San Jacinto River Waste Pits Superfund Site Technical Document Review: U.S. EPA Final Interim Feasibility Study Report – September 2016

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Background and site history through the construction of the temporary armored cap

The waste disposal impoundments were built in the mid-1960s for disposal of paper mill wastes. The waste was barged from the Champion Paper Inc. paper mill in Pasadena, Texas to the area waste pits. The Site consists of a set of impoundments located on the western bank of the San Jacinto River in Harris County, Texas just north of the Interstate 10 (I-10) bridge (referred to as the "northern Impoundments," along with and area south of I-10 (referred to as the "southern impoundments", and an area north of the impoundment referred to as the "upland separation area," and immediately surrounding area.

Large scale regional groundwater extraction for water supply in the 1970s and 1980s led to regional subsidence in the vicinity of the SJRWP, which resulted in increased exposure of the contents of the Northern Impoundments to the surface waters of the San Jacinto River. In 2008, the San Jacinto River Waste Pits Superfund Site (SJRWP) was added to the National Priorities List (NPL), or Superfund list, under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The potentially responsible parties (PRPs) for the wastes have been identified as McGinnis Industrial Maintenance Corporation and International Paper, who have been conducting investigation and interim remedial action on the site under the supervision of the EPA. In order to reduce exposure to the waste, the PRPs constructed a temporary armored cap on the Northern Impoundments in 2011 to isolate and contain the waste, pursuant a 2010 EPA administrative settlement agreement and order on consent.

The cap was designed in accordance with U.S. Army Corps of Engineers (USACE) and USEPA guidelines and capping guidance. The approximately 15.7-acre cap, designed and constructed at a cost of approximately $9 million. Portions of the cap include different construction methods. The portions of the cap above water are constructed with layers of armor stone, geotextile and geomembrane. The majority of the submerged area of the cap includes only armor stone and geotextile. Because of the steep angle, the submerged area on the northwestern edge of the impoundments, the cap consists solely of armor stone. The temporary armored cap was designed to withstand a 100-year storm event.

The Southern Impoundment is not currently in contact with surface water. It may have been used for disposal of paper mill waste, as well as other wastes, in the 1960s. Since the 1960s, a variety of industrial

and other activities have taken place on the upland area south of I-10. Most of the peninsula is currently in industrial or commercial use by marine services companies, with some parcels currently unused.

Dioxins and furans are the chemicals of primary concern (COPC) associated with the paper mill waste contamination site, because the highest risk to human health and ecosystems is associated with these chemicals. The highest concentration of contaminants occurs within the original 1966 impoundment perimeter, but elevated concentrations have been reported in sediment samples collected outside of the original perimeter boundary.

Site history since the construction of the cap

Since its completion in July 2011, the temporary armored cap on the Northern Impoundments has generally isolated and contained the wastes. However, a storm event July 2012, resulted in a disruption of about 200 square feet of armor rock, exposing the geotextile. Waste was not exposed or released. The exposed are was filled with armor rock in accordance with the EPA approved maintenance plan, as well as USACE and EPA guidance.

Due to this occurrence, the temporary armored cap's design and construction were the subject of a post-construction evaluation by the PRPs and a separate assessment by USEPA and USACE. Based on this review, USACE recommended enhancements (e.g., placing additional armor rock and constructing flatter slopes) to further ensure the protectiveness of the temporary armored cap. In January 2014, the PRPs implemented all of USACE's recommendations.

In December 2015 another area (approximately 22 feet by 25 feet) on the submerged area in northwest part of the cap was discovered by the USEPA Dive Team to be deficient in armor rock material, and submerged waste material was exposed to the San Jacinto River. Sampling of the exposed waste material found that it contained dioxin/furan over 43,000 nanograms per kilogram (ng/kg), or 215 times the protective concentration level (see below in next section). Sampling from nearby undisturbed areas of the cap did not show elevated levels of waste materials containing dioxin/furan. Repairs of this area were completed in January 2016 by installing a geotextile fabric over the area and covering it with armor stone. Additional areas of missing rock in the normally inundated Eastern Cell were discovered in February and March 2016. These deficiencies were corrected with the placement of additional rock to achieve the minimum required 1-foot thickness.

The EPA requested that USACE perform an evaluation of the cap deficiency area. In their evaluation, USACE found that the deficient area was most probably associated with the construction of the cap. As ground surveys showed subsidence over time in the deficient area, USACE believes that the defect area was caused by sinking of the cap over time due to either improper filter/support layer under the rock cap or unusual decomposition of organic matter under the area. USACE found that initial construction in the northwest area was "spotty" and a large area was deficient and required a second pass of capping to achieve sufficiency. This suggested to USACE that the construction did not have sufficient controls which probably led to the cause for the deficiencies. Additional deficient areas were found by manually

probing the Eastern Cell, indicating potential construction deficiencies. However, the deficiencies found in the Eastern Cell were notably smaller than those identified in the northwest area.

What is the purpose of this study?

The Final Interim Feasibility Study (FS) for the SJRWP, completed by the EPA, evaluates remedial (cleanup) alternatives for the site.

The FS Report presents eight remedial alternatives for the Northern Impoundments (Alternatives 1N, 2N, 3N, 3aN, 4N, 5N, 5aN, and 6N) for waste materials that contain dioxin/furan at levels above the protective concentration level/Preliminary Remediation Goal (PRG) 200 nanograms per kilogram (ng/kg) designed to be protective of a hypothetical recreational visitor and for sediment that contains dioxin/furan at levels above the PRG of 30 ng/kg for a hypothetical recreational fisherman. The alternatives range from continued maintenance of the existing temporary armored cap (Alternative 1N) to full removal of waste and impacted materials (Alternative 6N).

The remedial alternatives for the Southern Impoundment (Alternatives 1S to 4S) address three distinct locations in which subsurface soils contain dioxin/furan at levels above the PRG of 240 ng/kg for a hypothetical future construction worker.

What information and documents did the EPA utilize to complete the FS?

The FS builds upon findings in the following documents completed by the PRPs:

- Remedial Alternatives Memorandum (RAM)
- Remedial Investigation (RI) Report
- Baseline Human Health Risk Assessment (BHHRA)
- Baseline Ecological Risk Assessment (BERA).

The FS also incorporates additional information on remedial technologies presented in the USACE' Evaluation of the San Jacinto Waste Pits Feasibility Study Remediation (Alternatives Evaluation Report).

Finally, the FS reflects the EPA's modified PRGs for waste material in the northern waste pits and for soil and waste material in the southern impoundment, based on the PRPs' Relative Bioavailability Adjustment memorandum; and the modified PRG for sediment in a based on the EPA's memorandum Human Health Risk Evaluation and Recommended Sediment Cleanup Level memorandum.

What is the regulatory background for the FS?

The PRPs prepared the first draft of the FS report under EPA oversight. Following review and comment on the first draft by the EPA and other SJRWP stakeholders, the PRPs submitted a revised draft FS to the

EPA. Following review of the PRPs' second draft, the EPA decided that it would revise and complete the Feasibility Study report.

As part of the process, the EPA requested the technical assistance of the USACE to provide additional information for the revised FS. The USACE Alternatives Evaluation Report was prepared so that EPA could evaluate and supplement the FS work performed by the PRPs. The technical assistance provided by the USACE was to:

1. assess the remediation alternatives presented in the PRPs' draft FS;
2. identify any other remedial action alternatives, technologies or best management practices (BMPs) that might be appropriate for the SJRWP;
3. evaluate the numerical models used by the PRPs for the site; and
4. assess the hydraulic conditions in and around the San Jacinto River.

Specifically, the Alternatives Evaluation Report identified additional alternatives, including an enhanced version of Alternative 3N, referred to in this Feasibility Study as Alternative 3aN, and Alternative 6N*, a full removal alternative with more robust BMPs than the original Alternative 6N proposed by the PRPs. In the FS, EPA changed the name of Alternative 6N* to Alternative 6N, and removed from consideration the PRPs' original full removal alternative as it would result in much higher expected releases.

What did EPA determine from the USACE Alternatives Evaluation Report?

The Alternatives Evaluation Report provided new information for the FS regarding how the temporary armored cap would withstand a severe storm/flooding event in the area. According to the report, the most severe event simulated was the hypothetical simultaneous occurrence of Hurricane Ike and the San Jacinto River flooding that occurred in October 1994. The results from this simulation showed that overall about 80% of the cap experienced significant erosion with scour reaching approximately 2.4-feet through the cap and into the waste material, which may cause significant erosion of the paper mill waste.

The Alternatives Evaluation Report stated that releases from catastrophic events could potentially be addressed by additional cap improvements, including upgrading the blended filter in the Northwestern Area to control sediment migration into the cap, upgrading the armor stone size to a diameter of 15 inches and adding 2 feet of additional armor stone over the existing cap across the waste pits to minimize the potential for disturbance during a severe storm/flooding event. These improvements were incorporated into new Alternative 3aN in the FS. However, USACE did not model the impact of the most severe storm/flooding event simulated with the improvements added to Alternative 3aN. More importantly, based on the U.S. National Climate Assessment, EPA finds that future flooding may be even more intense, exceeding the limits of flood protection infrastructure designed for historical conditions.

The report's evaluation of the containment alternatives is contingent on the continued integrity of the armored cap and is limited by uncertainties in modeling. The USACE acknowledged that the uncertainty inherent in any quantitative analysis technique used to estimate the long-term reliability of the cap is very high, and the uncertainty associated with estimates of the effects of some of the potential failure mechanisms such as propwash and stream instability, is also very high.

In addition, the Corps Alternatives Evaluation Report did not evaluate changing river conditions or stream instability. New channels eroding during flooding, changes in channel cross section due to bank erosion, shoreline breaches, etc. during a high flow event caused by a major flood or hurricane is beyond the ability of existing sediment transport models to simulate. However, the October 1994 flood provides an example of how flooding can cause major erosion and create new water channels outside of the existing San Jacinto River bed, e.g. a 510 feet wide and 15 feet deep channel cut through the Banana Bend oxbow just west of the Rio Villa Park subdivision, about 2 ½ miles northwest of the site. A second major channel cut through Banana Bend just north of the channel through the oxbow. Both of these new channels were cut through areas where sand mining had been done before, as is the case in the vicinity of the SJRWP.

The report also provided information on best management practices (BMPs) that can be implemented to improve the performance of the full removal Alternative 6N. Several of the USACE's comparisons between containment and removal alternatives use the earlier version of Alternative 6N for the comparison, without BMPs, which resulted in relatively high modeled releases of hazardous substances during implementation. The expected releases from the PRPs' original version of Alternative 6N, not using BMPs, were estimated at 3.3% of the total waste to be removed during removal operations; the expected releases from the new Alternative 6N (Alternative 6N* in the Alternatives Evaluation Report) are between 0.2% and 0.34% of the waste, depending on whether sheet pile walls can be effectively used in the Northwest Cell.

The USACE Alternatives Evaluation Report also indicates that there are no documented cases of any armored cap or armored confined disposal facility breaches. However, there have been many occurrences of breaches and slope failures of armored dikes, jetties, and breakwaters, with some of those structures confining dredged material. Finally, the EPA has estimated that the dioxin/furan contaminated paper mill waste in the impoundments will remain hazardous for hundreds of years; none of the examples cited by the USACE have been in place over 100 years, and many are not in aquatic environments as dynamic as the site's location in the San Jacinto River.

How were the remedial action objectives and protective concentration levels for the SJRWP determined?

Remedial Action Objectives (RAOs) and the Preliminary Remediation Goals (PRGs) for waste material, soil and sediment are risk-based criteria that were developed as part of the RI/FS process. The RAOs are focused on remedial measures applicable to waste material, sediments and soils within the SJRWP area to reduce potential exposure pathways to humans and other living species. Therefore, the PRGs utilized in the development of remedial alternatives are those developed for waste materials, soils and

sediments. The PRGs are consistent with reasonably anticipated future uses and applicable to the areas north and south of I-10 for which remedial alternatives were developed.

What are the principal threat wastes and how do they relate to development of remedial alternatives?

The National Contingency Plan (NCP) is the federal government's blueprint for responding to the release of toxic substances. The NCP establishes an expectation that EPA will use treatment to address the principal threats posed by a site wherever practicable. In general, principal threat wastes are materials considered to be highly toxic or highly mobile which generally cannot be contained in a reliable manner or would present a significant risk to human health or the environment should exposure occur.

At the SJRWP, the Northern Impoundments contain dioxin/furan over 43,000 ng/kg, and the Southern Impoundment soils contains dioxin/furan over 50,000 ng/kg. The northern waste pits maximum dioxin/furan concentration is 215 times higher than the PRG, and the Southern Impoundment maximum dioxin/furan concentration is 208 times higher than its PRG. Dioxins and furans are highly persistent chemicals and will not breakdown for hundreds of years.

The site is located in the San Jacinto River, which has experienced a number of severe storms and floods in the past. For example, the 1994 flood exceeded the 100-year return period storm, resulted in severe riverbed scour while cutting new channels outside of the river bed, destroyed or damaged thousands of homes, and undermining and rupturing pipelines both inside and outside of the river channel. The 1994 storm crested at 27.09 feet at the Sheldon, Texas gauge located about five miles upstream of the site. Previous storm resulted in even higher crests of 31.5 feet in 1940 and 32.90 feet in 1929.

Because of both the high concentration and the persistence of dioxin/furan, there is a significant risk to human health or the environment should exposure occur. With the regular occurrence of severe storms and flooding in the area, there is high level of uncertainty that the waste material can be reliably contained for hundreds of years (for details, see the USACE Alternatives Evaluation Report on Galveston Bay Foundation's SJRWP technical assistance webpage in the *Summaries and Reviews of Cleanup Documents* section).

Remedial technologies presented in the FS were subjected to an initial screening process before being developed and included in the final set of remedial alternatives that are discussed in the FS Report. The initial screening process was performed by the PRPs pursuant to a unilateral administrative order issued by the EPA. As noted on the regulatory background above, the EPA subsequently decided to revise and complete the FS report itself. The EPA also entered into an agreement with the USACE to provide additional information and modelling analysis of remedial alternatives for the SJRWP, as shown in the Alternatives Evaluation Report.

What are the remedial alternatives for the Northern Impoundments?

For the area north of I-10, the remedial alternatives focus on containment, treatment, removal, and/or a combination of containment, treatment and removal, together with institutional controls (ICs). All of these alternatives recognize the existence of the temporary armored cap. The final alternatives developed and presented in the FS Report for the Northern Impoundments included:

Alternative 1N – Temporary Armored Cap and Ongoing Operations, Monitoring and Maintenance (No Further Action) - The No Further Action alternative is always included in an evaluation of alternatives in order to present a baseline and basis of comparison. This alternative assumes the temporary armored cap would remain in place, together with fencing, warning signs and access restrictions established as part of the temporary cap, and would be subject to ongoing OMM.

- Estimated Operation & Maintenance Cost (e.g., inspection, maintenance): $0.4 million
- Estimated Total Present Worth Cost: $0.4 million
- Estimated Construction Time: Construction complete

Alternative 2N – Armored Cap, ICs, Ground Water Monitoring, and Monitored Natural Recovery (MNR) - Includes actions described under Alternative 1N and ICs in the form of deed restrictions and notices implemented to place restrictions on dredging and anchoring to protect the integrity of the armored cap and to limit potential disturbance and resuspension of buried sediment near the upland sand separation area located west of the Northern Impoundments. MNR would be used to achieve the PRG for sediment (30 ng/kg) in the sand separation area. Ground water monitoring would be implemented to ensure that there are no long-term unacceptable impacts to ground or surface water resulting from the waste left in place. Monitoring may also involve collecting and analyzing sediment, tissue, and surface water and evaluating the data.

- Estimated Operation & Maintenance Cost: $2.0 million
- Estimated Total Present Worth Cost: $2.0 million
- Estimated Construction Time: Construction complete

Alternative 3N – Upgraded Cap, ICs, Ground Water Monitoring, and MNR - Includes actions described under Alternative 2N plus additional enhancements to the temporary armored cap. The Upgraded Cap will use rock sized for the “No Displacement” design scenario, which is more conservative than the “Minor Displacement” scenario used in the temporary armored cap’s design. This remedial alternative also includes additional measures to protect the Upgraded Cap from potential vessel traffic (e.g., rock berm).

- Estimated Capital Cost: $1.77 million
- Estimated In-Direct and Operation & Maintenance Cost: $2.38 million
- Estimated Total Present Worth Cost: $4.1 million
- Estimated Construction Time: 2 months

Alternative 3aN – Enhanced Cap, Protective Pilings, ICs, Ground Water Monitoring, and MNR - Includes enhancements to Alternative 3N suggested by the USACE in an attempt to address the 80% erosion of the Upgraded Cap (Alternative 3N above), which included substantial erosion of the underlying paper mill waste material. This alternative, 3aN, includes the actions described under Alternative 3N plus additional enhancements to the temporary armored cap recommended by the USACE. The additional cap enhancements added for this alternative include pre-stressed concrete or concrete filled steel pipe pilings placed 30 feet apart around the perimeter of the cap to protect from barge strikes. The spacing is designed to catch a typical barge, which is 35 feet wide. An additional armor stone cap with a thickness of at least 24 inches would be placed over the armor cap for Alternative 3N. The armor stone would have a median diameter of 15 inches. This additional armor stone would cover 13.4 acres of the 17.1 acre armored cap. Also, a course gravel filter layer would be placed on 1.5 acres of the Northwest Area where there is currently no geotextile under the armor cap. The actual scope and design of the cap enhancements, and additional area needed to construct the required slopes, would be determined in the Remedial Design. This additional weight of rock on top of the waste pits may cause cap settling and/or pushing the waste material out the sides of the cap.

- Estimated Capital Cost: $19.7 million
- Estimated In-Direct and Operation & Maintenance Cost: $5.1 million
- Estimated Total Present Worth Cost: $24.8 million
- Estimated Construction Time: 15 months

Alternative 4N – Partial Solidification/Stabilization, Upgraded Cap, ICs, Groundwater Monitoring, and MNR - Provides for solidification and stabilization (S/S) of the most highly contaminated material that exceeds 13,000 ng/kg. This alternative also includes the actions described under Alternative 3N; however, about 23 percent of the temporary armored cap (2.6 acres above the water surface and 1.0 acre in submerged areas) would be removed to provide for S/S of the most highly contaminated material. About 52,000 cubic yards (CY) of materials would undergo S/S. After the S/S is completed, the Upgraded Cap would be re-constructed and the same ICs and MNR as in Alternatives 2N and 3N would be implemented.

- Estimated Capital Cost: $11.13 million
- Estimated In-Direct and Operation & Maintenance Cost: $3.74 million
- Estimated Total Present Worth Cost: $14.8 million
- Estimated Construction Time: 17 months

Alternative 5N – Partial Removal, Upgraded Cap, ICs, Ground Water Monitoring, and MNR - Provides for removal of the most highly contaminated material that exceeds 13,000 ng/kg. The temporary armored cap would be partially removed and the same 52,000 CY of material that would undergo S/S under Alternative 4N would instead be excavated for off-site disposal. After the removal was completed, the Upgraded Cap would be re-constructed and the same ICs and MNR that are part of Alternatives 2N to 4N would be implemented.

- Estimated Capital Cost: $24.86 million

- Estimated In-Direct and Operation & Maintenance Cost: $4.94 million
- Estimated Total Present Worth Cost: $29.8 million
- Estimated Construction Time: 13 months

Alternative 5aN – Partial Removal of Materials Exceeding the PRG, Upgraded Cap, ICs, Ground Water Monitoring, and MNR - All material beneath the temporary armored cap in any location where the water depth is 10-feet or less and which has a contaminant concentration at or above the PRG for the waste material for a hypothetical recreational visitor of 200 ng/kg – about 137,600 CY – would be excavated for off-site disposal. To implement this alternative, about 11.3 acres (72 percent) of the temporary armored cap would be removed to allow for this material to be removed. After excavation of the material, the remaining areas of the temporary armored cap would be upgraded to create an Upgraded Cap. The same ICs and MNR as in Alternatives 2N and 3N would be implemented.

- Estimated Capital Cost: $60.38 million
- Estimated In-Direct and Operation & Maintenance Cost: $9.21 million
- Estimated Total Present Worth Cost: $69.6 million
- Estimated Construction Time: 19 months

Alternative 6N – Removal of Waste Materials Exceeding the PRG, MNR, and ICs - This is the same alternative as 6N* evaluated in the USACE Alternatives Evaluation Report. All waste material above the waste material PRG of 200 ng/kg located beneath the temporary armored cap would be removed. This alternative would involve removal of most of the existing temporary armored cap and the removal of approximately 152,000 CY of waste material. The full removal alternative will utilize BMPs to reduce the resuspension of sediment. The removal will be completed in stages or sections as appropriate to limit the exposure of the uncovered sections of the waste pits to potential storms. Raised berms, sheet piles, and silt curtains in addition to dewatering and removal in the dry to the extent practicable will be used to reduce the resuspension and spreading to the removed material. The berms would be armored on the external/river side with armor material removed from the areas that have geotextile present. The design approach for removal and design of BMPs will be determined in the Remedial Design. Residual concentrations of contaminants following excavation and removal will be covered by at least two layers of clean fill to limit intermixing of residual material with the clean fill. The removed materials would be transported to an off-site landfill.

- Estimated Capital Cost: $77.14 million
- Estimated In-Direct and Operation & Maintenance Cost: $9.83 million
- Estimated Total Present Worth Cost: $87 million
- Estimated Construction Time: 19 months

How did the EPA evaluate the alternatives for the Northern Impoundments? How well do they meet EPA's remedy criteria?

In evaluating the eight final remedial alternatives listed above, the EPA considered the location of the materials. The SJRWP is in a river environment that is subject to dramatic change, creating concerns

about the protectiveness of leaving the waste in and adjacent to the River. The area has a high threat of repeated storm surges and flooding from hurricanes and tropical storms. The history of repeated temporary armor cap maintenance to replace missing or eroded armor stone, with flooding that has been less severe than the design 100-year flood, also creates concerns about the long-term permanence of an armored cap.

Regardless of location, alternatives being considered must be evaluated by nine CERCLA criteria. The two key Threshold Criteria that must be met by a remedy are (1) to provide for overall protection of human health and the environment and (2) comply with the Applicable or Relevant and Appropriate Requirements (ARARs) identified for the site. ARARs are the local, state, and federal standards, requirements, criteria, or limitations that directly apply to a contaminant, location, or action as well as those that are might not directly apply to the study site, but apply to situations that are sufficiently similar to warrant their consideration during the development and evaluation of the site remedial action alternatives.

The containment alternatives (2N through 5aN) will only remain protective if they are properly maintained for the length of time (hundreds of years) that the impounded waste retains its toxicity, and assumes that their integrity is not compromised by extreme weather events, barge strikes and/or changes in the river channel which could result in a future release. Alternative 6N best realizes the Threshold Criteria of overall protectiveness because the waste material would be removed and therefore not subject to a potential future release of a significant amount of waste into the San Jacinto River, although there will be some short term releases of dioxin (estimated by the USACE as between 0.2% and 0.34% of the waste material with BMPs) as a result of implementing the full removal alternative.

Alternatives 1N and 2N rely on continued containment of materials exceeding the PRGs within the existing temporary armored cap. These two alternatives each include a requirement, based on the approved OMM plan, to monitor and maintain the temporary armored cap in accordance with USACE and USEPA guidance to ensure the long-term effectiveness of the cap system.

Alternative 3N includes the features of Alternatives 1N and 2N, together with construction of an Upgraded Cap that exceeds USACE and USEPA design guidance by placing additional armor rock and constructing flatter slopes. In addition, the Upgraded Cap uses larger rock sized for the “No Displacement” design scenario, which more conservative than the “Minor Displacement” scenario used in the temporary armored cap’s design. In addition, Alternative 3N includes the construction of a protective perimeter barrier or other measures around the perimeter of the Upgraded Cap to address concerns regarding potential damage from vessel traffic.

The USACE performed evaluations to address the permanence of the existing repaired temporary cap with the proposed modifications outlined in the capping Alternative 3N. Since its completion in July 2011, the armored cap has generally isolated the waste, but has required many repairs and extensive maintenance. The expected long-term releases from capping are very small in the absence of cap erosion or a major disturbance by a barge strike. However, the USACE found that a severe storm could

erode a sizable portion of the upgraded Alternative 3N cap. The most severe event simulated was the hypothetical simultaneous occurrence of Hurricane Ike (Category 2 hurricane) and the October 1994 flood, with a peak discharge of approximately 390,000 cubic feet per second occurring at the time of the peak storm surge height at the Site. Approximately 80 percent (12.5 acres) of the 15.7 acre upgraded Alternative 3N cap incurred severe erosion during the simulated extreme storm. The maximum scour depth in any grid cell within the cap boundary during this potential extreme event was 2.4 feet resulting in erosion and release of the paper mill waste material containing dioxin.

Some localized disturbances of the cap may occur from bearing capacity failures of the soft sediment, gas entrapment by the geomembrane or geotextiles, or barge strikes, requiring maintenance or repair. USACE believes that the expected releases from these localized disturbances would be very small, much smaller more than releases from removal of the contaminated sediment as predicted for Alternative 6N with enhanced resuspension BMPs, even if these disturbances are not quickly repaired.

USACE estimated that these issues related to cap permanence might be addressed by additional modifications to Alternative 3N (modifications included in Alternative 3aN), including upgrading the blended filter in the northwestern area to control sediment migration into the cap, upgrading the armor stone size with a median size of 15 inches, thickening of the armor cap by an additional 2-feet across most of the waste pits, and installing pilings to protect the cap from barge strikes. However, the USACE report did not consider changing river conditions in its evaluation of the long term permanence of a cap; new channels eroding during flooding as well as changes in channel cross section due to bank erosion, shoreline breaches, etc. during a high flow event caused by a major flood or hurricane is beyond the ability of existing sediment transport models to simulate. In addition, the uncertainty associated with estimates of the effects of some of the potential failure mechanisms, e.g., propwash, stream instability, is very high. Finally, even more severe hurricanes (exceeding Category 2) are possible during the hundreds of years that the dioxin waste will remain hazardous. Therefore, there is a high degree of uncertainty regarding the long term permanence of the cap, even with the improvements suggested by the USACE.

Alternatives 1N, 2N, 3N, and 3aN are containment alternatives that provide substantial long-term protectiveness under normal conditions while avoiding environmental impacts applicable to Alternatives 4N, 5N, 5aN and 6N, all of which require disruption of the existing temporary armored cap to conduct stabilization or removal/disposal of impacted materials. However, Alternatives 1N, 2N, 3N, and 3aN do not provide any further treatment or removal of the dioxin/furan waste. Alternatives 3N and 3aN provide additional long-term protectiveness compared to Alternatives 1N and 2N due to the additional cap enhancements and measures to minimize potential damage to the Upgraded Cap from vessel traffic. Alternative 6N provides the greatest long-term protectiveness and effectiveness because the waste material, except for the residuals, would be permanently removed from the San Jacinto River and there would be no potential for a future release from the Site, and neither would there be any concerns regarding the long term viability and effectiveness of a maintenance program that would have to persist for hundreds of years. Alternative 6N also provides for removal of the dioxin/furan waste, which will be treated for water removal as necessary for transportation and off-site disposal.

In situ capping is a demonstrated technology that has been selected by USEPA for sediment remediation sites across the United States. However, this site's location within the San Jacinto River creates an uncertainty regarding the ability of an engineered cap to reliably contain the dioxin waste over the hundreds of years that the dioxin will remain hazardous. The uncertainty comes from the severe storms and floods that have occurred in the area, and the potential for barge strikes to compromise the cap. The potential for barge strikes is heighted because of the increased barge traffic after the completion of the temporary armored cap. In summary, the armored cap is predicted by the USACE to have long-term reliability from scour related processes except under very severe hydrologic and hydrodynamic events. However, USACE also recognized that the uncertainty associated with estimates of the effects of some of the potential failure mechanisms, e.g., propwash, stream instability, is very high, and that potential changes in the river channel cannot be simulated due to modeling limitations.

Alternatives 4N, 5N, 5aN, and 6N include disruption of the existing temporary armored cap in order to conduct treatment or removal of materials beneath the cap. These alternatives employ design, engineering and operational controls to mitigate the resuspension of impacted waste materials that occurs when using these remedial technologies. Removal technologies have been used at sediment sites as well. Alternatives 4N and 5N would stabilize (4N) or remove (5N) materials. Alternatives 5aN and 6N would remove some (5aN) or all (6N) waste materials. Alternative 4N would stabilize 52,000 CY of the waste material from beneath the temporary armored cap, while Alternative 5N, 5aN, and 6N would remove and dispose of off-site volumes of material ranging from 52,000 CY (Alternative 5N), to 137,600 CY (Alternative 5aN) to 152,000 CY (Alternative 6N). Alternatives 5N, 5aN, and 6N may reduce the amount of long-term OMM associated with the capping and treatment-based alternatives (1N thorough 4N), while 6N would eliminate most OMM except for actions to implement and maintain the MNR and the ICs.

Alternative 3N has an estimated construction duration of 2 months and may require an offsite staging area for armored rock, while Alternative 3aN has an estimated duration of 15 months. Alternatives 4N, 5N, 5aN, and 6N have estimated construction durations ranging from 13 to 19 months. Each of these alternatives would require the establishment, and potential permitting of an off-site facility for sediment and material handling. For Alternatives 5N, 5aN, and 6N, this facility would be utilized for processing and managing removed sediments. The availability and location of an off-site facility could impact the implementability, duration, and costs of these alternatives and are beyond the scope of the FS.

Implementation of Alternatives 4N, 5N, 5aN, or 6N would require removing part of the temporary armored cap and either excavation, dredging, or stabilizing the underlying waste deposits. Stabilization under Alternative 4A is consistent with USEPA's preference for treatment. However, experience at sediment sites indicates that resuspension and release of waste material residuals and dioxins/furans into the water column will likely occur, although to a significantly reduced extent with robust BMPs. Such releases may result in increased fish tissue concentrations of contaminants for several years following completion of dredging.

The selection of management practices used in removal operations has a significant impact on the levels of potential waste material releases that USACE estimates may occur during implementation of a

removal alternative. The initial drafts of the FS prepared by the PRPs did not use robust BMPs, and therefore overestimated likely releases from removal alternatives in comparison with the Alternative 6N described in this FS. Depending on the selection of BMPs, flooding and high flow conditions during removal operations could significantly increase the erosion of waste material residuals. Releases from flood flows over the containment structure regardless of the removal alternative will be dependent on the height of the containment structure and the flood stage. A sheet pile wall built in and supported by an armored waste pit berm and along the southern shoreline to an elevation of about +10 ft. would protect the waste pit excavation from releases from more common floods (e.g., the 25-yr or 50-yr flood stage). Excavation would be performed in the dry to the extent practicable. Removals may be performed in small sections at a time such that the armor stone and geotextile within the small section would be removed, and then the sediment removed and a thin layer of sacrificial fill placed before advancing to the next section and repeating the process. Under these removal operations, it would also be advisable to limit or restrict removal activities to a period when there is a lower probability of tropical storms and flooding conditions. The actual design of protective sheet piles and berms will be determined during the Remedial Design.

BMPs would reduce the resuspension and release of waste material during construction. For alternatives 4N, 5N, 5aN, and 6N, a flood may occur during construction. Therefore, these alternatives will include design and construction methodologies to mitigate and reduce the impact of storms during construction.

For short-term effectiveness, Alternatives 1N and 2N are most favorable, followed by Alternative 3N. Short-term effectiveness ranks high for Alternatives 1N and 2N because these alternatives do not entail active construction and thus construction-related releases. Alternative 3N ranks lower, followed by Alternative 3aN, than Alternatives 1N and 2N for short-term effectiveness because it includes construction considerations such as increased truck traffic, worker safety, water quality, and construction equipment emissions of particulate matter (PM), greenhouse gases, and ozone.

Alternatives 4N, 5N, 5aN, and 6N also involve potential water quality impacts, worker safety risks, and air emission impacts that are estimated to be more than 8 to 20 times greater than for Alternative 3N. Traffic and community impacts for Alternatives 4N, 5N, 5aN, and 6N (measured as truck trips) are estimated to range from 6 to nearly 70 times greater than for Alternative 3N and may not fully account for truck trips associated with operation of an offsite materials management facility. While the removal alternatives are less favorable for short-term effectiveness, Alternatives 4N, 5N, 5aN, and 6N all provide either treatment or removal of waste, at least for a portion of the waste material. Alternative 4N includes treatment (solidification/ stabilization) for about 25% of the volume of the most highly contaminated portion of the waste. Alternative 5N and 5aN both include partial removal of the most highly contaminated waste, with Alternative 5N accounting for 25% of the volume, and Alternative 5aN accounting for about 2/3 of the waste volume. Alternative 6N includes full removal of the waste above the cleanup level.

USACE found that fish tissue contaminant concentrations are directly related to the releases to the water column, but are also related to the entirety of their food sources which are largely impacted by

the water column concentrations and releases. Consequently, depending on the BMPs employed and the feeding range of the fish species, fish tissue contaminant concentrations may be dozens of times higher (for Alternative 6N) than existing tissue concentrations for several years before returning to near existing values. The release amount referenced in the Corps' Report, 2 grams of dioxin, or 0.34% of the amount removed, is based on using silt curtains in the Northwestern Area. However, using robust BMPs, including sheet piles in the Northwestern Area, would reduce the release by 40% and therefore reduce the estimated fish tissue increases by 40% as well.

Construction of any of the proposed Alternatives is not expected to cause any flooding in the vicinity of the Site, and therefore should not require the implementation of any flood control measures during the construction of any of the Alternatives under consideration for the Site.

What is the comparative cost effectiveness for the Northern Impoundments alternatives?

Costs for Alternatives 4N, 5N, 5aN, and 6N are higher than for Alternatives 1N, 2N, 3N, and 3aN. This reflects the challenges of establishing and operating an off-site staging and processing area, removal of the temporary armored cap, in situ treatment or excavation and associated engineering controls, the quantity of materials being addressed, the duration of work, and the high cost of transportation and disposal of impacted sediments.

Alternatives 1N, 2N, 3N, and 3aN provide an equal reduction in the dioxins and furans in sediments in the river within t. For Alternatives 4N, 5N, 5aN, and 6N, the dioxins and furans in sediments in the river are predicted to increase the short-term releases from sediment re-suspension construction-related impacts (e.g., cap removal, disturbance of material below waterline, etc.).

The USACE estimates that the full removal alternative 6N with BMPs (Alternative 6N* in the USACE Alternatives Evaluation Report) including sheet piles in deeper water areas could result in a short-term release to the river of about 0.2% of the contaminant mass due to re-suspension during removal. For the enhanced capping Alternative 3N, no significant short-term release is expected and the cap is expected to be generally resistant to erosion except for very extreme floods, which could erode a sizable portion of the cap. A hypothetical simultaneous occurrence of Hurricane Ike and the October 1994 flood with a peak discharge of approximately 390,000 cubic feet per second was modeled. Approximately 80 percent (12.5 acres) of the 15.7 acre upgraded Alternative 3N cap incurred severe erosion with a release of underlying waste material during the simulated potential extreme storm.

The cost of Alternative 6N ($87 million) is about 21 times more that the cost of the upgraded capping Alternative 3N ($4.1 million), but is about 3.5 times more than the cost of enhanced capping Alternative 3aN ($24.8 million). However, the potential future dioxin release for the temporary cap with the upgrades described for the Upgraded Cap (Alternative 3N) during a future severe storm results in a release of approximately 29% of the dioxin in the waste pits. This modeled future storm erodes much of the cap with a potential release that is over 140 times higher than the short-term release for Alternative 6N using BMPs with sheet piles around all areas (0.2% release). If sheet piles cannot be used in deeper

water due to technical reasons, the short–term release would still be much less (0.34%) than the severe storm release. The additional cost for Alternative 6N ensures that that a future extreme storm will never result in a catastrophic cap failure and release of dioxin to the San Jacinto River.

What are the remedial alternatives for the Southern Impoundment? How well do they meet EPA's remedy criteria?

The area south of I-10 is part of a peninsula on which industrial activity has occurred since at least the early 1960s. In contrast with the area to the north of I-10, the peninsula south of I-10 contains active operations of several shipping and marine industrial services businesses, with the area serving as a transport hub and as a location for barge or ship maintenance, cleaning and painting. The peninsula south of I-10 has been a busy industrial community in the decades after disposal of paper mill wastes in the mid-1960s took place.

Three dioxin and furan source types have been identified in soils of the area of investigation south of I-10, only one of which has a fingerprint that is similar to the paper mill wastes contained in the North Impoundments. Another source is from general urban background, such as fuel combustion and other common municipal activities, or specific local sources. A third source type has a fingerprint that is distinct from the other two sources, and affects only soils in the area of investigation on the peninsula south of I-10. The nature and origin of this dioxin and furan source are unknown.

There are currently no risks to animal species from dioxins and furans in the area of investigation south of I-10. The only risks associated with the disposal of dioxins and furans associated with paper mill wastes in the area of investigation south of I-10 was for a hypothetical future construction worker who might come into contact with the dioxins and furans within the upper 10 feet of soil. The PRG for a hypothetical future construction worker was calculated to be 240 ng/kg in soil, and is applicable to the average concentration in a soil column of 10 feet.

Remedial alternatives were developed for the locations in the area south of I-10 where the average concentration of dioxin/furan in the upper 10-feet of soil below grade exceeds the PRG in soil for the hypothetical future construction worker. Remedial alternatives developed for the area south of I- 10 include:

- **Alternative 1S – No Further Action**
- **Alternative 2S – ICs**
- **Alternative 3S – Enhanced ICs**
- **Alternative 4S – Removal and Off-Site Disposal.**

The costs for these alternatives are $143,000 (Alternative 1S – No Further Action), $1,024,000 (Alternative 2S – ICs), $1,409,000 (Alternative 3S – Enhanced ICs) and $9.9 million (Alternative 4S – Removal and Off-site Disposal).

Other than Alternative 1S, the remedial alternatives for the area south of I-10 meet both of the CERCLA threshold criteria as established in the NCP: protectiveness and compliance with ARARs. The hypothetical future construction worker would be protected from exposure to soil with elevated dioxin/furan concentrations by warnings and restrictions (Alternatives 2S and 3S) or removal of impacted soil (Alternative 4S).

Alternative 4S offers the benefit of permanent removal of impacted soil from the 0- to 10- foot interval. The risk management achieved by ICs is somewhat lower, although with the addition of the physical markers that are part of Alternative 3S the risk management is improved. Alternatives 2S and 3S would not require exposing impacted soil or transporting material off-site and would be simpler to implement. However, the toxic and persistent dioxin waste material would remain susceptible to future flooding in the San Jacinto River. Excavation of impacted soil (Alternative 4S) would introduce short-term risks of exposure on-site and potentially off-site in the event of a release in route to the disposal facility. The cost of Alternative 4S (removal), $9.9 million, is about 7 times the cost of Alternative 3S (enhanced ICs). The additional cost for Alternative 4S insures that that a future extreme storm will never result in a catastrophic erosion of the waste material and release of dioxin to the San Jacinto River. Alternative 4S is the only alternative that provides for treatment or removal of the waste material.

In summary, Alternative 4S offers an increase in long-term effectiveness by removing the impacted soil; however, there is an increased short-term risk of exposure and potential traffic accidents. Alternatives 2S and 3S mitigate potential risks associated with exposure to soil in the area south of I-10 with reduced short-term exposure risks and at costs commensurate with the potential risk associated with the impacted soil at depth, although with a reduced long term protectiveness.