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Passaic River Proposed Plan Remedy Comments
Environmental Stewardship Concepts, LLC
On behalf of the New York/New Jersey Baykeeper

Introduction

The Proposed Plan for the Lower Eight Miles of the Lower Passaic River indicates that EPA's preferred alternative consists of bank-to-bank dredging with an engineered cap over the entirety of the lower 8.3 miles. The river would be dredged bank-to-bank to remove the surface contaminated sediment and so that the cap does not cause flooding by being above the original grading. The engineered cap would consist of two feet of sand, using stone for erosion prevention, where needed. The dredging depth is one of the topics on which EPA specifically requests comments.

Deep dredging of the lowest segment (about 2 miles) is an option that would remove all the contamination and open the navigational channel for greater access.

The other topic on which EPA specifically requests comment is the disposal/fate of the dredged contaminated sediment after removal. Two options are contemplated: 1) construction of a Confined Aquatic Disposal (CAD) facility in Newark Bay or 2) removal to a remote site and like disposal.

The New York/New Jersey Baykeeper requested analysis and comment on the following specific topics:

1. The CAD facility
2. Effectiveness of the Cooperating Parties Group's plan as an alternative to EPA proposals
3. Adaptive Management as applied to this site
4. The efficacy of a fish exchange for fisherpersons on the lower Passaic River
5. Bioremediation as an option for cleaning up sediment *in situ*

These five topics are presented below, followed by General Site Observations and Proposed Plan Comments. The Site Observations section contains observations relative to the site conditions before, during, and after remediation. Appendix A demonstrates the possible dewatering sites available for use along the Passaic River and Newark Bay. The Proposed Plan Comments section is based on EPA's "Lower Eight Miles of the Lower Passiac River Proposed Plan (April 2014)" and comments on the alternative chosen by EPA as the best cleanup remedy.

Confined Aquatic Disposal

The State of New Jersey, the Passaic River Federal Trustees, the NY/NJ Baykeeper, and many members of the Passaic community all disapprove of the use of a CAD in Newark Bay. Although CADs are touted as a low cost method for isolation of contaminants, the proposed CAD for Newark Bay will not ensure an efficient or appropriate cleanup. A CAD, which will need to be maintained in perpetuity, is not a complete cleanup for the Diamond Alkali Superfund Site; it is a method for leaving contaminants in place in the same estuarine/river system. It is essential that the EPA consider the negative long term ecological and economic impacts of placing a CAD in Newark Bay.

<u>Ecological Impacts</u>

One of the most concerning issues with the Passaic River CAD is the scale. At a total of 80 acres, the footprint of the Passaic River CAD would be larger than any other CAD site in the U.S. For reference, the New Bedford Harbor CAD in Massachusetts has a footprint of only 8.3 acres. Studies suggest that construction of the Passaic River CAD will take about five years - this five year period will disrupt the subtidal habitats that provide food, refuge, and spawning grounds for many aquatic species within Newark Bay, including over 100 species of fish (NY-NJ HEP 2012). These species are important ecologically, commercially and recreationally. Dredging of sediment from the bay bottom to create the CAD would increase suspended sediment and deposition levels for immobile eggs and fish in early life stages. It would also reduce dissolved oxygen levels, mask pheromones used by migratory fish, and smother immobile benthic macroinvertebrates (EPA 2014b).

Newark Bay is made up of intertidal and subtidal shallow waters that are home to many groundfish, such as winter flounder. Much of the bay is designated by NOAA as Essential Fish Habitat (EPA 2014b). Essential Fish Habitat is defined by NOAA as “the habitat necessary for managed fish to complete their lifecycle, thus contributing to a fishery that can be harvested sustainably” (NOAA). Many native fish populations are under intense pressure and run the risk of extirpation in Newark Bay. Several species in Newark Bay have special status, such as the Atlantic sturgeon, which is a federally listed endangered species. The shallow mudflats are also home to algae, crabs, clams and other invertebrates that serve as prey for fish like striped bass and bluefish (NY-NJ HEP 2012).

Due to years of contamination of the Passaic River, the Newark Bay ecosystem is already particularly susceptible to the negative impacts of construction in the bay. Eelgrass beds and oyster reefs in the bay are almost entirely gone. American shad populations are at historic lows (NY-NJ HEP 2012) and under a multi-agency effort to rebuild the populations. River herring and shad are also under federal and state jurisdictions and the Mid-Atlantic Fishery Management Council recently initiated an effort to coordinate federal and state agencies in order to increase those populations (MAFMC). Impairment from site-related contamination in Newark Bay has been documented in Atlantic tomcods, killifish, mummichogs, and many other aquatic species. A scientific study from the late 1990s and early 2000s on PCBs in anadromous fish of the Hudson River showed that juvenile Atlantic tomcod in Newark Bay were highly contaminated with PCBs, PCDDs, and PCDFs, compared to tomcods from seven different sites in the Hudson. The Newark Bay tomcods had PCDD levels over 19 times higher than the tomcods sampled in the Hudson River (Yuan 2006). A 2010 study on the health of killifish in Newark Bay showed that these fish suffered from morphological changes indicative of impaired reproductive health and endocrine disruption. Both male and female killifish exhibited decreased gonad weight and inhibited gonad development. The study concluded that "Similar effects on the reproductive development in less resilient species may limit their ability to repopulate the NY-NJ Harbor Estuary and similarly contaminated water systems" (Bugel 2010).

Long-term construction of a CAD in the bay is likely to lead to the decline of sensitive aquatic populations. The loss of native species in Newark Bay also means a loss of ecosystem services such as nourishment, clean water, protection from floods and erosion, and recreational opportunities (NY-NJ HEP 2012). The severe decline in the Eastern oyster population, for example, has widespread negative impacts on water quality in the bay. While oyster populations were historically depleted purely due to overfishing, Eastern oyster populations in Newark Bay today are at record lows in part due to the presence of toxic contaminants. As filter-feeders, oysters remove excess nutrients, algae, and pollutants from the water. An adult oyster can filter up to 50 gallons of water per day. Studies have shown that PCB exposure in sexually immature oysters impairs both lipid metabolism and reproductive success (Chu 2003).

<u>Human Health Impacts</u>

Recreational opportunities on the Lower Passaic River and in Newark Bay are also severely limited. The New Jersey Department of Environmental Protection fish and crab consumption advisories state that no species of fish or crab from the Lower Passaic River and the entire Newark Bay region should be eaten due to contamination (EPA 2014b). There is also a commercial fishing ban on striped bass (NJ Division of Fish and Wildlife 2012). The resuspension of contaminated sediments in the water during CAD construction and "filling" is a risk to human health as well. Not only will the resuspended contaminants come into contact with fish and wildlife, but people using the bay by boat are put at higher risk of coming into contact with toxic contaminants.

Construction Issues

While preliminary studies estimate that construction of the CAD cell will take about five years, it is very likely that construction could take much longer. The possible technical delays that the construction team may run into is one issue, while a more immediate concern is the seasonal dredging restrictions in Newark Bay for the migration of diadromous fish. These restrictions can change from year to year and are dependent upon the reproductive success of fish populations, so it is nearly impossible to predict what seasonal restrictions may be put in place years ahead of time.

Constructing the CAD will be largely inefficient. Rather than one large CAD cell, the site will actually be made up of multiple CAD cells, each of which will be fifty feet deep. The excavated clay from these cells will then be disposed of in an ocean disposal area offshore (EPA 2014b). This disposal process is not only inefficient, but it risks depositing contaminated sediment further offshore in the ocean, where mobilization of contaminated sediments will take place more quickly than in the bay.

Moving the excavated clay offshore, as well as general construction activities, will increase traffic in Newark Bay. The CAD sites considered by the EPA in the Passaic River Focused Feasibility Study are near major container terminals in the Newark Bay. The Port Newark Container Terminal (PNCT), located in Port Newark on the west side of the bay, occupies 259 acres. In 2011, the PNCT secured a long-term lease agreement to occupy the space through at least 2030. Before the year 2030, the PNCT will invest $500 million into expansion of the port. Already the PNCT handles over 600,000 containers annually, and this number will increase as the port expansion occurs (PNCT 2014). Increased traffic to and from the CAD site could interfere with port commercial traffic, as well as increasing the chances for boat accidents (EPA 2014b).

Even after the CAD cell construction is complete, significant recontamination risks remain. The Passaic River Proposed Plan expressly states that even with sheet pile walls on all sides and a silt curtain across the entrance channel, “some of the dissolved-phase contamination could still escape during dredged material disposal” (EPA 2014b, p. 35). In the document *Recommendations for the Diamond Alkali Superfund Site*, the National Remedy Review Board states that recontamination could occur through resuspension from the cleanup itself or through the transport of contaminants from Newark Bay. The Board points out that recontamination could inhibit the EPA’s goal of attaining and maintaining five parts per trillion of dioxin in Newark Bay sediment over time (NRRB 2014). In addition, the Proposed Plan does not account for monitoring leakage from the CAD cell over a long-term scale. The issue with Newark Bay in particular is that the bay is already so polluted that contaminants leaking out of the CAD cell would almost impossible to discern from contaminants that are already present in

Newark Bay waters. The Proposed Plan repeatedly mentions that the CAD will require monitoring in perpetuity, but no definitive monitoring measures are proposed or explained.

The cost for the Passaic CAD is estimated to be $1 billion. The cost for off-site disposal is estimated to be $1.7 billion (EPA 2014a). While EPA Headquarters advocates for the CAD because of the decreased cleanup cost, the negative consequences of using the CAD will come in the form of extra funds spent in the future, as the CAD requires a review every five years and maintenance in perpetuity. In the long run, the cost for off-site disposal of contaminated sediments may very well be cheaper than the cost of maintaining the CAD cell.

CAD versus Off-Site Disposal

While the CERCLA process requires five-year reviews of the CAD, it is likely that more frequent reviews will need to be conducted to verify that no leakage is occurring. Off-site maintenance, on the other hand, is done by permitted facilities and has a finite end date for cleanup. An off-site disposal facility could incinerate up to ten percent of contaminated sediment, whereas a CAD does not treat any contaminants. A CAD would also severely impact the sensitive ecosystem that is Newark Bay, whereas off-site disposal would not have long-term impacts on the bay (EPA 2014a). Construction of the CAD would require five years or more of increased boat traffic in the bay, whereas removing the dredged material by truck and by rail would increase road and rail traffic for a much shorter period of time.

Additionally, the risks of climate change pose more threats to a CAD than to off-site disposal. Climate change will bring more frequent and intense rainstorms, and thus flooding, to New Jersey. In the estuary, this flooding will increase water pollution from runoff and combined sewer overflows. Coastal storms and hurricanes may cause severe damage to the coastline, as well as destroying wetlands, which provide protection for the estuary and bay (NY-NJ HEP 2012). These disruptions to the Newark Bay ecosystem increase the risk for malfunctioning of the CAD.

Other CAD Sites

While it is important to examine the successes and failures of other CADs, it is also important to note that the Passaic CAD cannot be compared to other CADs in terms of size and contaminant concentration. The 80-acre footprint of the Passaic CAD is twice as large as the Puget Sound CAD and almost ten times as large as the New Bedford Harbor CAD. Additionally, the concentration of contaminants and the volume of dredged material for the Passaic Superfund site are both higher than at most other CAD sites. The Puget Sound CAD contains sediments with much lower contaminant concentrations than in the Passaic, and in New Bedford, only the least contaminated sediment was accepted for the CAD (Passaic River Federal Trustees 2014).

The Passaic River Proposed Plan cites the New Bedford Harbor in Massachusetts as a CAD that has been “constructed and maintained in a protective manner” (EPA 2014b, p. 39), yet there are no available data thus far to prove that the CAD is protective. Furthermore, the first CADs at New Bedford Harbor were only completed in 2004 and 2008. These CADs are still relatively new, and sufficient time has not yet passed to determine the ultimate success of these CADs.

One of the points raised at the forum on Confined Aquatic Disposal (CAD) cells at the NJIT Forum was that CAD cells are widely used and have been for quite some years. As reference for this statement, a paper by Palermo and Bosworth (2008) is cited as documenting 29 CAD/CDF facilities that are successful in confining contaminated materials.

The paper by Palermo and Bosworth does indeed list 29 facilities, all of which are described as Confined Disposal Facilities(CDF); the distinction between CAD and CDF is not subtle. A CAD is an in-water facility that has been excavated into clay, rock, etc. and is intended to create little vertical profile above the bottom. A CDF is a shore-side facility, often using berms or existing features as part of the containment. Palermo and Bosworth (2008) state: “A CDF is an engineered structure consisting of dikes or other structures that extend above any adjacent water surface and enclose a disposal area for containment of dredged material, isolating the dredged material from adjacent waters or land.”

Table 1 of Palermo and Bosworth (2008) lists 29 structures that include:

- One that is in the planning stages; construction not started
- Ten are inland waterways in freshwater lakes
- Several are upland and not at the shoreline
- The marine or estuarine CDFs are almost all at the shoreline
- Only three seem to be not at the shore or on shore

While the paper makes a strong case for the effectiveness of CDF’s, as described in the definition, little information is provided regarding offshore CAD’s. No CADs are discussed with the design characteristics of the CAD that would have to be constructed in Newark Bay for disposal of these highly contaminated sediments. In short, the Palermo and Bosworth (2008) paper is not a good source of specific information with which to authorize a massive CAD in Newark Bay.

References

Bugel, S.M., White, L.A., and Cooper, K.R. 2010. “Impaired reproductive health of killifish (*Fundulus heteroclitus*) inhabiting Newark Bay, NJ, a chronically contaminated estuary.” *Aquatic Toxicology*, 96(3):182-193.

Christie, Chris. November 28, 2012. “State of New Jersey’s Support for a Remedial Alternative for the Lower Eight Miles of the Lower Passaic River” Letter to Lisa P. Jackson, US EPA Administrator. Trenton, NJ.

Chu, Fu-Lin E., Philippe Soudant, and Robert C. Hale. 2003. "Relationship between PCB accumulation and reproductive output in conditioned oysters *Crassostrea virginica* fed a contaminated algal diet." *Aquatic toxicology,* 65(3):293-307.

Mid-Atlantic Fishery Management Council. “River Herring and Shad Management (Am 15.” http://www.mafmc.org/actions/msb/am15 Accessed July 31, 2014.

National Oceanic and Atmospheric Administration. “Essential Fish Habitat and Critical Habitat: A Comparison.” http://www.habitat.noaa.gov/pdf/efhcriticalhabitatcomparison.pdf Accessed July 8, 2014.

National Remedy Review Board and Contaminated Sediments Technical Advisory Group. April 11, 2014. “Recommendations for the Diamond Alkali Superfund Site, Lower Eight Miles of the Lower Passaic River (Focused Feasibility Study Area)”

New Jersey Division of Fish & Wildlife. “Marine Fisheries Administration Commercial Regulations.” March 13, 2012. http://www.nj.gov/dep/fgw/pdf/2012/comregs12.pdf. Accessed July 8, 2014.

New York-New Jersey Harbor & Estuary Program. 2012. “The State of the Estuary 2012: Environmental Health and Trends of the New York-New Jersey Harbor Estuary.”

Palermo, M. and W. Bosworth. 2008. Use of Confined Disposal Facilities for Sediment Remediation. Proceedings of the 39th Texas A&M Dredging Seminar and Western Dredging Association XXVIII Technical Conference, June 8-11, 2008, St. Louis MO.

Passaic River Federal Trustees. March 10, 2014. Letter to Alice Yeh, US EPA Remedial Project Manager.

Port Newark Container Terminal. "Terminal Info." http://www.pnct.net/. Accessed July 10, 2014.

US Environmental Protection Agency (EPA) Region 2. 2014a. "Proposed Plan for Cleaning Up the Lower 8 Miles of the Lower Passaic River." PowerPoint presentation, May 7, 2014, Newark, NJ.

US Environmental Protection Agency (EPA) Region 2. 2014b. "Lower Eight Miles of the Lower Passaic River, Superfund Proposed Plan." April 2014.

Yuan, Zhanpeng, Simon Courtenay, R. Christopher Chambers, and Isaac Wirgin. 2006. "Evidence of spatially extensive resistance to PCBs in an anadromous fish of the Hudson River." *Environmental Health Perspectives* 114 (1) (Jan.): 77-84.

CPG Sustainable Remedy Proposal

Background

The Sustainable Remedy proposal put forth by the Passaic Cooperating Parties Group (CPG) addresses hot spots of contamination along the entire 17 miles of the Lower Passaic River. About 25 highly contaminated areas along the river will be targeted and dredged. The Sustainable Remedy is estimated to take about five years, and CPG has projected it will reduce risk from surface sediment by 70-80%. Completion of targeted dredging would be followed by a review of the results and using adaptive management (CPG 2013). While the Sustainable Remedy plan would operate on a much shorter time scale than other proposed remedial options, and may reduce the cost due to the reduced cleanup time, there are a number of major issues with this particular form of remediation. The CPG has not yet released a final document detailing the proposed remedy for public review. Therefore, the following comments are based upon a limited amount of information released by the CPG.

Hot Spot Approach

The Sustainable Remedy approach aims to remove sediment from only the most contaminated areas within the Lower Passaic River. This method will remove only the highest concentrations from the ecosystem (>500 ppt of 2,3,7,8-TCDD), but there will still be contamination left in place that will continue to cycle through the environment and its organisms for years to come. The CPG touts the Sustainable Remedy approach as a holistic approach that addresses both human and environmental health.

Additional Sources of Contamination

The Sustainable Remedy only addresses contaminated sediment in the riverbed, while other areas of contamination are not addressed. For example, the wooden bulking on either side of much of the Lower Passaic is infused with a variety of contaminants. Wood can hold in contaminants such as PCBs for years, all the while slowly releasing contaminants back into the water. Furthermore, the Lower Passaic will also require shoreline restoration. The Sustainable Remedy plan accounts for mudflats and nearshore areas, but it does not account for the extensive shorelines of the Passaic that will require extensive cleanup, as would occur in a bank-to-bank cleanup.

Modeling COPC Concentrations

Like any model, the model for the Sustainable Remedy plan is based upon assumptions. However, without specifics, these assumptions on which the model is based cannot be analyzed to determine if they are faulty. In addition, CPG claims that the model uses more data than that used by EPA to estimate contaminant concentrations in each area of the river (CPG 2013). If CPG has collected additional data outside of that collected/used by EPA, it needs to be made available for review to evaluate whether it meets data collection criteria and is accurate in order to be used in this model.

Watershed Restoration

The CPG has also noted the necessity for efforts to control ongoing sources of pollution. Source control is undoubtedly important to sustaining the cleanup levels, however, it is not the largest objective relative to CPG's efforts, which should be focused on the best cleanup for the sediments currently contaminated.

Adaptive Management

The Sustainable Remedy proposal relies heavily upon an adaptive management approach for cleaning up river sediment. While adaptive management can be an appropriate option for contaminant remediation, it does not necessarily apply to this particular project. Significant alterations to the Passaic River Proposed Plan would be needed in order for the Passaic cleanup project to achieve its goal of using an adaptive management framework (see also our Adaptive Management comments). Adaptive management operates on the basis that restoration decisions will be modified over time in response to how the ecosystem is responding. In the case of the Passaic, it is already obvious that the condition of the ecosystem will not improve unless all contaminants are removed. Adaptive management will not prove to be useful when the outcomes of the Sustainable Remedy cleanup are already apparent before the process has even begun.

Fisheries Restoration

The Sustainable Remedy includes fisheries restoration as one facet of the project. However, no amount of "fisheries restoration" will make fish from the Lower Passaic safe for human consumption without removing the contaminants. A program that would "remove invasive species that drive this risk, such as carp, and replace them with more desirable native species like striped bass that are less affected by any sediment contamination that would remain after implementation" should not be the focus of CPG's efforts, and requires a massive scale effort beyond that of CPG's capacity. Further, the proposed fish exchange program, where contaminated wild caught fish from the Passaic can be traded in for aquaponics raised striped bass, obscures the necessity for a full and complete cleanup by CPG (see also our Fish Exchange comments).

References

The Lower Passaic River Study Area Cooperating Parties Group. 2013. "The Sustainable Remedy." http://www.lowerpassaiccpg.com/index.php/sediment-cleanup/the-sustainable-remedy Accessed August 5, 2014.

Adaptive Management

Introduction

Adaptive management is a process in which the management decisions involving the restoration and/or maintenance of an ecological system are modified over time in response to how those decisions affect the system. This type of management is most useful in projects with high uncertainty that make it difficult to select a more traditional management framework. This type of uncertainty is often seen at Superfund sites because of the unknown or uncertain distribution of contaminants, large scale and time frame. These uncertainties could range from the frequency and magnitude of major storm events to the interactions among trophic levels, and ultimately affect the potential success of any remediation project. This situation can be particularly true when managing major cleanup operations, which may rely on the interactions between a number of remediation procedures and technologies.

The proposed plan for the Lower Eight Miles of the Lower Passaic River indicates the intention to use an adaptive management framework with the preferred remedial alternative of Capping with Dredging for Flooding and Navigation. No matter the final remedy, sediment removal, treatment, capping, etc. will require coordinating multiple procedures and could include new methods. This situation is well-suited for use of an adaptive management approach.

Conditions for Using Adaptive Management

According to the Department of the Interior's Adaptive Management Applications Guide (Williams & Brown, 2012), there are five primary conditions that a site should meet to be considered an appropriate candidate for adaptive management. These conditions are:

1. Management action is needed
2. Decisions are based on clear measurable objectives
3. A range of management options exist
4. Monitoring will be conducted and can reduce uncertainty
5. Managers and stakeholders must commit to adaptive management

These conditions are explained below.

First, managers must determine that some type of management action is necessary in spite of substantial uncertainty. The Lower Passaic River meets the threshold whereby, in doing nothing, the risk to human health and the environment is greater than the risk posed by acting on a management plan with uncertain consequences. The high levels of contamination in fish and crab tissues present a significant risk to both human consumers and animals. The contaminants of concern (COCs) in sediments throughout the river must be addressed despite uncertainty in how the proposed management alternatives will affect the river system.

Second, there must be clear and measurable objectives around which to base management decisions. Without these goals and metrics, it can be difficult to determine if the actions taken are effectively improving the conditions of a site. The Lower Passaic River meets this condition also: in the Proposed Plan, preliminary remediation goals (PRGs) are given for various COCs. These PRGs take into account how sediment concentrations affect fish and crab tissue concentrations, as well as the human cancer risk of consuming different numbers of fish and crab meals per year. These PRGs provide the basis for clear objectives that can be measured via sediment and animal tissue concentrations to present a clear picture of the remediation's effectiveness.

Third, there must be a range of possible management alternatives from which to choose and the flexibility to change management approaches if the initial alternative proves to be less effective than anticipated. New alternatives can also be considered. It is this condition that distinguishes adaptive management from other management frameworks, and the use of adaptive management is counter-indicated if there is not a clear willingness to discontinue ineffectual management alternatives. The Lower Passaic River meets this condition in theory: the focused feasibility study (FFS) and proposed plan provide numerous potential management actions through combining three separate scenarios for managing the dredged materials with four separate remedial alternatives. However, the plan addresses the possibility of remedial actions being modified thusly: "Any remedy modifications will be made and documented in accordance with the CERCLA process, through an Explanation of Significant Differences or an Amendment to the ROD [Record of Decision]" (US EPA, 2014). While this provision technically allows for flexibility, neither an ESD or ROD amendment is appropriate for allowing modifications during the remedial process. The process of formally changing the ROD is not responsive enough to fully enter into the spirit of an adaptive management framework. Language will need to be inserted in the ROD to allow methodological or procedural modifications based on monitoring data or other information.

Fourth, there must be types of monitoring conducted during the remedial process that can reduce the level of uncertainty. The intent of the adaptive management framework is to use knowledge gained during the management action to better inform future decisions and adjustments in management. This modification is impossible without some type of monitoring that can provide information on the response of the site to the remedial actions. The Lower Passaic River does meet this condition: the Proposed Plan indicates that the preferred alternative includes long-term monitoring of COC concentrations in fish, sediment, and the water column. This information would allow site managers to determine if COC concentrations are behaving as modeled, and when certain goals have been achieved. Water column monitoring allows for modifications of in-water activities to reduce the input of contaminants.

Fifth, there must be an active and sustained commitment by the stakeholders to the principles of adaptive management and the complex role they play in remediating sites. Many large remediation projects require decades to complete, and the stakeholders must be able and willing to invest time and resources over the full course of the project. The Lower Passaic River meets this condition: there are a number of community advocacy groups, a coalition of parties responsible for the cleanup, and extensive involvement of both state and federal environmental regulators to ensure the adaptive management framework is used over the life of the remediation project.

Because the Lower Passaic River meets these five conditions, adaptive management is an appropriate management framework within which to carry out remediation of the river. This conclusion is particularly true due to the proposed use of dredging in the remedial alternatives. According to the National Research Council (2007), the size, long time-frame, and complexity of Superfund dredging projects demand the flexibility that adaptive management can offer. However, the typical Superfund process, in which a single remedial alternative is selected from those identified in the feasibility study and rarely modified significantly, remains largely incompatible with the spirit of adaptive management. In order for the Lower Passaic River remediation project to achieve its stated goal of using an adaptive management framework, significant alterations to the proposed plan are needed. The Hudson River PCB remediation offers a simple example of modifications in the operational changes to reduce airborne PCBs and to increase the rate of sediment removal to shorten the project duration.

Using Adaptive Management in the Lower Passaic River Remediation

Adaptive management is typically depicted as a cyclical process consisting of six primary steps in which monitoring provides the feedback necessary to initiate each iteration of the cycle (NRC, 2005). The six steps are presented below with comments on how well the Lower Passaic River Proposed Plan integrates each step.

Step 1: Assessing the Problem

The first step in adaptive management is to assess the problem. This includes establishing measurable goals and the metrics to measure progress towards those goals, as well as assessing any predictive models or forecasts to anticipate site-response to remedial actions (NRC, 2007). Within the Superfund process, this may begin in the early stages during the preliminary assessment (PA) and site investigation

(SI), but is primarily accomplished during the remedial investigation (RI) and feasibility study (FS). On the Lower Passaic River, field investigations and monitoring have been conducted since the 1990s, and conceptual modeling has been used to predict how COCs may move through the river system in each of the remedial alternatives. Management goals have also been set via the remedial area objectives and PRGs. However, not all of the necessary information has been collected to consider the problem fully assessed. The Proposed Plan admits the need for a fish migration study to help minimize the impact of remedial actions on migratory fish. In order for this step to be complete, all relevant information should be collected prior to finalizing a plan for remediation.

Step 2: Designing a Management Plan
The second step in adaptive management is to design a management plan. This step includes comparing and selecting remedial actions. This includes selecting indicator values which may trigger changes in the selected remediation plan. The remedial alternatives are compared based on likelihood of meeting management goals, cost, short- and long-term effectiveness, implementability, community acceptance, and other factors (US EPA, 2014). Adaptive management plans from this step can be either passive or active. In active adaptive management, multiple competing remedial alternatives are implemented in order to compare their actual effects on the resources being managed (NRC, 2005). This type of experimental design ideally leads to a better understanding of the impacts of the various alternatives, but is typically impractical for remediation projects of the size and scope of most Superfund projects. Passive adaptive management is more typical of the Superfund process, and involves selecting a single remedial alternative that is determined to be the most appropriate for the site.

Once a remedial alternative has been selected, it is important to determine what indicator values should trigger a change in the management action. In other words, if the preferred alternative does not perform as anticipated, there should be a clear and specific plan for modifying the management plan or using one of the other identified alternatives.

In the Proposed Plan for the Lower Passaic River, the various remedial alternatives from the FFS have been compared and evaluated, and the preferred alternative has been selected. Although this process is appropriate within a passive adaptive management framework, there must be some discussion of what criteria must be met for the preferred alternative to be modified or dismissed. Unfortunately, the proposed plan does not address this vital component of the adaptive management process other than to state that remedy modifications will be handled in standard CERCLA fashion via a change to the ROD. This general statement is entirely too vague to qualify as a good-faith effort in applying adaptive management to the site.

The preferred alternative involves dredging a 300-foot wide navigational channel out of the contaminated sediment, dredging to a 2.5 foot depth outside of the navigational channel, disposing of that sediment off-site, and covering the remainder of the contaminated sediment with an engineered cap. This alternative would require monitoring and maintenance of the cap in perpetuity to ensure that it is containing the contamination, and relies on the compliance of the general public with directives to protect the cap, such as not anchoring boats on the cap material. In addition, navigational channels must be periodically dredged to remain serviceable, and it is difficult to imagine a scenario in which the navigational channel is dredged without disturbing the cap. However, no provision is made in the proposed plan for the failure of the cap to contain the contamination, and there are no criteria listed that would trigger a significant modification to this management plan. Without this information, the Proposed Plan cannot be considered to be fully engaged in the principle of adaptive management.

Step 3: Implementing the Plan
The third step in the adaptive management process is simply to implement the plan as designed in Step 2. This includes making modifications to the plan according to the specific criteria agreed upon prior to implementation, with appropriate documentation and engagement with the stakeholders. Although the Lower Passaic River has not yet begun this step in the process, there may be difficulties during this process due to the issues outlined above.

Step 4: Monitoring
The fourth step in adaptive management is to monitor for quantifiable data that will indicate if the plan is being effective at achieving the remedial objectives. This monitoring should be designed in such a way as to assess whether the actions taken at the site were in compliance with the plan, whether the plan is meeting the remedial objectives, and whether the conceptual site model is using the correct parameters and relationships between variables. In the Lower Passaic River proposed plan, the primary monitoring parameters are COC concentrations in the water column, sediment, and fish and crab tissue. These are sufficient to determine progress towards the remedial objectives and to compare to the model, but it is unclear if they can be used to determine the level of compliance with the management plan without a more detailed plan.

Step 5: Evaluating Results Obtained from Monitoring

Once monitoring data have been collected, those results are compared to the models from Step 1 of the management process. The difference between the modeled outcomes and the results of the monitoring can provide greater insight into the dynamics of a complex system and reduce the level of uncertainty in making management decisions. This step is key in the utility of the adaptive management framework because it allows new information to create a better understanding of the remediation site and refine management decisions. Unfortunately, the Superfund process is not designed to provide an expedient and agile method of evaluating and responding to new information. The five-year review process can be used as a platform for performing this type of evaluation, but more informal, short-term evaluations may be more effective at identifying potential problems or faulty information in the models. The Lower Passaic River proposed plan does not identify how often or by what indicators monitoring data will be evaluated against conceptual or quantitative models. Without this information, it is unclear how an adaptive management strategy will be employed for this site.

Step 6: Adjusting the Management Plan in Response to the Monitoring Results

Once the new monitoring data has been evaluated and integrated into the site model, adjustments must be made to the management plan to account for any significant improvements in understanding. This involves updating models to reflect the new information, reviewing the remedial objectives to determine if they are still reasonable, and updating any management actions as appropriate. Under the current Superfund process, this would be accomplished during the five-year review. However, the Lower Passaic proposed plan does not give a thorough explanation of how the management plan can be modified without modifying the ROD. The process of updating remedies through modification of the ROD can be lengthy and does not reflect the intended goal of adaptive management, which is to provide a flexible framework for coping with uncertainty.

Once Step 6 is complete, the cycle continues back to Step 1 for another round of problem assessment. This allows the stakeholders to determine if the new information gathered in the previous cycle has illuminated additional aspects of the remediation site, or altered the understanding of a previous problem. With each iteration of the adaptive management cycle, uncertainty is reduced and management actions are refined to better target the problem. With its large scale and high levels of complexity and uncertainty, the Lower Passaic River is an excellent candidate for adaptive management. However, the current proposed plan advocates for an adaptive management approach without fully engaging in each step of the process. Without a very clear strategy for how management actions may be modified, including contingencies for the possible failure of the preferred alternative, the proposed plan is simply an attempt at management, not adaptive management.

<u>References</u>

National Research Council. 2005. “Superfund and Mining Megasites: Lessons from the Coeur d’Alene River Basin.” The National Academies Press. Washington, D.C.

National Research Council. 2007. “Sediment Dredging at Superfund Megasites: Assessing the Effectiveness.” The National Academies Press. Washington, D.C.

US Environmental Protection Agency (EPA) Region 2. 2014b. “Lower Eight Miles of the Lower Passaic River, Superfund Proposed Plan.”

Williams, B. K., and Brown, E.D. 2012. “Adaptive Management: The U.S. Department of the Interior Applications Guide.” Adaptive Management Working Group. U.S. Department of the Interior. Washington, D.C.

Fish Exchange

Introduction

The Lower Passaic River Focused Feasibility Study Area consists of eight miles of the Passaic River and is part of the Diamond Alkali Superfund Site in northeastern New Jersey. Contamination of the Passaic River goes back over 150 years, and chemicals of concern include polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), dioxins, pesticides, mercury, lead and other metals. Many of these contaminants are capable of biomagnification in the river's ecosystem, and humans who eat fish or seafood from the river are at risk of consuming dangerous levels of these chemicals (EPA 2014).

Of the various responsible parties that have contributed to the contamination over the years, there are almost 70 companies that are being held financially responsible for cleaning up the Lower Passaic, collectively known as the Lower Passaic River Study Area Cooperating Parties Group (CPG). The CPG has proposed that the best method for reducing the human exposures to the contaminants in the river is to institute an exchange program in which anglers fishing the river could exchange their contaminated catch for uncontaminated fish raised in aquaculture facilities nearby. Although this method was largely dismissed by both community activists and officials (Fallon 2013), and was not included in the Environmental Protection Agency's (EPA) Proposed Plan (2014), the CPG's continued insistence upon its consideration justifies further exploration into the concept and its potential applications for the Lower Passaic.

Fish Exchange Concept

The CPG has proposed a one-year pilot program to install and operate an aquaponics system within the City of Newark, administered by faculty from Rutgers University and operated by otherwise unemployed veterans. In this system, hybrid striped bass would be raised in indoor tanks and their waste products recycled to provide nitrate-rich water for vegetable gardens. The plants would then filter the water so it could be returned to the fish tanks and start the cycle over. This would provide a source of fresh fish and vegetables to local communities, provide job training for veterans, and could potentially serve as an educational opportunity for local school children (CPG 2013 and Jaffe 2014).

However, the primary purpose of this pilot program is to explore the possibility of mitigating human exposures to the Passaic River's contaminants by allowing anglers to exchange fish caught in the polluted river for those raised in the aquaponics system. Because consumption of contaminated fish and crabs is the primary source of human exposure to contaminants, the CPG contends that such an exchange program would more quickly and effectively reduce human exposures than a complete river remediation project. Unfortunately, there is very limited information available on this type of program ever being used at a contaminated site, and it is extremely difficult to assess its potential for success in reducing human exposures. However, in reviewing the information provided by the CPG about the plan, a number of potential challenges become apparent.

Potential Challenges

The CPG's aquaponics experiment is intended to be a one-year pilot program rather than a full-scale launch, and so the omission of some details on how a fully-funded program would operate is to be expected. However, there are several concerns that are not being addressed in the design of the pilot program. These have the potential to be significant obstacles not only to the success of a full implementation of the exchange program, but to the success of the pilot program as well.

The first step in implementing a new community program is to determine if there is demand for such a program in the community. The CPG does not present the results of any surveys to determine if anglers would be interested in exchanging fish they worked to catch for farmed fish. The plan neither addresses the languages that signage and educational materials would be published in, nor does it indicate what metrics would be used to determine if the community is actively using the exchange program, or how significantly human exposure is being reduced.

If it can be determined that the community would be interested in the fish exchange program, the next step would be to assess the extent of the demand and what facilities are needed to supply enough fish for the exchanges. The CPG originally submitted a request for a zoning variance that would allow them to build the aquaponics facility at Metropolitan Baptist Church in Newark, but later withdrew the application, commenting that the building would have required too much renovation. It is currently unclear what alternative facility the CPG is considering (Fallon 2014). The CPG does not indicate how many fish will be produced by their project in comparison to how many fish are routinely caught and eaten by local fishermen. Although this is a pilot program, there should be a sense of how many aquaponics facilities would be needed for a full implementation of this plan.

Another concern is that only one variety of fish—a striped bass hybrid—is to be produced by the aquaponics pilot project (CPG 2013).   This is a concern because it is unlikely that everyone in the local community will prefer eating this hybrid fish over the other options available in the Passaic River. The CPG's own research indicates that at least 25 percent of the fish consumed out of the Passaic River are carp (Fallon 2013), and media interviews with locals indicate that many people in the area target the

Passaic's crabs, despite a ban on crabbing in the river (Fallon 2013). If contaminated fish and crabs are consumed because they are preferred to the one species of fish on offer for exchange, there is no reduction of human exposure and the project will fail to meet its goals.

Another challenge that the CPG's plan fails to address is the simple logistics of such an ambitious exchange program. In order for the program to be utilized, it must not be cumbersome for local fishermen to exchange their catches for uncontaminated fish. It is not feasible to require low-income fishermen, who may or may not have reliable transportation, to haul their entire catch to a single central point for exchange. The alternative is to set up a number of exchange points convenient to the Passaic River where fishermen can exchange their contaminated catches without significant travel. However, fishing and crabbing are both activities that often occur outside normal business hours, and such exchange points would need to be staffed throughout the day, seven days per week to be genuinely effective.

Conclusion

The CPG's fish exchange pilot program does not adequately reduce human exposures to the toxic chemicals in the Passaic River. Any success from the program is largely dependent on how the program is implemented and what other measures are taken to remediate contamination in the river system. The CPG's position that the fish exchange program would reduce human exposures more quickly and effectively than a complete remediation of the river is not supported by any scientific literature, surveys, or previous experiences at other contaminated sites. The pilot project may provide some information on the potential of such a program, but should not be included as part of any formal remediation plan as its value is questionable and wholly unquantified.

References

Fallon, Scott. "A new angle on cleaning up Passaic River: Swap your catch for a cleaner fish." *The Record.* North Jersey News.com. November 23, 2013. http://www.northjersey.com/news/a-new-angle-on-cleaning-up-passaic-river-swap-your-catch-for-a-cleaner-fish-1.641759

Fallon, Scott. "Controversial plan for Passaic River fish swap faces uncertain future." *The Record.* Axiom Media Service.com. May 14, 2014. http://axiommediaservice.com/Passaic_River_Clean-up/Controversial_plan_for_Passaic_River_fish_swap_faces_uncetain_future__See_more_at_httpwwwnorthjersey_7313

Jaffe, Johnathan. “Passaic River’s best chance at a cleanup: Opinion.” *The Star-Ledger.* NJ.com. January 3, 2014. http://blog.nj.com/njv_guest_blog/2014/01/passaic_rivers_best_chance_at.html

Lower Passaic River Study Area Cooperating Partners Group. “A Sustainable Remedy for the Lower Passaic River.” 2013. http://www.lowerpassaiccpg.com/index.php/component/edocman/?task=document.viewdoc&id=13&Itemid=0

US Environmental Protection Agency (EPA) Region 2. 2014b. “Lower Eight Miles of the Lower Passaic River, Superfund Proposed Plan.”

Bioremediation

Background

Bioremediation uses living organisms to remove or neutralize contaminants in soil, sediment or water, including groundwater, and may be applied *in situ* or *ex situ*. *In situ* treatment involves addressing the contaminated material on-site, while *ex situ* treatment is the removal of the contaminated material for treatment elsewhere. Bioremediation can involve plants, composting, fungi, bacteria cultures, and various other methods of using living organisms. The use of plants to remove contaminants is known as phytoremediation. In the case of the contaminated sediments in the Passaic River, the challenges include chlorinated organics (PCBs, dioxins) and metals at a depth of at least 15 feet and the contamination layer may extend another 15 feet or more. The Passaic River is estuarine with a tidal range of about 6 feet; 8 miles of river bottom are proposed for remediation in the current phase, with another 8 miles upriver needing remediation eventually. Treating this volume and mass of contaminated material in place is a logistical and biological challenge that has not been accomplished or even attempted previously, to our knowledge.

Bioremediation of groundwater using bacterial metabolism is a standard practice in environmental remediation. The basic process works well on such contaminants as TCE, PCE, benzene and a variety of organic solvents. A sample of the contaminated groundwater is cultured in the lab to isolate and identify the bacteria that are present and able to break down the chemical(s). Next, the best nutritional substrate is identified to allow bacterial growth in field conditions, allowing the bacteria to flourish and metabolize the contaminants. Nutrient materials (e.g. glucose, lactose, molasses) are injected into the groundwater and the contaminant levels monitored.

Bioremediation Using Bacteria

One of the premier bioremediation companies currently at work is BioTech Restorations[1], a North Carolina-based company that has extensive work experience on the east coast. BioTech specializes in the cleanup of organic contaminants such as PCBs, dioxins, DDT and toxaphane. BioTech provides remedial solutions specifically formulated for the soil matrix at each site and its unique chemistry. To remediate a site, BioTech uses what they call a “Factor,” a simple protein that treats indigenous bacteria in contaminated soil. The Factor helps the bacteria to secrete enzymes that break down the contaminants. When applied to soil, the Factor is applied using common farming equipment, and then the soil is turned and irrigated with water every several days. Over a period of several weeks, contaminant levels can be reduced by 90%. Some of

[1] Disclaimer: Environmental Stewardship Concepts, LLC worked with BioTech Restorations on the first draft of the QAPP for the Housatonic River cleanup. ESC completed the project in May 2014 and is no longer under contract to BioTech Restorations.

BioTech's most well known remediation projects include the former New England Log Homes factory site in Great Barrington, Massachusetts and the Hercules Chemical Plant in Brunswick, Georgia (BioTech Restorations).

Although the Log Homes factory site is different from the Passaic in that the contaminants of concern at the Log Homes site were mainly dioxins and it was not a river site, the Log Homes site can be used as a comparison for possible bioremediation options for the Passaic. Geographically, the Log Homes site and the Passaic Superfund site are in similar areas of the northeast that experience essentially the same weather patterns. These weather patterns dictate a particular work schedule for soil remediation, and the schedule used at the Log Homes site in Great Barrington could also apply to ex situ remediation of sediments from the Passaic River. In addition, the Log Homes factory site is along the banks of the Housatonic River. While the Housatonic is not a tidal river like the Passaic, the two sites do share some biologic and geologic factors that make the soil matrices similar.

Despite successful bioremediation projects at terrestrial sites, it is important to note that bioremediation of soil has not yet been applied *in situ* to a riverbed. Thus, any bioremediation plans for the Passaic must take into account the tidal nature of the Passaic River as well as the difference between riverine/estuarine and terrestrial sediments.

In Situ Bioremediation

While the *in situ* bioremediation pilot study for the Passaic proposed by Dr. John Pardue, Maxus Energy, and Tierra Solutions could cut down remediation costs by eliminating the need for dredging, a number of challenges remain. The main issue is that *in situ* remediation in an estuarine river has not yet been performed, and there are no available data on which to base any assumptions for the study. Furthermore, the theories behind the pilot study are based on Dr. Pardue's bioremediation work with groundwater, which is quite different from the freshwater and brackish water of the Passaic. Although *in situ* bioremediation could very well be successful in the Passaic River, the present risks associated with this particular method seem to outweigh the possible benefits.

Several major implementation challenges need to be addressed:

1- Identification, isolation and culture of a bacterial strain that will dechlorinate dioxins and PCBs.
2- Delivery of the bacteria or nutrients to stimulate bacterial growth
3- Increasing the rate of breakdown of dioxins and PCBs to a level sufficiently high to remediate a site.

A bacterial strain that can dechlorinate PCBs has been identified and cultured by Dr. Bedard at Rensselaer Polytechnic Institute in NY (Bedard 2007), but this bacterial strain has never been applied in field conditions. The problem that Bedard indicated was that the bacterium is an obligate anaerobe and the lowest level of oxygen will poison the culture and eliminate any breakdown action.

Phytoremediation

Bioremediation research has shown that wetland plants can be successful at removing contaminants from wetland soils. Certain plants can remove stored elements from sediment pools and release them in an atmospheric form through tissue leaching and litter fall (Czako 2006). The marsh grass *Spartina* (*Spartina alterniflora*) is likely able to uptake PCBs and other contaminants from contaminated sediment (Mrozek 1982). *Spartina* is a hardy, fast-growing grass that can thrive in most wetland habitats. Studies have shown that *Spartina* does have the ability to take up, translocate and accumulate PCBs from contaminated sediments (Mrozek 1982). However, there is not yet enough published research to consider the use of *Spartina*, or any other single wetland plant for that matter, as a standalone remediation option. Phytoremediation could be one viable option when used in conjunction with other more drastic remediation options, such as ex situ soil remediation.

Future Direction

While bioremediation is still an emerging technology, there are already several success stories from around the country. The contaminated sediments in the Passaic River could benefit from certain bioremediation methods, although it is important to consider options outside of bioremediation as well. At present, the most applicable option for remediating the sediments of the Passaic seems to be the methods pioneered by the team at BioTech Restorations. Their work on dioxin remediation at the Log Homes factory site, while not a perfect model, could be used to help design a bioremediation plan for sediments in the Passaic River. Sediments dredged from the river would be moved to a terrestrial location, treated to remove the dioxins and PCBs, and then once cleaned, made available for beneficial use

References

Bedard, Donna L., Kirsti M. Ritalahti, and Frank E. Löffler. 2007. "The Dehalococcoides Population in Sediment-Free Mixed Cultures Metabolically Dechlorinates the Commercial Polychlorinated Biphenyl Mixture Aroclor 1260." *Applied and Environmental Microbiology* 73.8 (2007): 2513-21.

BioTech Restorations. “Field Application.”

http://www.biotechrestorations.com/btr_016.htm. Accessed July 31, 2014.

Czako, Mihaly, et al. 2006. "Transgenic Spartina Alterniflora for phytoremediation." *Environmental Geochemistry and Health* (2006), 28:103-110.

Mrozek, Edward Jr., Seneca, Ernest D., and Hobbs, Larry L. 1982. "Polychlorinated biphenyl uptake and translation by *Spartina alterniflora* loisel." *Water, Air, and Soil Pollution* (January 1982). 17(1):3-15.

General Site Observations and Proposed Plan Comments

<u>Site Observations</u>

Because of the proximity of residential areas to the Passaic, ESC expects that the community will want to insist that EPA implement a monitoring program during the remediation. A good example would be a monitoring program at least as rigorous as the one on the upper Hudson River PCB removal action under CERCLA that addresses both environmental conditions and quality-of-life measures. Environmental measures address both air and water quality, whereas quality-of-life measures on the upper Hudson include noise, odor, river traffic and light.

Shoreline restoration may be assumed or expected in several remediation options, but in truth, shoreline restoration/remediation needs to be made a part of any remediation plan for the Passaic River. Either by foot or by boat, a tour of the river front will reveal that the fine sediments, which are the organic matrix that binds PCBs and other toxic organic chemicals, deposit on the shoreline and have built up a layer of sediment that is likely contaminated.

In addition to the shoreline remediation, the shore zone, including the mid and upper intertidal zone, will have to be restored following sediment removal and replacement. The restoration needs to consider both structural demands of the shore zone, i.e. keeping structures in place, erosion control and prevention etc., but also providing habitat and substrate for biota that reside there now or that will be expected to re-establish following remediation. The restoration effort will also require re-vegetation in areas that are not altered by human activities in such a way as to prevent or control vegetation. An examination of the shore of the Passaic reveals that marsh grass (*Spartina alterniflora*) and wood shrubs currently inhabit the shore and will have to be replaced.

An examination of the lower Passaic also reveals numerous and extensive bulkheading and old pilings of wood that will certainly have absorbed toxic chemicals and that now need to be removed as part of the remedial activities. These wooden structures have been sinks for the deposition of chemicals and represent sources of chemicals that are and will continue to re-contaminate the Passaic. If not removed, these wooden structures will undermine the success of any remediation plan.

Appendix A demonstrates the possible dewatering sites available that are large enough for use along the Passaic River and Newark Bay.

Proposed Plan Comments

The contaminants of concern (COCs) at the site include dioxins/furans, PCBs, mercury, DDT, copper, Dieldrin, polyaromatic hydrocarbons, and lead. The capping will only consist of two feet of sand and are not substantial enough for storm events and will present challenges in maintaining the navigational channel in the 2.2 miles closest to Newark Bay. Additionally, capping must account for the issues the tide presents in that there is flow from both directions and a changing salt wedge where heavy rains will present a greater freshwater influx.

The Plan proposes dredging 4.3 million cubic yards for the purposes of re-grading the sediment surface before capping, but not in the context of testing sediment and dredging until clean. The intent of the dredging may be different, however, the act of dredging is not and dredge-until-clean is the most effective and permanent cleanup available. Even that which is dredged for the purposes of flooding prevention could be treated by in-situ methods rather than transported off-site to incinerators and landfills

EPA has considered treatment as a component of dredged material management but believes that additional treatment of all the sediment in the Focused Feasibility Study Area is not practicable. They believe it would not be cost effective given the high volume of sediment and the number of COCs that would need to be addressed. However, the current chosen remedy will require that institutional controls remain in place in the form of fish and crab consumption advisories until such time as concentrations drop and NJDEP can "relax" the advisories, but may never be able to remove them entirely. The chosen remedy requires costly long-term monitoring and maintenance of the engineered cap and costly long-term monitoring of fish and sediment. The long-term costs of the current remedy are high, both financially and with regards to ecological and human health. A more permanent cleanup that involves more dredging and in-situ treatment will cut out long-term costs, both financially and with regards to ecological and human health.

Appendix A

Figure 1 details three possible options for sediment dewatering sites on the Passaic River. Photos taken in the field were georeferenced with Google Earth imagery to create Figure 1. A photo of each site is also attached for review (Figures 2-4).

The sites are as follows:
Figure 2. Site 1 –Possible previous sediment/fill Lot near Piles Creek & South of Newark Bay
Figure 3. Site 2 – Vacant Lot off Distribution Avenue located on Kearny Point
Figure 4. Site 3 – Vacant/construction lot near abandoned building and off Lister Ave.

Figure 1. Possible options for sediment dewatering sites

Figure 2. Site 1: Possible previous sediment/fill Lot near Piles Creek & South of Newark Bay

Figure 3. Site 2: Vacant Lot off Distribution Avenue located on Kearny Point

Figure 4. Site 3: Vacant/construction lot near abandoned building and off Lister Ave