857799.520	3217301.198	-9.70	SJGB053	-66.7	0	-2	17	-26.7	57	-66.70	17	40	64.7	4036	4838	1.25	1.92	-24.78	1.71
SJSB053-C1	13857775.270	3217268.406	-7.40	SJGB053	-66.7	40	-2	17	-24.4	57	-64.40	17	40	62.4	3893	4838	1.25	0.26	-24.14	1.70
SJSB054	13857745.960	3217282.887	-7.40	SJGB053	-66.7	57	-2	17	-24.4	57	-64.40	17	40	62.4	3893	4838	1.25	0.26	-24.14	1.70
SJSB055	13857915.360	3217183.420	-4.90	SJGB003	-95.17	60	-2	33	-37.9	84.5	-89.40	33	51.5	87.4	5453	6229	1.25	5.42	-32.48	1.72
	13857915.360	3217183.420	-4.90	SJGB020	-48.17	113	1.5	22	-26.9	40	-44.90	22	18	46.4	2895	2177	1.25	13.32	-13.58	1.77
SJSB055-C1	13857843.355	3217150.478	-9.54	SJGB003	-95.17	30	-2	33	-42.54	84.5	-94.04	33	51.5	92.04	5742	6229	1.25	8.76	-33.78	1.72
SJSB056	13857942.460	3217077.154	-12.40	SJBG057	-73.1	113	-2	17	-29.4	63	-75.40	17	46	73.4	4579	5564	1.25	1.48	-27.92	1.71
	13857942.460	3217077.154	-12.40	SJGB020	-48.17	100	1.5	22	-34.4	40	-52.40	22	18	53.9	3363	2177	1.25	18.72	-15.68	1.78
SJSB056-C1	13857851.608	3217058.119	-4.29	SJSB003	-95.17	100	-2	33	-37.29	84.5	-88.79	33	51.5	86.79	5415	6229	1.25	4.98	-32.31	1.72
SJSB057	13857956.449	3216960.196	-17.1	SJSB057	-73.1	0	-2	17	-34.1	63	-80.10	17	46	78.1	4872	5564	1.25	4.87	-29.23	1.72
	13857956.449	3216960.196	-17.1	SJSB019	-49.82	77	1.5	20	-37.1	35.1	-52.20	20	15.1	53.7	3350	1826	1.25	21.82	-15.28	1.80
SJSB058	13857700.162	3216855.509	0.62	SJGB002	-58.75	43	-2	33.5	-32.88	59.5	-58.88	33.5	26	56.88	3549	3145	1.25	11.93	-20.95	1.75
SJSB070	13857778.065	3216886.192	-1.17	SJGB002	-58.75	43	-2	33.5	-34.67	59.5	-60.67	33.5	26	58.67	3660	3145	1.25	13.22	-21.45	1.75
SJSB071	13857719.189	3216821.133	-0.8	SJGB002	-58.75	43	-2	33.5	-34.3	59.5	-60.30	33.5	26	58.3	3637	3145	1.25	12.95	-21.35	1.75
SJSB072	13857614.250	3216842.652	1.42	SJCPT-011	-53.4	67	-2	33	-31.58	58.4	-56.98	33.00	25.40	54.98	3430	3072	1.25	11.23	-20.35	1.75
SJSB073	13857593.160	3216960.041	1.29	SJCPT-011	-53.4	67	-2	33	-31.71	58.4	-57.11	33.00	25.40	55.11	3438	3072	1.25	11.32	-20.39	1.75
SJSB074	13857543.710	3216728.114	3.34	SJGB001	-56	33	-2	29	-25.66	59.5	-56.16	29.00	30.50	54.16	3379	3689	1.25	4.94	-20.72	1.72
SJSB075	13857486.820	3216843.803	2.28	SJGB001	-56	93	-2	29	-26.72	59.5	-57.22	29.00	30.50	55.22	3445	3689	1.25	5.70	-21.02	1.73
SJSB076	13857508.770	3216910.806	2.26	SJCPT-011	-53.4	60	-2	33	-30.74	58.4	-56.14	33.00	25.40	54.14	3378	3072	1.25	10.62	-20.12	1.75
SJSB077	13857411.880	3216736.668	1.42	SJGB001	-56	100	-2	29	-27.58	59.5	-58.08	29.00	30.50	56.08	3499	3689	1.25	6.32	-21.26	1.73
SJSB078	13857430.030	3216823.139	1.82	SJGB001	-56	107	-2	29	-27.18	59.5	-57.68	29.00	30.50	55.68	3474	3689	1.25	6.03	-21.15	1.73
SJSB079	13857381.900	3216888.271	1.05	SJMW17	-60	177	-2	23	-21.95	63	-61.95	23.00	40.00	59.95	3740	4838	1.25	-1.51	-23.46	1.70
SJSB080	13857320.220	3216827.045	1.77	SJMW17	-60	100	-2	23	-21.23	63	-61.23	23.00	40.00	59.23	3695	4838	1.25	-2.03	-23.26	1.70
SJSB081	13857276.460	3217054.335	-2.26	SJMW17	-60	120	-2	23	-25.26	63	-65.26	23.00	40.00	63.26	3947	4838	1.25	0.88	-24.38	1.71
SJSB082	13857216.120	3217091.823	-1.75	SJMW17	-60	200	-2	23	-24.75	63	-64.75	23.00	40.00	62.75	3915	4838	1.25	0.51	-24.24	1.71
SJSB083	13857242.260	3217187.497	-2.93	SJGB008	-61	153	-2	23	-25.93	58	-60.93	23.00	35.00	58.93	3676	4233	1.25	3.35	-22.58	1.72
SJSB084	13857243.090	3217292.257	-3.86	SJGB008	-61	67	-2	23	-26.86	58	-61.86	23.00	35.00	59.86	3734	4233	1.25	4.02	-22.84	1.72
SJSB085	13857350.670	3217370.887	-5.67	SJGB007	-68.5	53	-2	23	-28.67	64.5	-70.17	23.00	41.50	68.17	4253	5020	1.25	2.74	-25.93	1.71
SJSB086	13857292.630	3217249.901	-2.72	SJGB008	-61	130	-2	23	-25.72	58	-60.72	23.00	35.00	58.72	3663	4233	1.25	3.20	-22.52	1.72
SJSB087	13857311.470	3217114.943	-3.01	SJMW17	-60	240	-2	23	-26.01	63	-66.01	23.00	40.00	64.01	3993	4838	1.25	1.42	-24.59	1.71
SJSB088	13857488.390	3217119.275	-2.12	SJCPT-011	-53.4	240	-2	33	-35.12	58.4	-60.52	33.00	25.40	58.52	3651	3072	1.25	13.78	-21.34	1.76
SJSB089	13857426.020	3217214.579	-2.88	SJGB007	-67.75	220	-2	23	-25.88	49.9	-52.78	23.00	26.90	50.78	3168	3254	1.25	6.53	-19.35	1.73
SJSB090	13857506.130	3217218.409	-1.50	SJGB007	-67.75	267	-2	23	-24.50	49.9	-51.40	23.00	26.90	49.40	3082	3254	1.25	5.53	-18.97	1.73
SJSB091	13857487.240	3217383.273	-3.58	SJGB007	-67.75	160	-2	23	-26.58	54.6	-58.18	23.00	31.60	56.18	3505	3822	1.25	5.17	-21.42	1.72
SJSB092	13857618.600	3217303.607	-4.93	SJGB053	-66.7	187	-2	17	-21.93	57	-61.93	17.00	40.00	59.93	3739	4838	1.25	-1.52	-23.45	1.70
SJSB093	13857582.780	3217129.479	-1.53	SJCPT-011	-53.4	200	-2	33	-34.53	58.4	-59.93	33.00	25.40	57.93	3614	3072	1.25	13.36	-21.17	1.76
SJSB094	13857691.550	3217241.216	-4.22	SJSB053	-69	120	-2	17	-21.22	57	-61.22	17.00	40.00	59.22	3695	4838	1.25	-2.03	-23.25	1.70
SJSB095	13857790.230	3217133.851	-2.07	SJGB003	-95.17	80	-2	33	-35.07	84.5	-86.57	33.00	51.50	84.57	5276	6229	1.25	3.38	-31.69	1.71
SJSB096	13857798.660	3217196.291	-6.55	SJGB003	-95.17	73	-2	33	-39.55	84.5	-91.05	33.00	51.50	89.05	5556	6229	1.25	6.61	-32.94	1.72
SJSB097	13857955.960	3217030.737	-15.64	SJSB057	-73.1	67	-2	17	-32.64	57	-72.64	17.00	40.00	70.64	4407	4838	1.25	6.20	-26.44	1.72
	13857955.960	3217030.737	-15.64	SJGB020	-48.17	80	-2	22	-37.64	32	-47.64	22.00	10.00	45.64	2847	1210	1.25	21.71	-15.93	1.82
SJSB098	13857874.760	3216977.358	-14.36	SJGB019	-49.82	137	1.5	20	-34.36	35.1	-49.46	20.00	15.10	50.96	3179	1826	1.25	19.84	-14.52	1.80
	13857874.760	3216977.358	-14.36	SJSB057	-73.1	80	-2	17	-31.36	58.2	-72.56	17.00	41.20	70.56	4402	4983	1.25	4.80	-26.56	1.72
SJSB099	13857764.250	3216947.207	-0.61	SJGB002	-58.75	80	-2	34	-34.11	59.5	-60.11	33.50	26.00	58.11	3625	3145	1.25	12.81	-21.30	1.75
SJSB100	13857919.310	3216899.688	-13.36	SJSB057	-73.1	67	-2	17	-30.36	63	-76.36	17.00	46.00	74.36	4639	5564	1.25	2.17	-28.19	1.71
	13857919.310	3216899.688	-13.36	SJGB019	-49.82	67	1.5	20	-33.36	35	-48.36	20.00	15.00	49.86	3111	1814	1.25	19.16	-14.20	1.79
SJSB101	13857709.580	3216809.881	-0.15	SJGB002	-58.75	63	-2	34	-33.65	59.5	-59.65	33.50	26.00	57.65	3597	3145	1.25	12.48	-21.17	1.75
SJSB102	13857180.230	3217192.143	-2.05	SJGB008	-61	133	-2	23	-25.05	58	-60.05	23.00	35.00	58.05	3622	4233	1.25	2.71	-22.34	1.71
SJSB103	13857998.430	3216974.835	-30.72	SJSB057	-73.1	43	-2	17	-47.72	57	-87.72	17.00	40.00	85.72	5348	4838	1.25	17.06	-30.66	1.75
	13857998.430	3216974.835	-15.35	SJGB020	-48.17	87	1.5	22	-37.35	32	-47.35	22.00	10.00	48.85	3048	1210	1.25	24.02	-13.33	1.82
SJSB104	13857613.240	3217397.901	-5.49	SJBG005	-65	140	-2	26	-31.49	60.5	-65.99	26.00	34.50	63.99	3992	4173	1.25	7.55	-23.94	1.73
SJSB105	13857485.550	3217440.440	-4.36	SJGB007	-67.75	153	-2	23	-27.36	64.5	-68.86	23.00	41.50	66.86	4171	5020	1.25	1.80	-25.56	1.71
SJSB106	13857469.990	3217311.018	-3.10	SJGB007	-67.75	173	-2	23	-26.10	64.5	-67.60	23.00	41.50	65.60	4093	5020	1.25	0.89	-25.21	1.71

Total BC Unit Weight	19.0	kN/m3	121.0	pcf
Total BC Unit Weight	19.5	kN/m3	124.1	pcf
Total Sediment Unit Weight	17.0	kN/m3	108.2	pcf
Water Unit Weight	9.8	kN/m3	62.4	pcf
Total FS	1.25			
Effective BC Unit Weight	9.2	kN/m3	58.6	pcf
Effective BS Unit Weight	9.7	kN/m3	61.8	pcf
Effective Sediment Unit Weight	7.2	kN/m3	45.8	pcf
Effective FS	1.5			
Conversion kN/m3 to pcf	6.37			

Notes:
ft = feet
NAD83 = North American Datum of 1983
piezo = piezometer
BC = Beaumont Clay
BS = Beaumont Sand
psf = pounds per square foot
kN/m^3 = kilonewtons per cubic meter
pcf = pounds per cubic foot
FS = Factor of Safety
Orange highlighted rows indicate instances where geotechnical conditions from the closest two geotechnical borings were applied to those locations to assess hydraulic heave. The more conservative of the two assumptions will be carried forward for the basis of design.

Table 2B

Elevations of Excavation to Maintain Hydraulic Heave Safety Factor of 1.25 - Assumption 2
Hydraulic Heave Analysis
Northern Impoundment - San Jacinto River Waste Pits Superfund Site

Location	Northing (NAD83)	Easting (NAD83)	Surface/Riverbed Elevation	Reference Borehole	BS Elevation in Reference Borehole (ft)	Distance From Borehole (ft)	Aquifer Piezo Elevation (ft)	BC Depth (ft)	BC Elevation (ft)	BS Depth (ft)	BS Elevation (ft)	Sediment Thickness (ft)	BC Thickness (ft)	Pressure Head (ft)	Uplift Porepressure (psf)	BC Layer Total Pressure (psf)	FS	Required Sediment Thickness (ft)	Total Analysis Required Minimum Excavation Elevation (ft)	Corresponding Effective Analysis FS
SJGB010	13857411.203	3216753.589	3.00	SJGB001	-56	107	-2	29	-26	59.5	-56	29	30	54	3369	3629	1.25	5.38	-20.62	1.73
SJGB011	13857474.591	3216925.733	3.00	SJCPT-011	-53.4	83	-2	33	-30	58.4	-53.4	33	23.4	51.4	3207	2830	1.25	10.89	-19.11	1.75
SJGB012	13857611.312	3216819.464	3.00	SJCPT-011	-53.4	93	-2	33	-30	58.4	-53.4	33	23.4	51.4	3207	2830	1.25	10.89	-19.11	1.75
SJSB013	13857852.438	3216918.897	-12.5	SJGB018	-53.43	113	-2	30	-42.5	37.5	-53.43	30	10.93	51.43	3209	1322	1.25	24.84	-17.66	1.82
SJGB014	13857716.960	3217158.780	-1.50	SJGB053	-66.7	166	-2	15	-16.5	81	-66.7	15	50.2	64.7	4036	6072	1.25	-9.48	-25.98	1.67
SJGB016	13857551.031	3217162.509	-0.50	SJCPT-011	-53.4	267	-2	33	-33.5	58.4	-53.4	33	19.9	51.4	3207	2407	1.25	14.80	-18.70	1.77
SJGB017	13857352.164	3217191.717	-0.50	SJGB008	-61	207	-2	23	-23.5	58	-61	23	37.5	59	3681	4536	1.25	0.60	-22.90	1.71
SJSB028	13857067.126	3217256.398	1.25	SJGB008	-61	264	-2	23	-25.26	58	-61	23	32.8	56.06	3497	3967	1.25	3.74	-21.48	1.72
SJSB029	13857119.314	3217153.087	2.64	SJGB008	-61	193	-2	23	-20.36	58	-61	23	40.64	59	3681	4916	1.25	-2.91	-23.27	1.69
SJSB030	13857220.516	3216971.008	4.33	SJMW17	-58	120	-2	23	-18.67	63	-58	23	39.33	56	3494	4757	1.25	-3.60	-22.27	1.69
SJSB031	13857295.051	3216774.912	6.00	SJMW17	-58	120	-2	23	-17	63	-58	23	41	56	3494	4959	1.25	-5.47	-22.47	1.68
SJSB032	13857444.802	3216651.498	3.21	SJGB001	-56	120	-2	29	-25.79	59.5	-56	29	30.21	54	3369	3654	1.25	5.15	-20.64	1.72
SJSB033	13857624.835	3216746.671	4.59	SJGB023	-61.66	100	-2	29.5	-24.91	59.8	-61.66	29.5	36.75	59.66	3722	4445	1.25	1.92	-22.99	1.71
SJSB034	13857689.491	3217045.977	8.00	SJCPT-011	-53.4	200	-2	33	-25	58.4	-53.4	33	28.4	51.4	3207	3435	1.25	5.30	-19.70	1.73
SJSB035	13857460.903	3217021.623	8.00	SJCPT-011	-53.4	167	-2	33	-25	58.4	-53.4	33	28.4	51.4	3207	3435	1.25	5.30	-19.70	1.73
SJSB036	13857475.106	3216859.930	2.00	SJCPT-011	-53.4	97	-2	33	-10.75	58.4	-53.4	12.75	42.65	51.4	3207	5159	1.25	-10.63	-21.38	1.66
SJSB037	13857687.402	3216908.317	2.00	SJGB002	-58.75	73	-2	33.5	-31.5	59.5	-58.75	33.5	27.25	56.75	3540	3296	1.25	10.44	-21.06	1.74
SJSB038	13857563.077	3217138.458	-0.50	SJCPT-011	-53.4	240	-2	33	-33.5	58.4	-53.4	33	19.9	51.4	3207	2407	1.25	14.80	-18.70	1.77
SJSB045	13857135.810	3217343.067	-2.10	SJGB008	-61	57	-2	23	-25.1	58	-61	23	35.9	59	3681	4342	1.25	2.39	-22.71	1.71
SJSB045-C1	13857149.350	3217285.350	-1.30	SJGB008	-61	63	-2	23	-24.3	58	-61	23	36.7	59	3681	4439	1.25	1.50	-22.80	1.71
SJSB046	13857183.750	3217236.016	-2.00	SJGB008	-61	96	-2	23	-25	58	-61	23	36	59	3681	4354	1.25	2.28	-22.72	1.71
SJSB046-C1	13857229.000	3217174.000	-2.39	SJGB008	-61	150	-2	23	-25.39	58	-61	23	35.61	59	3681	4307	1.25	2.72	-22.67	1.71
SJSB047	13857278.320	3217421.371	-2.10	SJGB047	-53.4	0	-2	22	-24.1	50	-53.4	22	29.3	51.4	3207	3544	1.25	4.29	-19.81	1.72
SJSB047-C1	13857302.550	3217340.988	-4.00	SJGB047	-53.4	80	-2	22	-26	50	-53.4	22	27.4	51.4	3207	3314	1.25	6.41	-19.59	1.73
SJSB048	13857396.530	3217503.368	-2.40	SJGB007	-67.75	107	-2	23	-25.4	64.5	-67.75	23	42.35	65.75	4102	5122	1.25	0.05	-25.35	1.70
SJSB048-C1	13857398.780	3217445.299	-4.00	SJGB007	-67.75	67	-2	23	-27	64.5	-67.75	23	40.75	65.75	4102	4929	1.25	1.83	-25.17	1.71
SJSB049	13857406.390	3217395.258	-5.10	SJGB007	-67.75	77	-2	23	-28.1	64.5	-67.75	23	39.65	65.75	4102	4796	1.25	3.06	-25.04	1.71
SJSB050	13857546.330	3217527.884	-3.40	SJGB005	-65	67	-2	26	-29.4	60.5	-65	26	35.6	63	3930	4306	1.25	5.61	-23.79	1.72
SJSB050-C1	13857558.160	3217389.116	-6.30	SJGB005	-65	120	-2	26	-32.3	60.5	-65	26	32.7	63	3930	3955	1.25	8.85	-23.45	1.73
SJSB051	13857682.020	3217424.684	-2.70	SJGB004	-62.75	93	-2	28	-30.7	59.5	-62.75	28	32.05	60.75	3790	3877	1.25	7.96	-22.74	1.73
SJSB052	13857661.470	3217319.770	-5.70	SJGB004	-62.75	133	-2	28	-33.7	59.5	-62.75	28	29.05	60.75	3790	3514	1.25	11.31	-22.39	1.74
SJSB052-C1	13857626.750	3217222.469	-2.20	SJGB053	-66.7	190	-2	17	-19.2	57	-66.7	17	47.5	64.7	4036	5745	1.25	-6.47	-25.67	1.68
SJSB053	13857799.520	3217301.198	-9.70	SJGB053	-66.7	0	-2	17	-26.7	57	-66.7	17	40	64.7	4036	4838	1.25	1.92	-24.78	1.71
SJSB053-C1	13857775.270	3217268.406	-7.40	SJGB053	-66.7	40	-2	17	-24.4	57	-66.7	17	42.3	64.7	4036	5116	1.25	-0.65	-25.05	1.70
SJSB054	13857745.960	3217282.887	-7.40	SJGB053	-66.7	57	-2	17	-24.4	57	-66.7	17	42.3	64.7	4036	5116	1.25	-0.65	-25.05	1.70
SJSB055	13857915.360	3217183.420	-4.90	SJGB003	-95.17	60	-2	33	-37.9	84.5	-95.17	33	57.27	93.17	5813	6927	1.25	3.13	-34.77	1.71
	13857915.360	3217183.420	-4.90	SJGB020	-48.17	113	1.5	22	-26.9	40	-48.17	22	21.27	49.67	3099	2573	1.25	12.02	-14.88	1.76
SJSB055-C1	13857843.355	3217150.478	-9.54	SJGB003	-95.17	30	-2	33	-42.54	84.5	-95.17	33	52.63	93.17	5813	6366	1.25	8.32	-34.22	1.72
SJSB056	13857942.460	3217077.154	-12.40	SJBG057	-73.1	113	-2	17	-29.4	63	-73.1	17	43.7	71.1	4436	5286	1.25	2.39	-27.01	1.71
	13857942.460	3217077.154	-12.40	SJGB020	-48.17	100	1.5	22	-34.4	40	-48.17	22	13.77	49.67	3099	1666	1.25	20.40	-14.00	1.80
SJSB056-C1	13857851.608	3217058.119	-4.29	SJSB003	-95.17	100	-2	33	-37.29	84.5	-95.17	33	57.88	93.17	5813	7001	1.25	2.45	-34.84	1.71
SJSB057	13857956.449	3216960.196	-17.1	SJSB057	-73.1	0	-2	17	-34.1	63	-73.1	17	39	71.1	4436	4717	1.25	7.65	-26.45	1.73
	13857956.449	3216960.196	-17.1	SJGB019	-49.82	77	1.5	20	-37.1	35.1	-49.82	20	12.72	51.32	3202	1539	1.25	22.76	-14.34	1.81
SJSB058	13857700.162	3216855.509	0.62	SJGB002	-58.75	43	-2	33.5	-32.88	59.5	-58.75	33.5	25.87	56.75	3540	3129	1.25	11.98	-20.90	1.75
SJSB070	13857778.065	3216886.192	-1.17	SJGB002	-58.75	43	-2	33.5	-34.67	59.5	-58.75	33.5	24.08	56.75	3540	2913	1.25	13.98	-20.69	1.76
SJSB071	13857719.189	3216821.133	-0.8	SJGB002	-58.75	43	-2	33.5	-34.3	59.5	-58.75	33.5	24.45	56.75	3540	2957	1.25	13.57	-20.73	1.76
SJSB072	13857614.250	3216842.652	1.42	SJCPT-011	-53.4	67	-2	33	-31.58	58.4	-53.40	33.00	21.82	51.40	3207	2639	1.25	12.65	-18.93	1.76
SJSB073	13857593.160	3216960.041	1.29	SJCPT-011	-53.4	67	-2	33	-31.71	58.4	-53.40	33.00	21.69	51.40	3207	2623	1.25	12.80	-18.91	1.76
SJSB074	13857543.710	3216728.114	3.34	SJGB001	-56	33	-2	29	-25.66	59.5	-56.00	29.00	30.34	54.00	3369	3670	1.25	5.00	-20.66	1.72
SJSB075	13857486.820	3216843.803	2.28	SJGB001	-56	93	-2	29	-26.72	59.5	-56.00	29.00	29.28	54.00	3369	3542	1.25	6.19	-20.53	1.73
SJSB076	13857508.770	3216910.806	2.26	SJCPT-011	-53.4	60	-2	33	-30.74	58.4	-53.40	33.00	22.66	51.40	3207	2741	1.25	11.71	-19.03	1.75
SJSB077	13857411.880	3216736.668	1.42	SJGB001	-56	100	-2	29.00	-27.58	59.5	-56.00	29.00	28.42	54.00	3369	3438	1.25	7.15	-20.43	1.73
SJSB078	13857430.030	3216823.139	1.82	SJGB001	-56	107	-2	29.00	-27.18	59.5	-56.00	29.00	28.82	54.00	3369	3486	1.25	6.70	-20.48	1.73
SJSB079	13857381.900	3216888.271	1.05	SJMW17	-60	177	-2	23	-21.95	63	-60.00	23.00	38.05	58.00	3618	4602	1.25	-0.73	-22.68	1.70
SJSB080	13857320.220	3216827.045	1.77	SJMW17	-60	100	-2	23	-21.23	63	-60.00	23.00	38.77	58.00	3618	4689	1.25	-1.54	-22.77	1.70
SJSB081	13857276.460	3217054.335	-2.26	SJMW17	-60	120	-2	23.00	-25.26	63	-60.00	23.00	34.74	58.00	3618	4202	1.25	2.97	-22.29	1.71
SJSB082	13857216.120	3217091.823	-1.75	SJMW17	-60	200	-2	23.00	-24.75	63	-60.00	23.00	35.25	58.00	3618	4264	1.25	2.40	-22.35	1.71
SJSB083	13857242.260	3217187.497	-2.93	SJGB008	-61	153	-2	23.00	-25.93	58	-61.00	23.00	35.07	59.00	3681	4242	1.25	3.32	-22.61	1.72
SJSB084	13857243.090	3217292.257	-3.86	SJGB008	-61	67	-2	23.00	-26.86	58	-61.00	23.00	34.14	59.00	3681	4129	1.25	4.36	-22.50	1.72
SJSB085	13857350.670	3217370.887	-5.67	SJGB007	-68.5	53	-2	23.00	-28.67	64.5	-68.50	23.00	39.83	66.50	4149	4818	1.25	3.40	-25.27	1.71
SJSB086	13857292.630	3217249.901	-2.72	SJGB008	-61	130	-2	23.00	-25.72	58	-61.00	23.00	35.28	59.00	3681	4267	1.25	3.08	-22.64	1.71
SJSB087	13857311.470	3217114.943	-3.01	SJMW17	-60	240	-2	23	-26.01	63	-60.00	23.00	33.99	58.00	3618	4111	1.25	3.81	-22.20	1.72
SJSB088	13857488.390	3217119.275	-2.12	SJCPT-011	-53.4	240	-2	33	-35.12	58.4	-53.40	33.00	18.28	51.40	3207	2211	1.25	16.61	-18.51	1.78
SJSB089	13857426.020	3217214.579	-2.88	SJGB007	-67.75	220	-2	23.00	-25.88	49.9	-67.75	23.00	41.87	65.75	4102	5064	1.25	0.58	-25.30	1.71
SJSB090	13857506.130	3217218.409	-1.50	SJGB007	-67.75	267	-2	23.00	-24.50	49.9	-67.75	23.00	43.25	65.75	4102	5231	1.25	-0.96	-25.46	1.70
SJSB091	13857487.240	3217383.273	-3.58	SJGB007	-67.75	160	-2	23.00	-26.58	54.6	-67.75	23.00	41.17	65.75	4102	4980	1.25	1.37	-25.21	1.71
SJSB092	13857618.600	3217303.607	-4.93	SJGB053	-66.7	187	-2	17.00	-21.93	57	-66.70	17.00	44.77	64.70	4036	5415	1.25	-3.42	-25.35	1.69
SJSB093	13857582.780	3217129.479	-1.53	SJCPT-011	-53.4	200	-2	33	-34.53	58.4	-53.40	33.00	18.87	51.40	3207	2282	1.25	15.95	-18.58	1.77
SJSB094	13857691.550	3217241.216	-4.22	SJSB053	-69	120	-2	17.00	-21.22	57	-69.00	17.00	47.78	67.00	4180	5779	1.25	-5.12	-26.34	1.69
SJSB095	13857790.230	3217133.851	-2.07	SJGB003	-95.17	80	-2	33.00	-35.07	84.5	-95.17	33.00	60.10	93.17	5813	7269	1.25	-0.03	-35.10	1.70
SJSB096	13857798.660	3217196.291	-6.55	SJGB003	-95.17	73	-2	33.00	-39.55	84.5	-95.17	33.00	55.62	93.17	5813	6727	1.25	4.97	-34.58	1.72
SJSB097	13857955.960	3217030.737	-15.64	SJSB057	-73.1	67	-2	17.00	-32.64	57	-73.10	17.00	40.46	71.10	4436	4894	1.25	6.01	-26.63	1.72
	13857955.960	3217030.737	-15.64	SJGB020	-48.17	80	1.5	22.00	-37.64	32	-48.17	22.00	10.53	49.67	3099	1274	1.25	24.02	-13.62	1.82
SJSB098	13857874.760	3216977.358	-14.36	SJGB019	-49.82	137	1.5	20.00	-34.36	35.1	-49.82	20.00	15.46	51.32	3202	1870	1.25	19.70	-14.66	1.79
	13857874.760	3216977.358	-14.36	SJSB057	-73.1	80	-2	17.00	-31.36	58.2	-73.10	17.00	41.74	71.10	4436	5049	1.25	4.58	-26.78	1.72
SJSB099	13857764.250	3216947.207	-0.61	SJGB002	-58.75	80	-2	33.50	-34.11	59.5	-58.75	33.50	24.64	56.75	3540	2980	1.25	13.35	-20.76	1.76
SJSB100	13857919.310	3216899.688	-13.36	SJSB057	-73.1	67	-2	17.00	-30.36	63	-73.10	17.00	42.74	71.10	4436	5170	1.25	3.47	-26.89	1.71
	13857919.310	3216899.688	-13.36	SJGB019	-49.82	67	1.5	20.00	-33.36	35	-49.82	20.00	16.46	51.32	3202	1991	1.25	18.58	-14.78	1.79
SJSB101	13857709.580	3216809.881	-0.15	SJGB002	-58.75	63	-2	33.50	-33.65	59.5	-58.75	33.50	25.10	56.75	3540	3036	1.25	12.84	-20.81	1.75
SJSB102	13857180.230	3217192.143	-2.05	SJGB008	-61	133	-2	23.00	-25.05	58	-61.00	23.00	35.95	59.00	3681	4348	1.25	2.34	-22.71	1.71
SJSB103	13857998.430	3216974.835	-30.72	SJSB057	-73.1	43	-2	17.00	-47.72	57	-73.10	17.00	25.38	71.10	4436	3070	1.25	22.87	-24.85	1.78
	13857998.430	3216974.835	-15.35	SJGB020	-48.17	87	1.5	22.00	-37.35	32	-48.17	22.00	10.82	49.67	3099	1309	1.25	23.70	-13.65	1.82
SJSB104	13857613.240	3217397.901	-5.49	SJBG005	-65	140	-2	26.00	-31.49	60.5	-65.00	26.00	33.51	63.00	3930	4053	1.25	7.94	-23.55	1.73
SJSB105	13857485.550	3217440.440	-4.36	SJGB007	-67.75	153	-2	23.00	-27.36	64.5	-67.75	23.00	40.39	65.75	4102	4885	1.25	2.24	-25.12	1.71
SJSB106	13857469.990	3217311.018	-3.10	SJGB007	-67.75	173	-2	23.00	-26.10	64.5	-67.75	23.00	41.65	65.75	4102	5038	1.25	0.83	-25.27	1.71

Total BC Unit Weight	19.0	kN/m3	121.0	pcf
Total BC Unit Weight	19.5	kN/m3	124.1	pcf
Total Sediment Unit Weight	17.0	kN/m3	108.2	pcf
Water Unit Weight	9.8	kN/m3	62.4	pcf
Total FS	1.25			
Effective BC Unit Weight	9.2	kN/m3	58.6	pcf
Effective BS Unit Weight	9.7	kN/m3	61.8	pcf
Effective Sediment Unit Weight	7.2	kN/m3	45.8	pcf
Effective FS	1.5			
Conversion kN/m3 to pcf	6.37			

Notes:
ft = feet
NAD83 = North American Datum of 1983
piezo = piezometer
BC = Beaumont Clay
BS = Beaumont Sand
psf = pounds per square foot
kN/m^3 = kilonewtons per cubic meter
pcf = pounds per cubic foot
FS = Factor of Safety
Orange highlighted rows indicate instances where geotechnical conditions from the closest two geotechnical borings were applied to those locations to assess hydraulic heave. The more conservative of the two assumptions will be carried forward for the basis of design.

Table 3

Elevations of Excavation to Maintain Hydraulic Heave Safety Factor of 1.25 - Assumption 1 and 2
Hydraulic Heave Analysis
Northern Impoundment - San Jacinto River Waste Pits Superfund Site

Boring Location	Required Elevations for Assumption 1 (')	Required Elevations for Assumption 2 (')	Recommended Elevations for Excavation Surface (')
SJGB010	-20.82	-20.62	**-20.62**
SJGB011	-19.91	-19.11	**-19.11**
SJGB012	-19.91	-19.11	**-19.11**
SJSB013	-16.29	-17.66	**-16.29**
SJGB014	-32.26	-25.98	**-25.98**
SJGB016	-20.89	-18.70	**-18.70**
SJGB017	-21.90	-22.90	**-21.90**
SJSB028	-21.48	-21.48	**-21.48**
SJSB029	-21.03	-23.27	**-21.03**
SJSB030	-22.54	-22.27	**-22.27**
SJSB031	-22.07	-22.47	**-22.07**
SJSB032	-20.76	-20.64	**-20.64**
SJSB033	-20.43	-22.99	**-20.43**
SJSB034	-18.51	-19.70	**-18.51**
SJSB035	-18.51	-19.70	**-18.51**
SJSB036	-22.57	-21.38	**-21.38**
SJSB037	-20.57	-21.06	**-20.57**
SJSB038	-20.89	-18.70	**-18.70**
SJSB045	-22.35	-22.71	**-22.35**
SJSB045-C1	-22.13	-22.80	**-22.13**
SJSB046	-22.32	-22.72	**-22.32**
SJSB046-C1	-22.43	-22.67	**-22.43**
SJSB047	-19.29	-19.81	**-19.29**
SJSB047-C1	-19.82	-19.59	**-19.59**
SJSB048	-25.02	-25.35	**-25.02**
SJSB048-C1	-25.46	-25.17	**-25.17**
SJSB049	-25.77	-25.04	**-25.04**
SJSB050	-23.35	-23.79	**-23.35**
SJSB050-C1	-24.16	-23.45	**-23.45**
SJSB051	-22.53	-22.74	**-22.53**
SJSB052	-23.36	-22.39	**-22.39**
SJSB052-C1	-22.69	-25.67	**-22.69**
SJSB053	-24.78	-24.78	**-24.78**
SJSB053-C1	-24.14	-25.05	**-24.14**
SJSB054	-24.14	-25.05	**-24.14**
SJSB055	-32.48	-34.77	**-13.58**
	-13.58	-14.88	
SJSB055-C1	-33.78	-34.22	**-33.78**
SJSB056	-27.92	-27.01	**-14.00**
	-15.68	-14.00	
SJSB056-C1	-32.31	-34.84	**-32.31**
SJSB057	-29.23	-26.45	**-14.34**
	-15.28	-14.34	
SJSB058	-20.95	-20.90	**-20.90**
SJSB070	-21.45	-20.69	**-20.69**
SJSB071	-21.35	-20.73	**-20.73**
SJSB072	-20.35	-18.93	**-18.93**
SJSB073	-20.39	-18.91	**-18.91**
SJSB074	-20.72	-20.66	**-20.66**
SJSB075	-21.02	-20.53	**-20.53**
SJSB076	-20.12	-19.03	**-19.03**
SJSB077	-21.26	-20.43	**-20.43**
SJSB078	-21.15	-20.48	**-20.48**
SJSB079	-23.46	-22.68	**-22.68**
SJSB080	-23.26	-22.77	**-22.77**
SJSB081	-24.38	-22.29	**-22.29**
SJSB082	-24.24	-22.35	**-22.35**
SJSB083	-22.58	-22.61	**-22.58**
SJSB084	-22.84	-22.50	**-22.50**
SJSB085	-25.93	-25.27	**-25.27**
SJSB086	-22.52	-22.64	**-22.52**
SJSB087	-24.59	-22.20	**-22.20**
SJSB088	-21.34	-18.51	**-18.51**
SJSB089	-19.35	-25.30	**-19.35**
SJSB090	-18.97	-25.46	**-18.97**
SJSB091	-21.42	-25.21	**-21.42**
SJSB092	-23.45	-25.35	**-23.45**
SJSB093	-21.17	-18.58	**-18.58**
SJSB094	-23.25	-26.34	**-23.25**
SJSB095	-31.69	-35.10	**-31.69**
SJSB096	-32.94	-34.58	**-32.94**
SJSB097	-26.44	-26.63	**-13.62**
	-15.93	-13.62	
SJSB098	-14.52	-14.66	**-14.52**
	-26.56	-26.78	
SJSB099	-21.30	-20.76	**-20.76**
SJSB100	-28.19	-26.89	**-14.20**
	-14.20	-14.78	
SJSB101	-21.17	-20.81	**-20.81**
SJSB102	-22.34	-22.71	**-22.34**
SJSB103	-30.66	-24.85	**-13.33**
	-13.33	-13.65	
SJSB104	-23.94	-23.55	**-23.55**
SJSB105	-25.56	-25.12	**-25.12**
SJSB106	-25.21	-25.27	**-25.21**

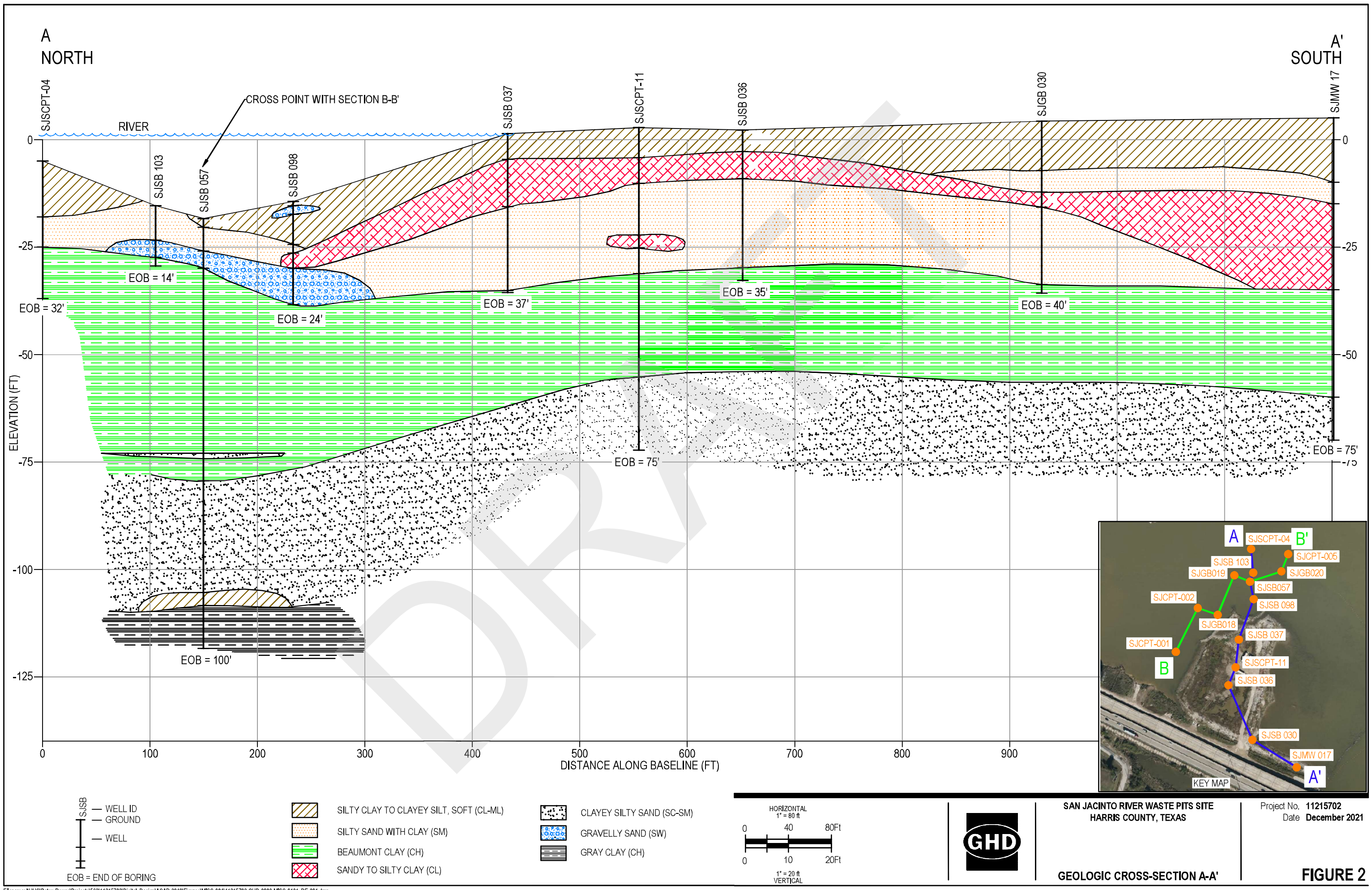
Table 4

Hydraulic Heave Evaluation Summary
Hydraulic Heave Analysis
Northern Impoundment - San Jacinto River Waste Pits Superfund Site

Boring Location	FS = 1.25 Excavation Limit (')	Minimum Excavation Elevation (')*	Heave Concern (Delta ')	Elevation of Water Level Needed to Counter Heave (')
SJGB010	-20.62	-6.32	-14.30	-
SJGB011	-19.11	-9.59	-9.52	-
SJGB012	-19.11	-7.57	-11.54	-
SJSB013	-16.29	-16.04	**-0.25**	-
SJGB014	-25.98	-9.22	-16.76	-
SJGB016	-18.70	-6.07	-12.63	-
SJGB017	-21.90	-17.85	**-4.05**	-
SJSB028	-21.48	-1.52	-19.96	-
SJSB029	-21.03	2.68	-23.71	-
SJSB030	-22.27	4.33	-26.60	-
SJSB031	-22.07	5.12	-27.19	-
SJSB032	-20.64	-8.29	-12.35	-
SJSB033	-20.43	-8.88	-11.55	-
SJSB034	-18.51	6.99	-25.50	-
SJSB035	-18.51	6.64	-25.15	-
SJSB036	-21.38	-10.75	-10.63	-
SJSB037	-20.57	-9.57	-11.00	-
SJSB038	-18.70	-12.98	-5.72	-
SJSB045	-22.35	-2.10	-20.25	-
SJSB045-C1	-22.13	-13.30	-8.83	-
SJSB046	-22.32	-20.00	**-2.32**	-
SJSB046-C1	-22.43	-20.39	**-2.04**	-
SJSB047	-19.29	-2.10	-17.19	-
SJSB047-C1	-19.59	-20.00	**0.41**	-
SJSB048	-25.02	-2.40	-22.62	-
SJSB048-C1	-25.17	-22.00	**-3.17**	-
SJSB049	-25.04	-19.10	-5.94	-
SJSB050	-23.35	-3.40	-19.95	-
SJSB050-C1	-23.45	-6.30	-17.15	-
SJSB051	-22.53	-2.70	-19.83	-
SJSB052	-22.39	-5.70	-16.69	-
SJSB052-C1	-22.69	-2.20	-20.49	-
SJSB053	-24.78	-9.70	-15.08	-
SJSB053-C1	-24.14	-7.40	-16.74	-
SJSB054	-24.14	-23.40	**-0.74**	-
SJSB055	-13.58	-4.90	-8.68	-
SJSB055-C1	-33.78	-13.54	-20.24	-
SJSB056	-14.00	-12.40	**-1.60**	-
SJSB056-C1	-32.31	-4.29	-28.02	-
SJSB057	-14.34	-26.39	**12.05**	**-7.50**
SJSB058	-20.90	-17.38	**-3.52**	-
SJSB070	-20.69	-15.17	-5.52	-
SJSB071	-20.73	-18.80	**-1.93**	-
SJSB072	-18.93	-20.58	**1.65**	-
SJSB073	-18.91	-10.71	-8.20	-
SJSB074	-20.66	-4.66	-16.00	-
SJSB075	-20.53	-9.72	-10.81	-
SJSB076	-19.03	-9.74	-9.29	-
SJSB077	-20.43	-14.58	-5.85	-
SJSB078	-20.48	-20.18	**-0.30**	-
SJSB079	-22.68	-10.95	-11.73	-
SJSB080	-22.77	-8.23	-14.54	-
SJSB081	-22.29	-14.26	-8.03	-
SJSB082	-22.35	-11.75	-10.60	-
SJSB083	-22.58	-14.93	-7.65	-
SJSB084	-22.50	-9.86	-12.64	-
SJSB085	-25.27	-13.67	-11.60	-
SJSB086	-22.52	-2.72	-19.80	-
SJSB087	-22.20	-19.01	**-3.19**	-
SJSB088	-18.51	-20.12	**1.61**	-
SJSB089	-19.35	-14.88	**-4.47**	-
SJSB090	-18.97	-11.50	-7.47	-
SJSB091	-21.42	-3.58	-17.84	-
SJSB092	-23.45	-18.93	**-4.52**	-
SJSB093	-18.58	-15.53	**-3.05**	-
SJSB094	-23.25	-16.22	-7.03	-
SJSB095	-31.69	-18.07	-13.62	-
SJSB096	-32.94	-18.55	-14.39	-
SJSB097	-13.62	-15.64	**2.02**	-
SJSB098	-14.52	-28.36	**13.84**	**-4.45**
SJSB099	-20.76	-12.61	-8.15	-
SJSB100	-14.20	-15.36	**1.16**	-
SJSB101	-20.81	-12.15	-8.66	-
SJSB102	-22.34	-20.05	**-2.29**	-
SJSB103	-13.33	-15.36	**2.03**	-
SJSB104	-23.55	-5.49	-18.06	-
SJSB105	-25.12	-20.36	**-4.76**	-
SJSB106	-25.21	-5.10	-20.11	-

Note:
* Elevation of deepest concentration >30 nanograms per kilogram (ng/kg) TEQ. Some boring locations may require deeper excavation based on the final grading plan.
FS = Factor of Safety


SJCPT-004
SJCPT-005
SJGB020
SJCPT-006
SJCPT-003
SJGB019
SJSB057
SJCPT-006A
SJCPT-002A
SJGB013
SJGB003
SJCPT-002
SJGB018
SJSB053
SJGB004
SJCPT-007
SJGB002
SJGB014
SJSB058
SJSB037
SJSB034
SJCPT-001
SJSB033
SJMW-014
SJGB012
SJGB005
SJGB023
SJMW-015
SJMW-016
SJSB038
SJCPT-011
SJGB006
SJGB016
SJGB015
SJSB050
SJGB027
SJCPT-008
SJGB001
SJSB036
SJGB011
SJSB035
SJSB032
SJGB021
SJGB010
SJGB017
SJCPT-009
SJGB026
SJGB007
SJSB031
SJGB009
SJSB047
SJGB025
SJSB030
SJGB008
SJGB022
SJSB029
SJGB024
SJMW-017
SJSB028
SJCPT-010
Legend
SDI CPT Boring Location
CPT Calibration Boring
Shear Vane Testing
SDI Shallow Piezometer Location
SDI Intermediate Piezometer Location
SDI Deep Piezometer Location
SDI Deep Piezometer with SPT and Shelby Tubes Location
RI Geotechnical Core with Primary and Secondary COPCs
RI Geotechnical Core
PDI-1 Geotechnical Boring Location
PDI-1 Analytical and Geotechnical Boring Location
PDI-2 Analytical Geotechnical Boring Location
PDI-2 Geotechnical Boring Location
SDI Geotechnical Stratigraphy Borings
Conceptual BMP Alignment
Non-impacted Berm Area
TCRA Cap Perimeter
Extent of ACBM
Paper Size ANSI B
0 30 60 90 120
Feet
Map Projection: Lambert Conformal Conic
Horizontal Datum: North American 1983
Grid: NAD 1983 StatePlane Texas South Central FIPS 4204 Feet
N
GHD
SAN JACINTO RIVER WASTE PITS SITE
HARRIS COUNTY, TEXAS
SITE LOCATIONS PLAN -
SOUNDING LOCATIONS
Project No. 11215702
Revision No. -
Date Dec 7, 2021
FIGURE 1
I:\GIS\GIS\Projects\11180000s\11187072\Layouts\MISC001\11187072-00(MISC001)GIS-BR073.mxd
Print date: 07 Dec 2021 - 08:39
Data source: Imagery - Google, 2019.



GHD

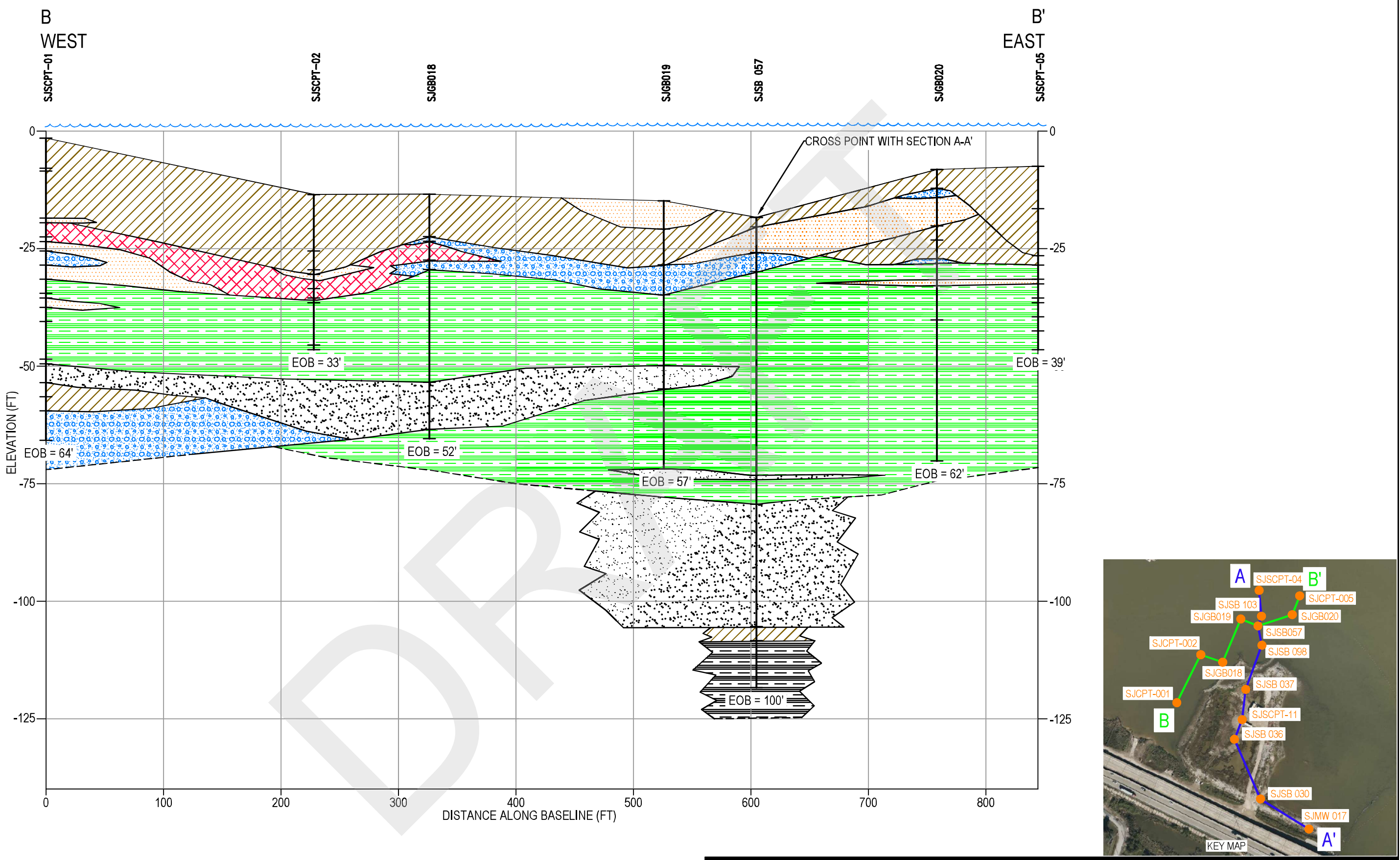
SAN JACINTO RIVER WASTE PITS SITE
HARRIS COUNTY, TEXAS

Project No. 11215702
Date December 2021

GEOLOGIC CROSS-SECTION A-A'

FIGURE 2

Filename: N:\US\Baton Rouge\Projects\562\11215702\Digital_Design\ACAD 2019\Figures\MISC-001\11215702-GHD-0000-MISC-0101_DE-001.dwg
Plot Date: 07 December 2021 9:52 AM



— WELL ID
— GROUND
— WELL
EOB = END OF BORING

SILTY CLAY TO CLAYEY SILT, SOFT (CL-ML)
SILTY SAND WITH CLAY (SM)
BEAUMONT CLAY (CH)
SANDY TO SILTY CLAY (CL)
CLAYEY SILTY SAND (SC-SM)
GRAVELLY SAND (SW)
GRAY CLAY (CH)

HORIZONTAL 1" = 80 ft
VERTICAL 1" = 20 ft

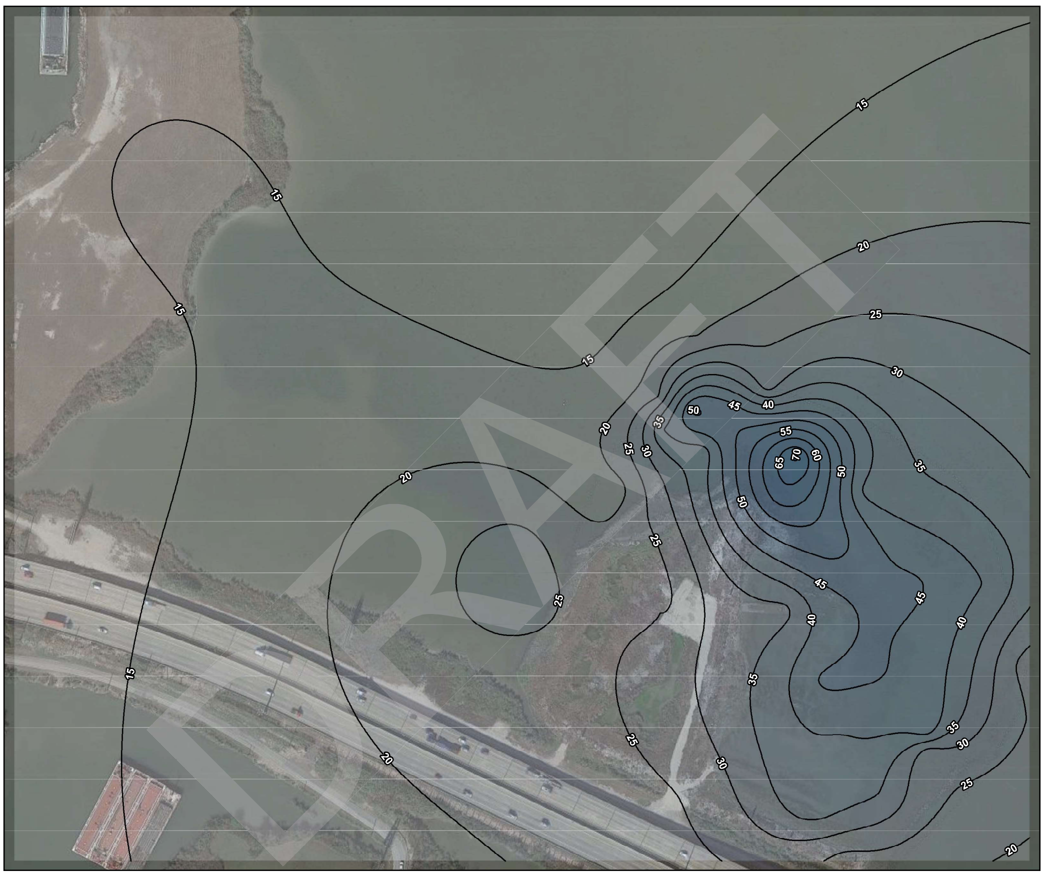
SAN JACINTO RIVER WASTE PITS SITE
HARRIS COUNTY, TEXAS

Project No. 11215702
Date December 2021

GEOLOGIC CROSS-SECTION B-B'

FIGURE 3

DRAFT



Legend

- Contour (20)

Thickness (ft)

- 0 - 15
- 15 - 20
- 20 - 25
- 25 - 30
- 30 - 35
- 35 - 40
- 40 - 45
- 45 - 50
- 50 - 55
- 55 - 60
- 60 - 65
- 65 - 70
- 70 - 75

Paper Size ANSI B

0 50 100 150 200

Feet

N

Map Projection: Lambert Conformal Conic
Horizontal Datum: North American 1983
Grid: NAD 1983 StatePlane Texas South Central FIPS 4204 Feet

GHD

SAN JACINTO RIVER WASTE PITS
CHANNELVIEW, HARRIS COUNTY, TEXAS

BEAUMONT CLAY THICKNESS CONTOUR

Project No. **11215702**
Revision No. **-**
Date **Dec 6, 2021**

FIGURE 4

Q:\GIS\PROJECTS\11215000s\11215702\Beaumont Clay\11215702_202111_BeaumontClay_GIS004.mxd

Data source: Google Earth, Imagery Date 11/16/2020

Appendices

Appendix A

Beaumont Clay Sample Photographs

Site Photographs

Photo 1 ***Figure D.1: Sample G11 (40 to 42 feet (ft) deep in borehole SJSB-018).***

Photo 2 ***Figure D.2: Sample G07 (30 to 32 ft deep in borehole SJSB-019).***

Photo 3 ***Figure D.3: Sample G14 (40 to 42 ft deep) in borehole SJSB-020.***

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Appendix C

Use of Area-Based Average Concentration to Meet Cleanup Level

Appendix C
Use of Area-Based Average Concentration to Meet Cleanup Level

1. Introduction

GHD Services Inc. (GHD), on behalf of International Paper Company and McGinnes Industrial Maintenance Corporation (collectively Respondents), has analyzed how the clean-up level of 30 nanogram per kilogram (ng/kg) Toxicity Equivalence (TEQ) of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) for the Northern Impoundment of the San Jacinto River Waste Pits Superfund Site, located in Harris County, Texas (Site) was developed. GHD performed this analysis as a basis for proposing that the clean-up level of 30 ng/kg TEQ be implemented on an area-based average concentration rather than on a point-by-point basis. That analysis, detailed below, was presented to the United States Environmental Protection Agency (USEPA) during a Technical Working Group (TWG) Meeting on November 16, 2021. During that meeting, the USEPA expressed its position that this approach cannot be used because the Record of Decision (ROD; USEPA, 2017a) does not specifically authorize the use of average concentrations.

2. Use of Average Concentrations to Meet Clean-up Level

Several lines of evidence support the use of an average concentration statistic as the appropriate way to achieve the clean-up level of 30 ng/kg TEQ. These are discussed below as they pertain to 1) the derivation of risk estimates for the Northern Impoundment by Integral Consulting and Anchor QEA (Integral & Anchor; 2013) and USEPA (2016); 2) how the clean-up level of 30 ng/kg TEQ was derived; and 3) the proper application of the clean-up level based on how it was derived.

The general premise underlying the use of average concentrations is that estimates of risk, which are the basis of action for the ROD, are based on exposures to conservative estimates of the average concentrations of chemical (USEPA 1989, 2002a). When human health risk assessments are conducted, risk is not characterized based on exposure to a single concentration of a chemical. It is instead assessed based on exposure to a concentration that represents an average of the concentrations to which a person is exposed over time. This is a fundamental principle of risk assessment and risk management. As such, it is appropriate to apply the clean-up level for the Northern Impoundment on an area averaged basis and not on a point-by-point basis.

2.1 Assessment of Risk to Human Health

2.1.1 Baseline Human Health Risk Assessment (Integral and Anchor, 2013)

A site-specific baseline human health risk assessment (BHHRA) was conducted by Integral and Anchor (2013) to determine potential pathways by which human receptors could be exposed to upland or aquatic contamination in sediment, soil, water, or biota, the amount of contamination receptors of concern they may be exposed to, and the toxicity of those contaminants if no action were taken to address contamination at the Northern Impoundment (Integral & Anchor 2013b, Integral 2012). Subsequently, the USEPA (2017) accepted the BHHRA as:

> "*the basis for taking action and [to] identify the contaminants and exposure pathways that need to be addressed by the remedial action.*" (p. 37).

The cancer risks and non-cancer hazards developed in the BHHRA are based on a series of exposure assumptions applicable to the three types of exposures evaluated: 1) ingestion of sediment or soil; 2) dermal absorption of chemicals from sediment or soil; and 3) the ingestion of fish or shellfish. Specifically, the risk estimates for the *recreational child fisher*, identified in the ROD as the basis for action, were based on exposure through direct contact with sediment (incidental ingestion and dermal contact), and ingestion of finfish (represented by hardhead catfish).

Cancer risks and non-cancer hazards for the *child recreational fisher* presented in the BHHRA were calculated using exposure point concentrations (EPCs) for each exposure medium (i.e., sediment and fish). Consistent with USEPA guidance (1989, 2002a), the EPCs used in the BHHRA were conservative estimates of the *arithmetic average* for each medium. These EPC values were chosen because, as described in USEPA guidance (1989, page 6-19):

> *"The concentration term in the intake equation is the arithmetic average of the concentration that is contacted over the exposure period. Although this concentration does not reflect the maximum concentration that could be contacted at any one time, it is regarded as a reasonable estimate of the concentration likely to be contacted over time. This is because in most situations, assuming long-term contact with the maximum concentration is not reasonable."* (*Emphasis added*).

Therefore, consistent with USEPA guidance and policy, conservative estimates of the mean were used to calculate cancer risks and non-cancer hazards for the child recreational fisher that served as the basis for action at the Northern Impoundment. Exposure to a child was found to be more conservative than exposure to adult or a combined adult and child exposure. The excess lifetime cancer risk for the *child recreational fisher* scenario was calculated from direct exposure to sediment through: 1) the incidental ingestion of sediment; 2) dermal contact with sediment; and 3) indirect exposure to sediment through the ingestion of fish. The cancer risk estimated for the child recreational fisher at Beach Area E was $2x10^{-5}$, which is within USEPA's generally accepted excess cancer risk range of $1x10^{-6}$ to $1x10^{-4}$. The BHHRA also assessed the potential for non-carcinogenic effects posed by exposure to site-related chemicals. The non-cancer hazard index (HI = sum of hazard quotients [HQ]) for the recreational fisher was greater than 1, which is USEPA's threshold of significance for non-cancer health impacts for chemicals with similar target organs and mechanisms of action. For the child recreational fisher, a HI of 45 was calculated based on dermal contact and incidental ingestion of sediment and direct consumption of fish from the Northern Impoundment. The breakdown is as follows:

Exposure Pathway	Hazard Quotient	Percent Contribution to Hazard Index
Sediment - dermal contact	37	82%
Sediment - incidental ingestion	7	16%
Fish - ingestion	1	2%
Hazard Index (ΣHQ)	**45**	

Based on the results of the BHHRA, dermal contact and incidental ingestion of sediment contributed to 98 percent of the non-cancer hazard, whereas ingestion of fish contributed to only 2 percent.

2.1.2 Human Health Risk Evaluation and Recommended Clean-up Level (USEPA, 2016)

In August 2016, the USEPA re-evaluated the risks posed to the child recreational fisher and derived the sediment clean-up level of 30 ng/kg TEQ, based mostly on the same exposure assumptions used to develop the cancer risk and non-cancer hazards in its human health re-assessment. In reassessing cancer risks and non-cancer hazards, and in developing the recommended sediment clean-up level, USEPA utilized exposure assumptions that were either equal to, or were generally consistent with, those used in the BHHRA. This included using conservative estimates of the arithmetic average concentration for sediment and fish tissue.

2.1.2.1 Risk Re-evaluation

In USEPA's reassessment of risk, the cancer risk for the child recreational fisher was 6.6×10^{-4}, which is marginally greater than the upper end of USEPA's cancer risk range of 1×10^{-6} to 1×10^{-4}. The non-cancer hazard for the child recreational fisher was generally consistent but slightly higher than that calculated in the BHHRA. The HI in the USEPA's reassessment was 66 versus 45 in the BHHRA. The breakdown is as follows:

Exposure Pathway	Hazard Quotient	Percent Contribution to Hazard Index
Sediment - dermal contact	47	71%
Sediment - incidental ingestion	17	26%
Fish - ingestion	2	3%
Hazard Index (ΣHQ)	**66**	

Consistent with the BHHRA, dermal contact and incidental ingestion of sediment contributed to 97 percent of the non-cancer hazard, whereas ingestion of fish contributed only 3 percent to the final HI.

2.1.2.2 Development of the TEQ Clean-up Level

As described in USEPA 2016, the clean-up level 30 ng/kg TEQ for dioxin and dioxin-like compounds was based on the non-cancer hazards posed by this class of chemicals. This clean-up level was based on a non-cancer HI of 1 for a child recreational fisher exposed to Beach Area E. The USEPA acknowledged that this clean-up level is also protective of potential cancer risks posed to the child recreational fisher and results in a cancer risk estimate of 2×10^{-5}. The USEPA adopted the child recreational fisher scenario because:

> *"Risk to a child was found more conservative than exposure to adult or a combined adult and child exposure."* [USEPA 2016, p. 3]

Consequently, the clean-up level developed by the USEPA for the child recreational fisher is protective of all other reasonably possible human receptor populations. The steps by which the USEPA derived the clean-up level are described below.

2.1.2.2.1 Dermal Exposure

For dermal exposure by the child recreational fisher, the USEPA derived a health-protective sediment preliminary remediation goal (PRG) of 2.77×10^{-4} milligram per kilogram (mg/kg) or 277 ng/kg TEQ. This equates to 0.000277 mg/kg or 277 ng/kg. This PRG differs from other PRGs developed by the USEPA (2016), in that dermal exposure was by far the greatest driver of risk (71 percent of the HI) in both the BHHRA and USEPA's reassessment, yet this PRG is orders of magnitude greater than the PRG associated with the fish ingestion pathway (35 ng/kg - see Section 2.1.2.2.4), which only accounted for 3 percent of the non-cancer hazard.

2.1.2.2.2 Incidental Ingestion

For incidental ingestion of sediment by the child recreational fisher, which represented 26 percent of the HI, the USEPA derived a health-protective sediment PRG of 7.86×10^{-4} mg/kg TEQ or 786 ng/kg. As with dermal exposure, this PRG is orders of magnitude greater than the PRG associated with the fish ingestion pathway (35 ng/kg - see Section 2.1.2.2.4), which only accounted for 3 percent of the non-cancer hazard.

2.1.2.2.3 Fish Ingestion

For ingestion of fish by the child recreational fisher, which represented only 3 percent of the risk posed to this receptor, the USEPA derived a health-protective fish tissue PRG of 3.13^{-6} mg/kg TEQ or 3.13 ng/kg. This value is only slightly lower than the fish tissue exposure point concentration (EPC = 5.63 ng/kg; 95% upper confidence limit (UCL) of the mean concentration) used in the risk assessment.

2.1.2.2.4 Total Sediment Clean-up Level

The USEPA subsequently derived a total health protective sediment clean-up level that included risk contributions from:

– Dermal exposure to the conservative estimate of an arithmetic average concentration of sediment (277 ng/kg);
– Incidental ingestion of the conservative estimate of an arithmetic average concentration of sediment (786 ng/kg); and
– Ingestion of a conservative estimate of the arithmetic average concentration in fish.

Deriving a sediment clean-up level for direct exposure to sediment (dermal exposure and incidental ingestion) is straightforward and is completed by calculating a sediment concentration that corresponds to a safe level of sediment exposure (i.e., an HI of 1). Deriving a sediment clean-up level that translates to a safe concentration in fish is more complicated. To calculate a sediment PRG for human protection from ingestion of fish, a biota-sediment accumulation factor (BSAF) is required that correlates sediment concentrations to fish tissue concentrations. This is accomplished by the following equation used by USEPA (2016):

$$Sediment_{fish}PRG = \frac{Fish\ PRG}{BSAF}$$

Where:

$Sediment_{fish}PRG$ (ng/kg)	=	sediment PRG for fish consumption
Fish PRG (ng/kg)	=	fish tissue concentration deemed safe to eat
BSAF	=	the ratio of contaminant concentration in tissue to the contaminant concentration in sediment.

The BSAF is an extremely important parameter that describes the relationship between the concentration of a chemical in sediment and the concentration of that chemical in animal tissue and should be selected based on sound science.

In deriving a sediment concentration that yields a health-protective fish tissue concentration, the USEPA selected and applied a generic TEQ BSAF of 0.09 (found in USEPA guidance documents [2000 and 2005a]) to calculate the sediment PRG for the fish consumption pathway. The selection of this generic TEQ BSAF assumes a fish lipid content of 7 percent for fish species which may or may not be relevant to the Northern Impoundment and a sediment total organic carbon (TOC) content of 3 percent. USEPA disregarded a site-specific 2,3,7,8-TCDD BSAF (Usenko, et al., 2012) and other BSAFs available from USEPA (2003a). USEPA also disregarded its own recommendation (USEPA 2000) to use different BSAF values for different homolog classes - hexaCDD/Fs, heptaCDD/Fs, and OCDD/F, despite the relevance of these homologs with respect to the Northern Impoundment. Instead, the USEPA arbitrarily chose a value presented in the *Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities* (USEPA 2005a).

By applying a generic TEQ BSAF of 0.09 unscientifically without regard to appropriate consideration of sediment total organic carbon, the lipid content of the fish that would be found in the vicinity of the Northern Impoundment, or the various homologue classes, the USEPA derived a sediment PRG for fish consumption of 3.5×10^{-5} mg/kg or 35 ng/kg.

By adding in the incremental non-cancer hazard from exposure to dioxin and dioxin-like compounds through dermal contact with sediment and incidental ingestion of sediment, the USEPA derived a “total PRG” of 2.89×10^{-5} mg/kg or 28.9 ng/kg, which the USEPA rounded up to 30 ng/kg TEQ. This value was adopted as the clean-up level in the 2017 ROD. The table below summarizes the risk components that drive the 30 ng/kg TEQ clean-up level.

Exposure Pathway	Sediment PRG (ng/kg TEQ)	Percent Contribution to Remedial Goal	Percent Contribution to Risk (USEPA 2016)
Sediment - dermal contact	277	11%	71%
Sediment - incidental ingestion	786	4%	26%
Fish - ingestion	35	85%	3%
Clean-up Level	**30**		

The clean-up level adopted in the ROD is driven primarily by the fish consumption pathway. Although this pathway accounted for 85 percent of the final clean-up level, it only accounted for 3 percent of the risk in USEPA’s risk re-evaluation (USEPA 2016). Therefore, risk at the Northern Impoundment is driven by dermal contact with and incidental ingestion of sediment (97 percent), but paradoxically, fish ingestion is the dominant driver of the clean-up level (85 percent). This paradox is attributable solely to the USEPA’s arbitrary selection of its BSAF.

2.1.3 USEPA’s BSAF is not Appropriate

Regardless of the serious shortcomings of USEPA’s arbitrary selection of the TEQ BSAF used to derive the 30 ng/kg clean-up level, a BSAF never corresponds to a single location represented by a single sediment concentration, as suggested by the USEPA. USEPA’s own research (2009, page 5) states specifically:

> *“Probably the most important factor in measuring a BSAF with predictive power is the requirement that the sediment samples analyzed be reflective of the foraging range of the fish.”*

Therefore, a fish BSAF represents the relationship between the fish tissue concentration and the concentration in sediment over the foraging range of the fish. It *does not* represent the relationship between the fish tissue concentration and the maximum concentration in sediment to which the fish is exposed. As such, any clean-up goal based on a BSAF should represent an *average* sediment concentration over which a fish is potentially exposed.

Not only does USEPA’s own research establish that a fish BSAF does not correspond to a single sediment concentration (and instead represents the exposure over the foraging area of the fish) but there is a vast body of scientific knowledge that supports this (e.g., USEPA 1995, USEPA 2009, Gobas and Arnot, 2010, Usenko, et al.,2012, Burkhard, et al., 2010, Carbonaro and Howell, 2009, etc.).

To underscore the importance of this issue, the flathead catfish, which was used by USEPA as a conservative estimate of exposure through fish ingestion, is not a sedentary species. Flathead catfish are known to move and forage over areas much larger than the area contained within the Northern Impoundment. Daugherty and Sutton (2005) documented a mean seasonal home range of flathead catfish of in the spring of 1.5 km, 1.3 km in the fall, and 0.5 km in the summer months. Vokoun and Rabeni (2006) radio-tracked adult flathead catfish and documented linear movement paths with a median of 0.6 km in just 24 hours. Another study documented movement distances in the Pascagoula River of up to 23 km (Barabe, 2009). Therefore, applying the chosen TEQ BSAF as if that fish was exposed only to conditions in the Northern Impoundment and not to conditions across a much larger range results in a clean-up standard that is much lower than what the data supports.

USEPA’s direct misuse of the TEQ BSAF without regard to fish lipid content or sediment total organic carbon adds another level of conservatism to the 30 ng/kg clean-up level. The chosen TEQ BSAF of 0.09 is based on a fish lipid content of 7 percent and a sediment organic carbon content of 3 percent. While the organic carbon content of 3 percent falls within the range of values in the Northern Impoundment, flathead catfish (used by USEPA to estimate exposure through fish ingestion) are known to have lipid contents significantly lower than 7 percent.

Application of the TEQ BSAF using more site-specific values would have a significant impact on the derived clean-up level. Using a lipid content of 1.31 percent for flathead catfish in the Houston shipping channel (Carbonaro and Howell, 2009) would increase the clean-up level to 243 ng/kg. This example alone illustrates how the current clean-up level of 30 ng/kg TEQ is not consistent with site-specific data.

Lastly, to illustrate how inappropriate USEPA's BSAF is, if its TEQ BSAF of 0.09 was applied to the existing sediment EPC that was used in the BHHRA and used by USEPA (2016), the predicted fish tissue concentration would be 1,170 ng/kg. This is 200 times higher than the maximum fish tissue concentration ever measured at the Northern Impoundment. Therefore, USEPA's TEQ BSAF of 0.09 overpredicts fish tissue concentrations by two orders of magnitude. This fact alone should have been a red flag to the USEPA, indicating the need to re-evaluate the appropriateness of the chosen TEQ BSAF and either choose a more realistic TEQ BSAF or to follow its own guidance and account for sediment total organic carbon, the lipid content of the fish, and use different BSAFs for various homologue classes. The end result would be a more appropriate BSAF or set of BSAFs that would result in more realistic fish tissue concentrations and, thus, a more appropriate clean-up level.

2.2 Appropriate Application of a BSAF-Based Clean-up Level

Compliance with any BSAF-based sediment clean-up level, including USEPA's 30 ng/kg TEQ clean-up level, should be on a surface-weighted average concentration (SWAC). Application of a BSAF-based clean-up level on a point-by-point basis is inappropriate for the Northern Impoundments for the following reasons:

- Estimates of risk, which are the basis of action for the ROD, are based on exposures to conservative estimates of the average concentrations of chemical (USEPA 1989, 2002a). This is a fundamental principle of risk assessment and risk management.
- At the Northern Impoundment, assuming long-term contact with the maximum concentration is not reasonable (USEPA 1989). Therefore, the sediment clean-up level of 30 ng/kg, which is the concentration that the USEPA (2016) maintains is protective of human health must be based on:

> *".. the arithmetic average of the concentration that is contacted over the exposure period. Although this concentration does not reflect the maximum concentration that could be contacted at any one time, it is regarded as a reasonable estimate of the concentration likely to be contacted over time." (USEPA 1989).*

- BSAFs represent the relationship between tissue concentrations and exposure to sediment over the entire foraging range of a fish (USEPA 2009). Therefore, because BSAFs are based on an average exposure over a foraging area, any sediment clean-up criteria derived using a BSAF should be interpreted and applied to an area-weighted average concentration.
- With our current knowledge of the nature and extent of contamination at the Northern Impoundment, remediation of all sediment with concentrations above 30 ng/kg TEQ achieves an EPC - which is based on an average concentration - of 14.9 ng/kg TEQ. This is the 95% Adjusted Gamma UCL recommended by USEPA's ProUCL software.

2.3 Applicable Pathways After Remediation

Following remediation, the only applicable exposure pathway would be the potential ingestion of fish. Incidental ingestion of sediment and sediment direct contact pathway will be completely eliminated. Therefore, any PRG for the Northern Impoundment should be based only on the fish consumption pathway. This means that the USEPA's reduction of the PRG for the fish consumption pathway (of 35 ng/kg TEQ, derived using an inappropriate TEQ BSAF) to 30 ng/kg TEQ to reflect the other pathways was inappropriate.

2.4 Achieving the Intent of the Remedial Goal

In the simplest terms, the intent of establishing a clean-up level of 30 ng/kg TEQ, is to protect human health and the environment. An EPC of 30 ng/kg at the Northern Impoundment is best represented by generally accepted and USEPA approved risk assessment practices as "*the arithmetic average of the concentration that is contacted over the exposure period.*" (USEPA 1989). The sections below describe the approach that was proposed to USEPA to achieve the intent of the ROD and meet the clean-up level using an exposure point concentration of 30 ng/kg.

2.4.1 Excavation Strategy

The Respondents proposed at the November 2021 TWG Meeting to demonstrate compliance with the clean-up level in a manner that is consistent with the underlying assumptions used to develop it - by utilizing a site-wide SWAC.

Using the abundant analytical data that has been collected at the Northern Impoundment over the years, a target excavation surface had been developed for all of the Northern Impoundment (excluding the northwest corner, as to which an entirely different remedy will be required). The excavation surface was developed utilizing several guiding principles:

– Areas that are sensitive to hydraulic heave were identified;
– Areas in which there were several feet of clean overburden atop a low-level exceedance of the clean-up level were identified;
– Target excavation depths were identified across the Northern Impoundment such that the resulting surface will meet the clean-up level of 30 ng/kg TEQ on a SWAC basis; and
– A not-to-exceed threshold value lower than 200 ng/kg was applied to the extent practicable.

Using the above guidelines, an excavation surface was developed across the Northern Impoundment that would be implementable, protective of human health and the environment, and results in an exposed surface that is below the clean-up level on a SWAC basis.

In order to determine the excavation surface, each of the 79 soil borings across the Northern Impoundment was assigned a polygon with a defined surface area. Some soil borings were combined due to close proximity or redundant data with the more conservative (i.e., higher) TEQ values selected to carry forward. Each of the remaining soil borings was examined to determine the appropriate excavation elevation. As previously mentioned, areas that are at risk of hydraulic heave and/or areas with several feet of clean overburden were targeted for shallower excavation elevations. A "not-to-exceed" value of 200 ng/kg TEQ was applied, such that concentrations above this level would not be left in place, no matter the depth. There were three exceptions to this "rule" in locations in which hydraulic heave was a problem, but the resulting surface concentration of those polygons was only 347 ng/kg at -18 to -20 ft NAVD88 (SJSB047-C1), 369 ng/kg at -18 to -20 ft NAVD88 (SJSB054), and 219 at -20 to -22 ft NAVD88 (SJSB048-C1), and did not affect the overall SWAC that was calculated to be below 30 ng/kg TEQ (23.31 ng/kg TEQ). Once the target excavation elevations were selected, the SWAC was calculated by multiplying the resulting surface concentration (post-excavation) by the assigned surface area for that polygon and calculating an overall average across the resulting surface of the Northern Impoundment.

An example that was shared in the November 2021 TWG Meeting is shown below to illustrate the methodology for determining the excavation surface. In this example, the selected excavation depths are 4 feet below ground surface (bgs) at Soil Boring 1 (SB-1), 12 feet bgs at SB-2, 6 feet bgs at SB-3, 4 feet bgs at SB-4, and 2 feet bgs at SB-5. Assuming all material above these depths will be removed, the remaining surface concentrations would be 26.8 ng/kg (SB-1), 1.3 ng/kg (SB-2), 24 ng/kg (SB-3), 27 ng/kg (SB-4), and 53 ng/kg (SB-5). Each of these concentrations is then multiplied by the surface area specific to that polygon and a surface weighted average for the entire 0.94-acre area is calculated to be 25.89 ng/kg, which is below the clean-up level of 30 ng/kg.

	Soil Boring 1	Soil Boring 2	Soil Boring 3	Soil Boring 4	Soil Boring 5
0-1	34,700	4,050	1,400	42,000	820
1-2	34,700	4,050	1,400	42,000	820
2-3	45,900	25,065	5.9	720	53
3-4	45,900	25,065	5.9	720	53
4-5	26.8	24,424	340	27	18
5-6	26.8	24,424	340	27	18
6-7	2.24	17,740	24	44	3.5
7-8	2.24	17,740	24	44	3.5
8-9	1.03	12	5.6	25	52
9-10	1.03	12	5.6	25	52
10-11	1.48	340	2.5	4.3	34
11-12	1.48	340	2.5	4.3	34
12-13	0.52	1.3	34	7.0	2.00
13-14	0.52	1.3	34	7.0	2.00
14-15	44.6	1.7	1.4	11	2.30
15-16	44.6	1.7	1.4	11	2.30
16-17	45.4	34	110	7.8	0.40
17-18	45.4	34	110	7.8	0.40
18-19		0.52	8.9		
19-20		0.52	8.9		
20-21		120	3.9		
21-22		120	3.9		
22-23		0.81	4.0		
23-24		0.81	4.0		

Boring Location	Polygon Area (Acres)	Concentration (ng/kg)	Concentration per Acre
Soil Boring 1	0.21	26.8	5.62
Soil Boring 2	0.25	1.3	0.32
Soil Boring 3	0.1	24.0	2.40
Soil Boring 4	0.16	27.0	4.32
Soil Boring 5	0.22	53.0	11.66
Sum	0.94		24.33

Total concentration per acre (24.33) / Total polygon area (0.94) = **25.89 ng/kg**

Total SWAC of 25.89 ng/kg < 30 ng/kg

This excavation surface results in approximately 177,000 cubic yards of total volume removed (not including the northwest corner), which accounts for 99.8 percent of the total mass of dioxins calculated to be present beneath the TCRA cap (excluding dioxins present in the northwest corner). It is important to note that the resulting surface concentrations would be verified through post-confirmation sampling. Placement of a clean cover over the excavated surface could be used as a means of further eliminating exposure pathways.

2.4.2 Validity of a SWAC

Remediation goals based on SWACs are typically applied to bioaccumulative chemicals for human health and wildlife receptors, whereas specific action levels (i.e., not-to-exceed values) are typically used for chemicals that result in an acute toxicity to small home range, sediment-dwelling biota (Pelletier, et al., 2019). This is consistent with application of a SWAC for the Northern Impoundment remedy.

For sites where clean-up goals are established to protect human health based on the fish consumption pathway (as is the case here), the use of a SWAC to determine the effectiveness of a remedy is appropriate. This has been demonstrated at numerous Federal Superfund sites including the Housatonic River, Hudson River, Lower Passaic River Study Area, Fox River, Willamette River, Lower Duwamish Waterway, LCP Chemicals, and Devils Swamp Lake, Kalamazoo River, and Sheboygan River, as detailed in the table below.

Site	USEPA Region	Contaminant	Risk Driver
Housatonic River	Region 1	PCBs	Fish ingestion
Hudson River	Region 2	PCBs	Fish ingestion
Lower Passaic River	Region 2	PCBs/Dioxins	Fish/shellfish ingestion
LCP Chemical	Region 4	PCBs/Mercury	Fish ingestion
Fox River	Region 5	PCBs	Fish ingestion
Kalamazoo River	Region 5	PCBs	Fish ingestion
Sheboygan River	Region 5	PCBs	Fish ingestion
Devil’s Swamp	Region 6	PCBs	Fish ingestion
Willamette River	Region 10	PCBs/Dioxins/Furans	Fish ingestion
Lower Duwamish	Region 10	PCBs/Dioxins/Furans	Fish ingestion

In the sites listed above, the fish/shellfish ingestion pathway was the primary risk driver upon which the remedial goals were based. The remedy for each of these sites were chosen because it resulted in a SWAC(s) that not only achieved concentrations in fish/shellfish tissue that were protective of human health, but also significantly reduced the total mass of the constituents driving the risk. These SWAC goals are measurable, directly related to the risk posed to receptors, and are consistent with final remedies. These are only some of the examples of contaminated sites where post-remediation SWACs were achieved to address unacceptable levels of contamination in fish tissue. Pelletier *et al.* (2019) documented that USEPA RODs used SWAC-based sediment remediation goals appropriately at 21 sites evaluated in their study.

Although not addressed at the presentation during the November 2021 TWG Meeting, at some of the many Superfund sites that employ SWAC-based clean-up strategies, the USEPA has relied on Explanation of Significant Differences (ESDs) and ROD Amendment documents to establish the use of SWACs to determine compliance. For example, at the St. Maries Creosote site located on the St. Joe River in Idaho, the ROD (USEPA 2007) did not specify how compliance would be measured. In response to this gap, the USEPA issued an ESD (USEPA 2014) that established a SWAC of polyaromatic hydrocarbons (PAHs) in the top two feet of sediment to be used to determine compliance with the ROD. In the ESD, the USEPA specifically noted that by using the SWAC-based approach, the remedy remained protective of human health and the environment and that the SWACs meets the ROD standards.

Another precedent comes from the *Fourth Explanation of Significant Differences for the L.A. Clarke and Son Superfund Site* (USEPA 2015b). Because the ROD did not contain an ecological clean-up level for surface soil, the USEPA adopted an ecological clean-up level 50 mg/kg total PAHs as a site-wide average, with a not-to-exceed value of 100 mg/kg total PAHs. This ecological clean-up level reflected soil-based ecological exposures as well as exposures based upon migration to aquatic areas.

Lastly, the USEPA has also used ROD amendments to alter clean-up levels and how they are implemented. One example of the USEPA using a ROD Amendment to implement a SWAC comes from the Continental Steel Superfund Site, Kokomo, Indiana (USEPA, 2003b). USEPA altered their approach to site clean-up by incorporating a SWAC-based approach along lengths of a Kokomo and Wildcat Creeks. The SWAC approach was undertaken because the area over which humans might be exposed was much larger than the areas containing contaminated sediment. For this reason, the USEPA determined that the average concentration was more appropriate and should be used.

2.4.3 Protectiveness of a 30 ng/kg SWAC

Because fish integrate exposure to sediments over the areas where they forage, SWAC-based remediation goals are used as a basis for developing remedies to be health protective against exposures from the ingestion of contaminated fish (e.g., USEPA 2015a and 2017b). The use and validity and protectiveness of a SWAC approach for risk management has been established by the USEPA in several guidance documents (e.g., USEPA 2002b, 2005b, 2007).

The acknowledged protectiveness of a SWAC by USEPA is underscored in the ROD for the Sheboygan Harbor & River Superfund Site (USEPA 2000) where a SWAC of 0.5 mg/kg of PCBs was established to achieve fish tissue concentrations protective of human health:

> *"The selected remedy is protective of human health and the environment, complies with federal and state applicable or relevant and appropriate requirements that are legally applicable or relevant and appropriate to the remedial action, and is cost effective."*

The remedies for more than 20 Superfund sites employ SWACs in their clean-up strategies. Given this widespread acceptance of SWAC-based remedies, it is undeniable that the application of a 30 ng/kg SWAC for the Northern Impoundment will be protective of human health and the environment.

2.5 Consistency with the NCP

According to the National Contingency Plan (NCP), 40 Code of Federal Regulations (CFR) §300.430(a)(1)(i), the "national goal of the remedy selection process is to select remedies that are protective of human health and the environment, that maintain protection over time, and that minimize untreated waste."

The SWAC-based application of a clean-up level is consistent with the NCP. Within the methodology used by the USEPA to develop the clean-up level, 30 ng/kg represents an exposure point concentration to which the child recreational fisher may be exposed through incidental ingestion, dermal contact, and the average concentration to which a fish is exposed. By virtue of this alone, USEPA's own guidance establishes this exposure assumption as "a conservative estimate of the average chemical concentration in an environmental medium" (USEPA 1989). This conservative estimate, coupled with the use of other conservative although not technically justified exposure assumptions (e.g., all fish eaten come from the Northern Impoundment), were used to establish the 30 ng/kg, which make it a highly conservative human health protective clean-up criterion. As such, the application of a BSAF-based clean-up level on an area average basis is consistent with the NCP.

3. Conclusion

The 30 ng/kg TEQ clean-up level developed by the USEPA is based on bad science and is not supportable. It is based on a generic BSAF that does not remotely represent the relationship between sediment concentrations and fish tissue concentrations. Besides being selected arbitrarily, it was misapplied when the USEPA did not account for fish lipid content or sediment TOC. Therefore, there is a basis to re-assess the clean-up level of 30 ng/kg TEQ for the Northern Impoundment. Should that not occur, the Respondents propose to demonstrate compliance with the clean-up level in a manner that is consistent with the underlying assumptions used to develop it - by utilizing a SWAC to determine excavation elevations and for use in confirmatory sampling. Given that the risk assessment methodology used to develop the 30 ng/kg TEQ clean-up level relies on, not only estimates of average contaminant concentration to which humans are exposed, but also on the average concentration of sediment to which fish are exposed, the Respondents contend that the most appropriate way to implement the clean-up level of 30 ng/kg TEQ is on an area-weighted average concentration, and not on a point-by-point basis. Remediation goals based on SWACs are common at Superfund sites because the utilization of SWACs not only achieves concentrations in fish/shellfish tissue that are protective of human health, but also significantly reduces the total mass of the constituents driving the risk. Likewise, SWAC goals are measurable, directly related to the risk posed to receptors, and are consistent with final remedies.

The abundant analytical data that has been collected at the Northern Impoundment allows for the development of a well-informed target excavation surface that meets a 30 ng/kg SWAC. In the Respondents' plan, the excavation surface was established by creating polygons with defined surface areas using the soil borings across the Northern Impoundment. The resulting SWAC is 23.31 ng/kg, which results in a 99.8 percent reduction in the mass of dioxins. These concentrations would subsequently be validated by the post-confirmation sampling required by the ROD (which would also be based upon a SWAC). Following remediation, the only applicable exposure pathway will be the potential ingestion of fish. Incidental ingestion of sediment and the sediment direct contact pathway will be eliminated completely given the depth below the river surface of the sediment. Because the bottom of the excavation will be significantly below the river surface, there is no reasonable way for a human receptor to contact these sediments. However, to fully eliminate all exposure pathways, a clean cover could be placed over the excavated surface. Consequently, with complete pathway elimination and a 99.8 percent reduction in the mass of dioxins, the proposed remediation plan would be effective in both the short-term and long-term, and would reduce the volume and mobility of dioxins, thus protecting both human health and the environment.

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