



Appendix N

Remedial Alternatives Evaluation

1. Introduction

ARCADIS U.S. Inc. (ARCADIS) has prepared this Remedial Alternatives Evaluation as an appendix to the Downstream Areas Data Assessment Report (DADAR) for ExxonMobil Environmental Services Company (EMES) on behalf of ExxonMobil Pipeline Company (EMPCo) for the Mayflower Pipeline Incident Response located in Mayflower, Arkansas (the site). This document was prepared in response to the request by the Arkansas Department of Environmental Quality (ADEQ 2013a). The agency requested that EMES evaluate remedial alternatives for factors including, but not limited to: overall protection of human health and the environment; compliance with applicable and relevant rules and regulations; reduction of toxicity and mobility; effectiveness (short- and long-term); cost; and implementability. This Remedial Alternatives Evaluation relies on the results of a refined ecological risk evaluation provided in the DADAR Section 10, and on the sheen monitoring and characterization results discussed in the DADAR Section 11.

The overall purpose of this Remedial Alternatives Evaluation is to propose an appropriate mitigation plan that achieves the remedial action objectives (RAOs) established for the site. The specific objectives of this Remedial Alternatives Evaluation are to:

- Develop RAOs specific to the site.
- Screen various remedial technologies and develop a list of retained technologies that can reliably and effectively achieve the RAOs.
- Identify potential remedial alternatives to address the RAOs and evaluate the alternatives against the evaluation factors requested by ADEQ.
- Develop an appropriate plan to mitigate remaining risks and oil sheens related to the Pegasus Pipeline.

For the purposes of this document, the site consists of the areas located downstream from the residential neighborhood affected by the incident, and has been divided in three areas:

- Drainage Ways: Shallow ditch along North Main Street (A-Main), which then flows east under the railroad to Highway 365 (A-365W) and then under I-40 (A-365E)
- Dawson Cove Inlet Channel (Inlet Channel): Main channel between I-40 and the Open Water Area of Dawson Cove

- Dawson Cove Open Water Area (Open Water Area): Open marsh and water area located between Dawson Cove Inlet Channel and the heavily vegetated area.

2. Development of Remedial Action Objectives (RAOs)

RAOs are guidelines used to evaluate potential remedial technologies and to develop remedial action alternatives. This section presents the RAOs for the site, which were developed based on the site sampling activities, sheen monitoring and sampling activities results, and refined ecological risk evaluation results, all of which are presented in the DADAR.

RAOs to address constituents in soils and sediments related to the Mayflower Pipeline Incident are not necessary, as no unacceptable risks to ecological receptors are expected based on the site-specific ecological risk evaluation presented in the DADAR.

One RAO is identified for the site, and this is to mitigate surface water sheens resulting from the crude oil from the Pegasus Pipeline, to the extent practicable. Because crude oil sheens were not observed in the drainage ways, no action is necessary in the drainage ways. Therefore, screening and evaluation of remedial technologies and remedial alternatives to control sheens focuses on the Dawson Cove Inlet Channel and Open Water Area. Approximate areas for sheen mitigation are shown on Figure N-1. The extent of the Open Water Area is based on the approximate edge-of-water position shown in Figure N-1, which corresponds to the normal high water level in Dawson Cove of 262.87 feet (NAVD88) during summer.

3. Technology Screening and Development of Remedial Alternatives

This section describes the process through which potential remedial technologies for achieving the site RAO were identified, evaluated, and screened, which consists of:

- Identifying applicable general response actions (GRAs) and associated remedial technologies that are able to meet the established RAO for the site.
- Screening potential remedial technologies using the evaluation criteria of effectiveness, implementability, and relative cost, in accordance with U.S. Environmental Protection Agency (USEPA) guidance (USEPA 1988), to identify potential remedial alternatives for further evaluation and screening. Remedial technologies were evaluated and screened for the Inlet Channel and Open Water Area.

3.1 Identification and Description of Remedial Technologies

GRAs are generic technology types that can be used individually or combined with other GRAs to achieve the RAO. GRAs and associated remedial technologies were identified as an initial step to developing potential remedial alternatives to meet the RAO for the site. Remedial technologies were evaluated and screened for the Inlet Channel and Open Water Area to account for area-specific conditions.

The GRAs and associated technologies identified to meet the site RAO and site constraints are shown in the following table and described below.

GRA	Technology
No Action	No Action
Natural Recovery	Monitored Natural Recovery
	Enhanced Natural Recovery
Containment	Non-Reactive Capping
	Reactive Capping
Removal	Targeted Removal (in the Dry or Wet) with Off-Site Disposal
Treatment	In-Situ Mixing of Amendments
	Ex-Situ On-Site Treatment and Reuse

3.1.1 No Action

Under this GRA, no further action would be completed to address impacts related to the Mayflower Pipeline Incident. “No Action” is implementable at no cost, and is included as a baseline for comparing the potential overall effectiveness, implementability, and cost of the other technologies.

3.1.2 Natural Recovery

Monitored Natural Recovery (MNR)

MNR includes monitoring natural recovery processes, which have the ability to reduce the mass, volume, and toxicity of sheen-bearing material. Natural recovery can reduce sheens via naturally occurring physical, chemical, and/or biological processes, such as burial, advection, dispersion, dissolution, sorption, oxidation/reduction, and biodegradation (USEPA 2005). These processes will attenuate any residual crude-oil-related sources of surface water sheens over time. Since MNR does not require active cleanup methods, it does not cause additional impacts on the aquatic environment or benthic community (API 2013). However, MNR does require periodic sampling and monitoring of sheen-bearing material to assess the degree to which natural recovery has mitigated conditions over time.

Enhanced Natural Recovery

Enhanced natural recovery (ENR) consists of placement of a thin-layer of clean material over crude oil-affected sediments to create a new sediment surface layer with lower chemical concentrations than existed before the oil release. Natural recovery is accelerated through several processes, including mixing of the clean layer with underlying sediments through bioturbation. The thin-layer cap is usually composed of sand or clean sediment that is typically only a few inches thick, and is not designed to form an isolation barrier between underlying sediments and the water column. Rather, it is intended to enhance natural recovery processes with minimal impact on the aquatic environment and benthic community (Merritt et al. 2010, USEPA 2005). Periodic sampling and monitoring of sheen-bearing material is required to assess the degree to which natural recovery has mitigated conditions over time.

3.1.3 Containment Technologies

Remedial technologies associated with this GRA consist of measures to mitigate surface water sheens without removal or treatment. The remedial technology applicable to the Inlet Channel and/or Open Water Area is capping, which primarily involves chemically and/or physically isolating underlying sediments from receptors, and therefore, reducing exposure. The two capping options evaluated were non-reactive and reactive capping. Either of these would be installed in a controlled manner “in the wet” on top of the existing soils and sediments where sheens have been observed. Some capping options may require removing vegetation and debris prior to cap construction and some may involve the installation of a biological layer as the top layer of the cap after placement of underlying isolation and armor components. Monitoring during construction would be required for both non-reactive and reactive capping options to assess achievement of cap thickness and settling.

Non-Reactive Capping

Non-reactive caps provide an engineered physical isolation layer, usually consisting of sand with thickness ranging from two feet up to several feet, to isolate underlying sediments from ecological exposure. This type of cap can reduce the release of chemicals to water when diffusion is the main transport mechanism, but they may not be effective at mitigating sheens as sand does not provide sorption of sheens. Barrier layers can be incorporated in such caps; however, these layers have a disadvantage of potentially obstructing the release of gasses created by sediment decomposition and they may also impede natural groundwater discharge to surface waters.

Reactive Capping

Reactive caps consist of a reactive barrier to isolate sediments from the overlying surface water, while simultaneously enhancing biodegradation and/or sequestration of constituents via the addition of amendments. Over the last 10 years, reactive caps have been installed as full-scale remedies at many sediment sites (USEPA 2013).

Typical amendments used in reactive caps include granular activated carbon, organoclay, and AquaGate™. Organoclay is a clay that is organically modified to improve its oleophilic sorption capacity as a means of sorbing oils and/or sheens, thereby eliminating or greatly reducing sheen transport from sediments to the water column (Reible and Lampert 2008, Reible et al. 2011, Alther 2008). Three types of reactive capping technologies using organoclay have been considered for the site: (1)

reactive core mat (RCM™); (2) combination of AquaGate™/AquaBlok™; and (3) mixture of sand/organoclay. The RCM™ developed by CETCO uses organoclay within a geotextile envelope that is readily transported and deployable. The combination of AquaGate™/AquaBlok™ provides a funnel and gate approach with a thin AquaBlok™ layer forming a very low permeability isolation layer and AquaGate™ providing a sorptive medium to sorb constituents and sheens. The mixture of sand/organoclay installed as an organoclay layer is an effective sorptive medium for constituents and sheens, and has been installed to mitigate sheens at several pilot-scale studies and sediment sites (EPRI 2011, ODEQ and USEPA 2011, USEPA 2013). Sand would be mixed with organoclay to facilitate cap deployment.

3.1.4 Removal Technologies

Removal consists of excavating sheen-bearing material either “in the wet” or “in the dry”. Removal “in the dry” reduces excavated material dewatering requirements and reduces redistribution of constituents in surface water during dredging. This remedial technology type is applicable to both the Inlet Channel and Open Water Area, and would consist of targeted excavation in areas consistently producing sheens. Auxiliary technologies such as placing backfill, dewatering of saturated soil/sediment, and transport of excavated material to a permitted off-site disposal facility would also be necessary. The water generated during processing would be treated by appropriate methods and discharged back to the water body in accordance with applicable rules and regulations.

Removal of sheen-bearing material in the dry would involve dewatering the submerged area via construction of a temporary diversion dam, pumps and bypass pipelines, and then use of conventional excavation equipment. Bypass pipelines would intercept and transport creek water around the removal area to maintain a dewatered condition. Removal of sheen-bearing material in the wet would involve the use of mechanical dredges to remove the sheen-bearing material, and use of turbidity curtains and absorbent booms during implementation of the mitigation action.

3.1.5 Treatment

Remedial technologies associated with this GRA consist of those that treat or stabilize sheen-bearing material. Technologies evaluated are:

- In-situ mixing of amendments into the sheen-bearing material to reduce sheen mobility through adsorption/absorption processes.

- Excavation followed by ex-situ on-site treatment and reuse with a constructed temporary land treatment unit located within the upland floodplain area within Dawson Cove. The land treatment area would be restored following the replacement of treated materials.

In-Situ Mixing of Amendments

In-situ mixing of amendments reduces sheen mobility through adsorption/absorption processes and/or enhances the rate of biodegradation. The amendments considered for this site are a mixture of sand/organoclay (applied as a mixed-in amendment, rather than as a sediment cap) and Absorbent W®. Amendments would act in concert with natural recovery processes to reduce sheens and the mass of any other residual constituents over time.

Removal followed by Ex-Situ On-Site Treatment and Reuse

Ex-situ on-site treatment and reuse consists of ex-situ enhanced biodegradation of sheen-bearing material in a constructed temporary land treatment unit located within the upland floodplain area within Dawson Cove. The treatment process involves the addition of amendments and moisture via mechanical mixing after excavation and placement in the treatment area to enhance biodegradation in a controlled setting. If applied in the Open Water Area, submerged sediments would require dewatering following excavation and prior to treatment. Excavated areas would be backfilled with the treated soils or sediments and re-graded after treatment.

3.2 Remedial Technology Screening Criteria

Potentially applicable remedial technologies described in Section 3.1 were subjected to evaluation and screening to retain those that could be implemented and effectively meet the RAO for the site in both the Inlet Channel and Open Water Area.

The three criteria used to evaluate and screen the remedial technologies are:

- **Effectiveness** – This criterion is used to evaluate the ability of a remedial technology to demonstrate short-term and long-term effectiveness to eliminate or reduce mobility of any residual crude oil, mitigate surface water sheens, and provide protection of ecological receptors. Short-term effectiveness refers to the ability of a remedial alternative to provide protection of ecological receptors in the short term considering the amount of time required until the RAO is achieved, and

potential adverse impacts that may occur during the construction and implementation period. Long-term effectiveness refers to the ability of a remedial technology to reduce mobility of any residual crude oil, mitigate surface water sheens, and provide reliable protection of ecological receptors in the long term.

- *Implementability* – This criterion encompasses technical feasibility of designing and constructing a remedial technology to meet the RAO based on site conditions, as well as the availability of specific equipment, materials, services, and technical specialists to design, install, operate, and maintain the remedial technology.
- *Relative Cost* – This criterion evaluates the overall cost required to implement the remedial technology. As a screening tool, relative capital and operation and maintenance (O&M) costs are used rather than detailed cost estimates. For each remedial technology, relative costs are presented as low, moderate, or high. Costs are estimated on the basis of engineering judgment and industry experience.

Based on the criteria described above, technologies were ranked on a scoring system from relatively less preferable (score = 1) to relatively more preferable (score = 3) as shown in the table below.

Remedial Technology	Effectiveness	Implement-ability	Relative Cost	Screening	
				Total Score	Retained?
No Action	N/A	N/A	N/A	N/A	YES*
Monitored Natural Recovery	1	3	3	7	YES
Enhanced Natural Recovery	1	3	2	6	NO
Non-Reactive Capping	2	1	2	5	NO
Reactive Capping	3	3	2	8	YES
Targeted Removal	3	3	1	7	YES
In-Situ Mixing of Amendments	2	2	1	5	NO
Ex-Situ On-Site Treatment/Reuse	3	1	1	5	NO

Note: *Retained for comparison purposes only. N/A = not applicable

Remedial technologies with the highest total screening scores are retained for further evaluation. These are described below, followed by a discussion of the technologies that were not retained for further evaluation. Details of the technology evaluation and screening are provided in Table N-1.

- *No Action*: Although the “No Action” alternative may not meet the identified RAO in both areas of the site in the short term, this alternative may meet the RAO in the long term (although no monitoring would be performed to confirm this). As there would be no construction required, this alternative would have no construction-related impacts on human health or the environment and it is readily implementable at no cost. It was retained to serve as a baseline against which other alternatives will be compared.
- *MNR*: Although MNR may not meet the RAO in both areas of the site in the short term, this alternative was retained as it may meet the RAO in the long term, and periodic monitoring would be conducted to ensure mitigation goals are achieved. As there would be no construction required, MNR is readily implementable at a low cost with no construction-related impacts to human health or the environment during implementation.
- *Reactive Capping* – Reactive capping would mitigate surface water sheens by functioning as a reactive barrier between sheen-bearing material and the water column as well as providing a mechanism for the interception and sorption of sheens via organoclay, which is an effective oleophilic sorptive medium. Although this technology would not remove constituents, it would reduce their mobility in the short and long term. During construction and implementation, some short-term impacts would likely occur, as the placement of cap materials may result in some sheen release. The three reactive capping options described in Section 3.1 are all likely to meet the site RAO. However, the option retained for further evaluation is the mixture of sand/organoclay. This option is readily implementable and presents low to moderate costs compared to the other reactive capping technologies described in Section 3.1 (i.e., RCM™ and combination of AquaGate™/AquaBlok™). The RCM™ option was not retained due to implementability limitations over irregular surface with vegetation and obstructions and loss of habitat use. The AquaGate™/AquaBlok™ option was not retained due to relatively higher costs compared to the mixture of sand/organoclay option.
- *Targeted Removal (in the Dry or Wet)* – Removal would meet the site RAO and reduce the mobility, volume, and toxicity of constituents in the short and long term by permanently removing sheen-bearing residual crude oil (i.e., not necessarily all sheen-bearing material removed) from targeted areas of the site. During

implementation, particularly in the Open Water Area, there is the potential for significant ecological receptor exposure, as the disturbance of sheen-bearing material would likely result in some sheen release. Short-term ecological impacts would also be likely, such as the destruction of biota and habitats. Additionally, some residuals may remain after the removal action. This remedial technology is implementable, but dewatering, off-site disposal, and habitat impacts are significant considerations with this alternative, and it would be the most costly approach.

Rationale for not retaining the following remedial technologies for further evaluation is provided below:

- *ENR* – This remedial technology would accelerate natural recovery of sheen-bearing material with minimal impacts to the aquatic environment and benthic community, but would not be expected to achieve the RAO in the short term since the thin-layer cap is not designed to provide physical or reactive isolation of the sheen-bearing material.
- *Non-Reactive Capping* – A non-reactive cap may not be implementable due to the required cap thickness and the shallow water depth in Dawson Cove. Placement of such a cap would likely change wetland characteristics by significantly raising the bottom elevation.
- *In-Situ Mixing of Amendments* – In-situ treatment via the mixing of amendments would be expected to achieve the RAO, assuming the appropriate type and amount of amendments were applied to the sheen-bearing material and the absorptive/adsorptive capacity was enhanced through effective application methods. To select the most appropriate type and amount of amendment for this site, field tests would have to be conducted prior to full-scale application. Application methods would require mixing to promote contact between the amendment and constituents, causing disruption to habitats. Uniform mixing of amendments into and/or over sheen-bearing material may be difficult to achieve and would require application of a safety factor to account for variation which would increase the cost for this technology. Additionally, amendments may initially be erodible/mobile with wind-driven currents or stormwater runoff until consolidation onto surface sediments occurs.
- *Ex-Situ On-Site Treatment and Reuse* – This remedial technology would achieve the site RAO and is implementable, but the on-site treatment of sheen-bearing material in the upland floodplain area within Dawson Cove would cause significant habitat destruction, and stormwater management within the treatment area would

be an added complexity. Total costs would be relatively high and may not present any advantage over removal and off-site disposal.

The retained technologies have been assembled into the site-wide alternatives presented in Section 3.3.

3.3 Description of Remedial Alternatives

Following the remedial technology evaluation and screening process, as described in Section 3.2, retained remedial technologies that are potentially effective, implementable, and cost-effective were combined to develop an assembled range of remedial alternatives. This section provides an overview of the remedial alternatives that were evaluated, each of which is potentially capable of meeting the established site RAO in the Inlet Channel and Open Water Area, with the exception of the “No Action” alternative.

Descriptions of the remedial alternatives provided in this section are conceptual, with sufficient details for comparative feasibility evaluation purposes.

Alternative 1: No Action

Under Alternative 1, no mitigation activities would be performed, which includes no further monitoring. The *No Action* alternative serves as a baseline for comparison of the other remedial alternatives. It would not achieve the RAO in the short term, and no monitoring would be done in the long term to document whether the RAO has been achieved over time. It could be implemented at essentially no cost.

Alternative 2: MNR in the Inlet Channel and in the Open Water Area

The main components of Alternative 2 include:

- Conducting periodic sheen monitoring in the Inlet Channel and Open Water Area to evaluate the rate of natural recovery of crude-oil-related sheens.
- It is assumed that sheen monitoring would be conducted semi-annually for at least 1 year and up to 3 years to document changes in sheen occurrence over time.

Alternative 3: Reactive capping in the Inlet Channel and in the Open Water Area

The main components of Alternative 3 include the following:

- Installing a reactive cap over sediment where sheens have been observed in the Inlet Channel and in the Open Water Area (see Figure N-2 for potential cap placement area). Pre-design sampling would be conducted to determine the horizontal boundaries of the cap. Additional elements of this remedial alternative are as follows:
 - Removing vegetation/debris from the target areas to the extent needed for cap installation. Large diameter trees would be left in place.
 - The reactive cap would consist of a mixture of sand/organoclay, and the thickness and percentage of organoclay would be determined during remedial design.
 - Cap materials would be placed via broadcasting methods either using dry particle or slurry methods. Staging locations for cap material preparation would be established, as needed, to support cap placement.
 - After the cap is placed, staging areas would be re-graded and restored by planting native vegetation.

Alternative 4: Targeted removal in the Inlet Channel, and reactive capping in the Open Water Area

The main components of Alternative 4 include the following:

- Excavating up to 1 foot of localized sheen-bearing soils and sediments affected by the Mayflower Pipeline Incident in the Inlet Channel (see Figure N-3). The excavation depth is based on sampling results presented in the DADAR that indicated no sheen-bearing material below 1 foot. Pre-design sampling would be conducted to determine the horizontal boundaries of removal and to evaluate whether a thinner removal thickness would be adequate.
 - Removing vegetation/debris from the target areas, to the extent needed, to allow for excavation using mechanical methods (such as excavators). Large-diameter trees would be left in place.
 - Transporting excavated materials to an on-site staging area using low-ground pressure vehicles.

- Dewatering and stabilizing excavated material, as needed, for off-site transport.
 - Transporting stabilized excavated materials to the appropriate licensed off-site disposal facility.
 - Placing clean backfill material in the excavated areas if needed for restoration.
 - Restoring the excavated areas by re-grading and re-planting with native species.
- Installing a reactive cap over where sheens have been observed in the Open Water Area (see Figure N-3). Pre-design sampling would be conducted to determine the horizontal boundaries of the cap. Additional elements of this remedial alternative are as follows:
 - Removing vegetation/debris from the target areas to the extent needed for cap installation. Large diameter trees would be left in place.
 - The reactive cap would consist of a mixture of sand/organoclay, and the thickness and percentage of organoclay would be determined during remedial design.
 - Cap materials would be placed via broadcasting methods either using dry particle or slurry methods. Staging locations for cap material preparation would be established, as needed, to support cap placement.
 - After the cap is placed, staging areas would be re-graded and restored by planting native vegetation.

Alternative 5: Targeted removal in the Inlet Channel and the Open Water Area

The main components of Alternative 5 include the following:

- Excavating up to 1 foot of localized sheen-bearing soils and sediments affected by the Mayflower Pipeline Incident in the Inlet Channel and Open Water Area (see Figure N-4 for potential excavation area). Pre-design sampling would be conducted to determine the horizontal boundaries of removal and to evaluate whether or not a thinner removal thickness would be adequate.
 - Removing vegetation/debris from the targeted areas to the extent needed to allow for excavation using mechanical methods (such as excavators). Large-diameter trees would be left in place.

- Transporting excavated materials to an on-site staging area using low-ground pressure vehicles.
- Dewatering and stabilizing excavated material, as needed, for off-site transport.
- Transporting stabilized excavated materials to the appropriate licensed off-site disposal facility.
- Placing clean backfill material in the excavated areas if needed for restoration.
- Restoring the excavated areas by re-grading and re-planting with native species.

3.4 Evaluation of Applicable Regulations

Table N-2 provides a summary of the state and federal regulations potentially applicable to the five remedial alternatives evaluated for the site. Each alternative has been reviewed in comparison to the regulations. Alternative 1 is the “No Action” alternative, and therefore no regulations apply to this alternative. Implementation of the remaining four alternatives described in Section 3.3 will require permits and authorizations from state and federal agencies with regulatory purview over solid waste, water quality, waters of the U.S., including wetlands, and other environmental resources. Implementation of any alternative will also require compliance with several Arkansas state regulations related to solid waste handling, transport, and disposal. EMES would ensure that the handling, transport, and disposal of all solid waste associated with the preferred alternative would comply with requirements of Arkansas Regulations 22 and Regulation 23.

3.5 Remedial Alternative Screening Criteria

The remedial alternatives described in Section 3.3 were evaluated and screened against the following six evaluation criteria, as requested by ADEQ, to select a preferred alternative for the site:

- Overall protection of ecological receptors
- Compliance with applicable rules and regulations
- Short-term effectiveness
- Long-term effectiveness

- Implementability
- Relative cost

For a remedial alternative to be selected as the preferred alternative, it must meet the two threshold criteria (overall protection of ecological receptors and compliance with applicable rules and regulations). The other four criteria are balancing criteria, and they provide comparisons between the alternatives to help select a preferred alternative.

The two threshold criteria are as follows:

- *Overall Protection of Ecological Receptors* -- This criterion refers to the ability of a remedial alternative to eliminate, reduce, or control exposure pathways through containment, removal, or treatment. As per direction of ADEQ, the risk screening evaluation and thus the remedial alternative screening focuses on protection of ecological receptors. Human exposure to constituents in soil and sediment at the site is possible, but unlikely to be significant due to site conditions; the dense vegetation that develops naturally along the drainage ways and in Dawson Cove limits direct human exposure to site media.
- *Compliance with Applicable Rules and Regulations* – This criterion refers to the ability of a remedial alternative to meet all appropriate rules and regulations.

The four balancing criteria are as follows:

- *Short-Term Effectiveness* – This criterion refers to the ability of a remedial alternative to provide protection of ecological receptors in the short term considering amount of time required until RAO is achieved, and potential adverse impacts that may occur during the construction and implementation period.
- *Long-Term Effectiveness* – This criterion refers to the ability of a remedial technology to reduce mobility of any residual crude oil, mitigate surface water sheens, and provide reliable protection of ecological receptors in the long term.
- *Implementability* – This criterion encompasses the technical feasibility of designing and constructing/implementing a remedial alternative based on site-specific constraints, as well as the availability of specific equipment, materials, services, and technical specialists need to design, install, operate, and maintain the remedial alternative.
- *Relative Cost* -- This criterion evaluates the overall cost required to implement the remedial alternative. As a screening tool, relative capital and O&M costs are used

rather than detailed cost estimates. For each remedial alternative, relative costs are ranked from lowest to highest. Costs are estimated on the basis of engineering judgment and industry experience. Detailed cost estimates are provided in Attachment N-1.

3.6 Comparative Analysis of Remedial Alternatives

A detailed evaluation and screening for the retained technologies based on the criteria described in Section 3.5 is provided in Table N-3, and Table N-4 provides a comparative screening of site-wide remedial alternatives based on the evaluation for the retained technologies provided in Table N-3. Table N-4 consists of an assessment of each site-wide remedial alternative against the six evaluation criteria (two threshold criteria and four balancing criteria), which were used to rank the alternatives on a relative scoring system ranging from lowest to highest. The remedial alternative with the highest total score at the end of the screening process is selected as the preferred and proposed remedial alternative for the site.

The ranking of the remedial alternatives from most preferred to least preferred is as follows:

- *Alternative 4 (Targeted removal in the Inlet Channel and reactive capping in the Open Water Area):* Most preferred and recommended due to moderate to high rankings on all of the balancing criteria and high rankings on the threshold criteria, with the highest total screening score of 24.
- *Alternative 3 (Reactive capping in the Inlet Channel and in the Open Water Area):* Second most preferred due to moderate to high rankings on all of the balancing criteria and high rankings on the threshold criteria, with the second highest total screening score of 22.
- *Alternative 5 (Targeted removal in the Inlet Channel and the Open Water Area):* Third most preferred due to low to moderate rankings on the balancing criteria and high rankings on the threshold criteria, with the third highest total screening score: 19. Alternative 5 is not recommended, particularly in the Open Water Area, as there is the potential for significant ecological receptor exposure due to disturbance of sheen-bearing material resulting in some sheen release. Short-term ecological impacts would also be likely, such as the destruction of biota and habitats. Additionally, some residuals may remain after the removal action. This alternative is implementable, but dewatering, off-site disposal, and habitat impacts, particularly

in the Open Water Area, are significant considerations with this alternative, and it would be the most costly alternative.

- *Alternative 2 (MNR in the Inlet Channel and in the Open Water Area)*: Low to moderate rankings on the balancing criteria and low to moderate rankings on the threshold criteria, with the second lowest total screening score of 16. MNR may not meet the RAO in both areas of the site in the short term, and therefore site-wide MNR is not the recommended alternative.
- *Alternative 1 (No Action)*: Lowest ranking on the threshold criteria, with the lowest total screening score of 13. No Action may not meet the RAO in both areas of the site in the short term and could not be demonstrated to achieve the RAO in the long-term as it does not include monitoring. Therefore, No Action is not the recommended alternative.

It is proposed that Alternative 4 be implemented to mitigate crude oil-related sheens in the downstream areas. Alternative 4, which is the highest-scoring alternative, consists of targeted removal in the Inlet Channel and reactive capping in the Open Water Area. Based on the evaluations presented in this section, a recommended path forward was prepared and is included in Section 13 of the DADAR. A pre-design study will be required to confirm the preferred remedial alternative approach, to support the design and permitting of the preferred alternative, and to confirm and refine the mitigation area, and it is provided in Appendix O of the DADAR. Subsequent to the pre-design study, the design will be completed and then implemented.

3.7 Required Permits for the Preferred Remedial Alternative

Implementation of the preferred alternative will require the permits and authorizations from state and federal agencies listed in Table N-2. The preferred Alternative 4 includes dewatering and excavation of sediment, disposal of solid waste off-site, and placement of materials within waters of the U.S., including wetlands. Therefore, implementation of Alternative 4 requires permits and authorizations from the U.S. Army Corps of Engineers (USACE) under Clean Water Act Section 404 and/or Section 10 of the Rivers and Harbors Act of 1899. For the purposes of this analysis, it is assumed that the USACE will require an Individual Permit (IP) for the project because of the amount of potential fill to waters of the U.S. is likely to exceed ½ acre.

Preparation of permit applications to USACE and ADEQ will require preparation of a preliminary wetland delineation to identify and inventory waters of the U.S., including wetlands. It is anticipated that a formal delineation will be necessary to accurately

document existing conditions and calculate potential impacts resulting from the preferred alternative. This task would be conducted during the pre-design study described in Appendix O of the DADAR. Included in the permit application will be an estimate of potential temporary and permanent impacts on waters of the U.S. It is anticipated that permanent impacts on waters of the U.S. may not be accurately known at the time of project implementation and ongoing monitoring may be required by USACE and ADEQ.

Because an IP is anticipated, a 404(b)(1) Alternatives Analysis will be prepared that will identify the potential alternatives to the project. The purpose of the 404(b)(1) Alternatives Analysis is to identify the least environmentally damaging practicable alternative (LEDPA). The USACE can only issue a permit for the alternative that is determined to be the LEDPA. The LEDPA is the alternative that has the least impacts on aquatic resources and which achieves the project purpose.

Pre-application coordination with the USACE and ADEQ will be necessary to facilitate timely review during the permitting process. It is anticipated that obtaining permits and authorizations for the preferred alternative will take a minimum of 120 days after USACE and ADEQ receipt of the application submittal. This includes the initial application review period, required interagency coordination and a 30-day public notice period required for IPs.

The USACE is required to coordinate with U.S. Fish and Wildlife Service (USFWS) under Section 7 of the federal Endangered Species Act and with Arkansas State Historic Preservation Officer (SHPO) under Section of the National Historic Preservation Act. It is not expected that implementation of the project will result in impacts on federally listed threatened or endangered species or adverse effects on historic resources. However, the coordination is still required and the application package submitted to USACE will include information to facilitate the USACE's consultation with USFWS and Arkansas SHPO.

For the USACE permit to be valid, ADEQ must certify that the project meets state water quality objectives as stated under Clean Water Act Section 401. Excavation would require dewatering and discharging into Dawson Cove. An individual National Pollution Discharge Elimination System (NPDES) permit from ADEQ would be required. Discharge into Dawson Cove would include measures to maintain water quality standards including dissipaters and monitoring at discharge point. It is anticipated that an application and water quality protection plan can be submitted to ADEQ for review and approval within 90 days of approval of the DADAR.

4. References

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Appendix N – Remedial Alternatives Evaluation

Mayflower Pipeline Incident
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Attachments

N-1	Cost Estimates
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Tables

Table N-1
Detailed Evaluation of Remedial Technologies

Downstream Areas Data Assessment Report
ExxonMobil Environmental Services Company
Mayflower Pipeline Incident Response, Mayflower, Arkansas

General Response Action	Remedial Technology	Description	Effectiveness (1) Ability to meet and continue to meet the RAO of mitigating surface water sheens. (2) Short-term effectiveness: Ability to provide protection of ecological receptors in the short term until the RAO is achieved, and potential adverse impacts during the construction and implementation. (3) Long-term effectiveness: Ability to reduce mobility of any residual crude oil, mitigate surface water sheens, and provide reliable protection of ecological receptors in the long term.	Implementability (1) Technical feasibility of designing and constructing the technology to meet the RAO given the site conditions. (2) Availability of specific equipment, materials, services, and technical specialists to design, install, operate, and maintain the remedy.	Relative Cost ¹
No Action	No Action	- No further action would be completed to address sheen-bearing material. - Serves as baseline for comparison of the overall effectiveness, implementability, and cost of the other technologies.	(1) Could not be demonstrated to achieve the RAO, as no monitoring would be conducted. (2) Would not reduce surface water sheens in the short term; potential for exposure to ecological receptors in the short term. No construction-related impacts to human health or the environment. (3) May reduce sheens in the long term through recovery processes (although no monitoring would be conducted to document).	(1) Technically feasible. (2) No specific requirements.	Low.
Natural Recovery	Monitored Natural Recovery	- Includes physical, chemical, and biological recovery processes that act in combination to reduce the mass, volume, and toxicity of sheen-bearing material. - Requires periodic sampling and monitoring to assess the natural recovery of sheen-bearing material over time.	(1) Expected to achieve the RAO in the long term, but not in the short term. Would not reduce surface water sheens or the mobility, volume, or toxicity of sheen-bearing material in the short term. (2) Would not reduce surface water sheens in the short term; potential for exposure to ecological receptors in the short term. No construction-related impacts to human health or the environment. (3) Reduction of exposure to ecological receptors in the long term, assuming natural recovery of constituents over time. Monitoring would be required to assess effectiveness over time.	(1) Technically feasible to implement site-wide. (2) Would not require specialty equipment, materials, services, or technical specialists other than those needed to conduct monitoring.	Low construction and O&M costs.
	Enhanced Natural Recovery	- Placement of a thin-layer of clean material (typically sand or clean sediment) over sheen-bearing material to accelerate natural recovery through several processes, including via mixing of the clean layer through bioturbation with underlying sediments, that act in combination to reduce the mass, volume, and toxicity of sheen-bearing material. - Thin-layer materials would be installed in the wet. - Requires periodic sampling and monitoring to assess the natural recovery of sheen-bearing material over time.	(1) Would likely achieve the RAO in the long term, but may not be effective in the short term as the thin-layer material would not physically isolate constituents nor provide sorption of sheens. Would not remove constituents from the site, although the volume and toxicity of constituents would be reduced over time via accelerated natural recovery through several processes, including via mixing of the clean layer through bioturbation with underlying sediments. (2) Low potential for exposure to ecological receptors during construction and implementation. Environmental impacts during thin-layer placement, although minimal, include disturbing biota/habitat, and creating turbidity in the location of thin-layer placement. Environmental benefits include placement of a semi-"clean" surface for use by benthic organisms, limited disturbance of sediments and odor generation during thin-layer placement, and the removal and off-site disposal of sheen-bearing material would not be required. (3) Reduction of exposure to ecological receptors in the long term, assuming natural recovery of constituents over time.	(1) Technically feasible to install. Only a thin layer of clean material is required for installation. Shallow water and irregular surface from roots, stumps, or other causes present installation challenges that can be addressed through proper selection of remedial approach and equipment. (2) Equipment, materials, services, and the technical specialists necessary to install a thin-layer cap are available.	Moderate construction and low O&M costs.

Table N-1
Detailed Evaluation of Remedial Technologies

Downstream Areas Data Assessment Report
ExxonMobil Environmental Services Company
Mayflower Pipeline Incident Response, Mayflower, Arkansas

General Response Action	Remedial Technology	Description	<u>Effectiveness</u> (1) Ability to meet and continue to meet the RAO of mitigating surface water sheens. (2) Short-term effectiveness: Ability to provide protection of ecological receptors in the short term until the RAO is achieved, and potential adverse impacts during the construction and implementation. (3) Long-term effectiveness: Ability to reduce mobility of any residual crude oil, mitigate surface water sheens, and provide reliable protection of ecological receptors in the long term.	<u>Implementability</u> (1) Technical feasibility of designing and constructing the technology to meet the RAO given the site conditions. (2) Availability of specific equipment, materials, services, and technical specialists to design, install, operate, and maintain the remedy.	Relative Cost ¹
Containment	Non-Reactive Capping	<ul style="list-style-type: none"> - Application of an isolation layer of non-reactive clean material (typically sand with thickness ranging from two up to several feet) over sheen-bearing material to provide a physical barrier to minimize surface water sheen. - Cap materials would be installed in the wet. - Monitoring during construction would be required to assess achievement of cap thickness and settling. 	(1) Would likely achieve the RAO in the long term, but may not be effective in the short term as sand does not provide sorption of sheens. Would reduce the mobility of constituents in sheen-bearing material (via a physical barrier) and reduce the potential for exposure to constituents. Would not remove constituents from the site, although they may degrade over time below the cap. (2) Low potential for exposure to ecological receptors during construction and implementation. Environmental impacts during construction potentially include removing vegetation, disturbing biota/habitat, creating turbidity in the location of cap installation, and altering hydrology/water depth of the site. Environmental benefits include creation of a "clean" surface for use by benthic organisms, limited disturbance of sediments and odor generation during cap construction, and the removal and off-site disposal of sheen-bearing material would not be required. (3) Reduction of exposure to ecological receptors in the long term, assuming natural attenuation/recovery of constituents over time, and reduced contaminant diffusive flux due to physical barrier. Maintenance during construction would be required to assess achievement of cap thickness and settling. Any future intrusive activities at the site, such as excavation, may reduce the long-term effectiveness of this technology; however, such activities are unlikely.	(1) Technically feasible to install, although shallow water depth might create challenges during cap construction. Additional investigation activities may be required to design the cap. Irregular surface from roots, stumps, or other causes present installation challenges that can be addressed through proper selection of remedial approach and equipment. (2) Equipment, materials, services, and the technical specialists necessary to construct a non-reactive cap are available.	Moderate construction and O&M costs.
	Reactive Capping	<ul style="list-style-type: none"> - Application of a mixture of sand/organoclay layer over sheen-bearing material to provide a physical and chemical barrier, while simultaneously providing sequestration of constituents and sheens via the addition of organoclay. - Reactive cap would be installed in the wet. - Monitoring during construction would be required to assess achievement of cap thickness and settling. 	(1) Would achieve the RAO. Would reduce the mobility of constituents in sheen-bearing material (via sorption and the presence of a physical barrier) and reduce the potential for exposure to constituents. Would not remove constituents from the site, although they may degrade over time below the cap. (2) Low potential for exposure to ecological receptors during construction and implementation. Environmental impacts during construction potentially include removing vegetation, disturbing biota/habitats, creating turbidity in the location of cap installation, and altering the hydrology/water depth of the site. Environmental benefits include creation of a clean surface for use by benthic organisms, limited disturbance of sediments and odor generation during cap construction, and the removal and off-site disposal of sheen-bearing material would not be required. (3) Would mitigate the potential for sheens on the surface water. Monitoring during construction would be required to assess achievement of cap thickness and settling. Any future intrusive activities at the site, such as excavation, may reduce the long-term effectiveness of this technology; however, such activities are unlikely.	(1) Technically feasible to install. The ratio of organoclay to sand would be selected to provide adequate cap effectiveness. Additional investigation activities may be required to design the cap. Shallow water and irregular surface from roots, stumps, or other causes present installation challenges that can be addressed through proper selection of remedial approach and equipment. (2) Thickness of the cap required to mitigate sheens may present installation challenges in shallow water. (3) Equipment, materials, services, and the technical specialists necessary to construct a reactive cap amended with organoclay are available.	Moderate construction and O&M costs.

Table N-1
Detailed Evaluation of Remedial Technologies

Downstream Areas Data Assessment Report
ExxonMobil Environmental Services Company
Mayflower Pipeline Incident Response, Mayflower, Arkansas

General Response Action	Remedial Technology	Description	<u>Effectiveness</u> (1) Ability to meet and continue to meet the RAO of mitigating surface water sheens. (2) Short-term effectiveness: Ability to provide protection of ecological receptors in the short term until the RAO is achieved, and potential adverse impacts during the construction and implementation. (3) Long-term effectiveness: Ability to reduce mobility of any residual crude oil, mitigate surface water sheens, and provide reliable protection of ecological receptors in the long term.	<u>Implementability</u> (1) Technical feasibility of designing and constructing the technology to meet the RAO given the site conditions. (2) Availability of specific equipment, materials, services, and technical specialists to design, install, operate, and maintain the remedy.	Relative Cost ¹
Removal	Targeted Removal (in the Dry or Wet)	<ul style="list-style-type: none"> - Excavate sheen-bearing material from targeted areas consistently producing sheen related to Pegasus crude oil, and/or presenting constituent exposures deemed to cause ecological risk. - If in the wet, mechanical dredges would be used, and the equipment either would operate from shore or a floating barge (due to presence of extensive woody debris, hydraulic dredging is likely not an effective option). - If in the dry, conventional excavation equipment would be used, and the area would be dewatered using pumps and a bypass pipeline to pump the creek flow around the work area prior to excavation. - Estimated depth of excavation is up to 1 foot below sediment surface based on previous sampling performed at the site. - Water generated during processing would be treated and discharged back to the water body, and would be subject to the appropriate permits. - Dewatered, excavated material would be transported to a permitted off-site disposal facility. - Following excavation, a clean backfill layer would be installed, if needed, for seeding and restoration. 	(1) Would achieve the RAO. Would reduce the mobility, volume, and toxicity of constituents in the short and long term by permanently removing sheen-bearing material. However, residuals may remain after excavation. (2) Potential for exposure to ecological receptors during implementation. Community impacts during implementation include truck traffic and elevated levels of noise, dust, and odors. Environmental impacts during implementation include turbidity generation, re-suspension of sediments, an increased area of inundation due to the lowering of topographic elevations, removing vegetation, disturbing biota/habitat, high energy use, and the generation of sheen-bearing waste for off-site disposal. (3) Would reduce the long-term potential for exposure to ecological receptors, although residuals may remain after excavation. Natural recovery/attenuation may reduce mobility, volume, and toxicity of residuals in the long term.	(1) Technically feasible to implement. It would take an estimated 1 to 2 months to implement for localized removal in sheen areas. The duration of implementation is dependent on the extent of media requiring excavation (estimated to be 1,500 cubic yards of material removed per day). Excavated material would need to be transported off site for disposal and would require dewatering prior to transporting off site. (2) Equipment, materials, services, and the technical specialists needed are readily available.	High construction and moderate O&M costs.

Table N-1
Detailed Evaluation of Remedial Technologies

Downstream Areas Data Assessment Report
ExxonMobil Environmental Services Company
Mayflower Pipeline Incident Response, Mayflower, Arkansas

General Response Action	Remedial Technology	Description	Effectiveness (1) Ability to meet and continue to meet the RAO of mitigating surface water sheens. (2) Short-term effectiveness: Ability to provide protection of ecological receptors in the short term until the RAO is achieved, and potential adverse impacts during the construction and implementation. (3) Long-term effectiveness: Ability to reduce mobility of any residual crude oil, mitigate surface water sheens, and provide reliable protection of ecological receptors in the long term.	Implementability (1) Technical feasibility of designing and constructing the technology to meet the RAO given the site conditions. (2) Availability of specific equipment, materials, services, and technical specialists to design, install, operate, and maintain the remedy.	Relative Cost ¹
Treatment	In-Situ Mixing of Amendments	<ul style="list-style-type: none"> - In-situ mixing of amendments to sheen-bearing material to reduce the mobility and bioavailability of constituents through adsorption/absorption and/or enhanced rate of natural biodegradation. - Amendments considered for the site are: (1) mixture of sand/organoclay and (2) Absorbent W®. - Would require monitoring to demonstrate the reduction of potential mass, volume, and toxicity of sheen-bearing material over time. 	(1) Would achieve the RAO of mitigating surface water sheens. Would reduce the mobility of constituents (via adsorption/absorption) in the short term, assuming the proper dosage of amendments is applied and absorptive/adsorptive capacity is maximized. Would reduce the volume and toxicity of sheen-bearing material in the long term via natural biodegradation. (2) Low to medium potential for exposure to ecological receptors during implementation. Environmental impacts during implementation potentially include removing vegetation/habitat destruction and disturbing biota. Ecological impacts associated with the amendments would also be possible and would require evaluation. (3) Would reduce the long-term potential for exposure to ecological exposure, although additional amendments might have to be applied in the future and/or constituent-containing amendments might have to be removed and disposed off-site. Future intrusive activities at the site may reduce the long-term effectiveness of this technology.	(1) Technically feasible to implement, although the type and amount of amendments applied to the site would have to be determined during implementation to achieve proper dosage. Amendments would have to be mixed into the subsurface to maximum absorptive/adsorptive capacity. Some of the amendments have not been used for the intended purpose; therefore, field tests might be necessary. (2) Equipment, materials, services, and technical specialists necessary to apply amendments are available.	Moderate to high capital and O&M costs.
	Ex-Situ On-Site Treatment and Reuse	<ul style="list-style-type: none"> - Ex-situ enhanced biodegradation of sheen-bearing material in a constructed land treatment unit located within the upland floodplain area (normally exposed soils) within Dawson Cove. - Treatment process would involve addition of amendments, nutrients, and moisture to enhance natural biodegradation of constituents in a controlled setting. - Submerged sediments would require dewatering prior to treatment. - Stormwater runoff from ex-situ treatment area would be managed and filtered prior to discharge to Dawson Cove. - Excavated areas would be backfilled and re-graded after treatment, if needed, with the potential for beneficial reuse of remediated media. 	(1) Would achieve the RAO. Would reduce the mobility, volume, and toxicity of constituents in the short and long term by removing and treating sheen-bearing material. However, residuals may remain after removal and treatment. (2) Medium to high potential for exposure to ecological receptors during implementation. Community impacts during implementation potentially include truck traffic and elevated levels of noise, dust, and odors. Environmental impacts during implementation potentially include removing vegetation/habitat destruction (from excavation areas, upland floodplain area, and staging areas), increased erosion and runoff, creating an increased area of inundation due to the lowering of topographic elevations, disturbing biota, and high energy use. (3) Would reduce the long-term potential for exposure to environmental receptors, although residuals may remain after removal and treatment. Natural recovery/attenuation may reduce potential mobility, volume, and toxicity of residuals in the long term.	(1) Technically feasible to implement. Sheen mitigation is anticipated to occur immediately after the excavation of sheen-bearing material. It would take an estimated 2 to 4 months to treat excavated material. The duration of implementation is dependent on the size of the treatment area and the number of batches (or lifts) of excavated material. Dewatering of saturated soils may be needed. The land treatment unit must be designed and constructed with appropriate erosion and runoff controls. National Pollutant Discharge Elimination System and/or stormwater management permits and monitoring of discharge from cell areas may be required. May be administratively challenging to construct and operate an on-site treatment unit. (2) Equipment, materials, services, and technical specialists necessary to excavate and treat impacted media are available. There are two types of tilling/mixing options generally available: <ul style="list-style-type: none"> - Soil mixing, which uses typical land farm unit mixing equipment. This is capable of treating approximately 2,000 to 6,500 tons per acre, depending on the lift thickness. -Windrow treatment, which uses an excavator/front-end loader to create windrows, and then specialized equipment (e.g., Brown Bear) to help mix the windrow piles. This option treats approximately 3,000 cubic yards per acre. Additional dewatering of saturated soils may be needed. 	Moderate to high capital and O&M costs.

Table N-1
Detailed Evaluation of Remedial Technologies

Downstream Areas Data Assessment Report
ExxonMobil Environmental Services Company
Mayflower Pipeline Incident Response, Mayflower, Arkansas

Notes:
O&M = operation and maintenance
RAO = remedial action objective

¹ Relative cost estimates are based on the available information regarding the site investigation and the anticipated scope of the remedial technology. Changes in cost elements are likely to occur as a result of new information and data collected during the engineering design of the remedial technology. Utilization of this comparative cost estimate information beyond the stated purpose is not recommended. ARCADIS is not licensed to provide financial or legal consulting services; as such, this relative cost estimate information is not intended to be utilized for complying with financial reporting requirements associated with liability services.

Table N-2
Applicable Permits and Authorizations

Downstream Areas Data Assessment Report
ExxonMobil Environmental Services Company
Mayflower Pipeline Incident Response, Mayflower, Arkansas

Regulation	Agency	Citation	Requirement	Compliance	Applicable to Alternative				
					Alternative 1 (No Action)	Alternative 2	Alternative 3	Alternative 4	Alternative 5
State Regulations									
Hazardous Waste Management	ADEQ and APCEC	APCEC Regulation No. 23 (August 12, 2012)	Applies to the management of soils or sediment excavated as part of a remedial action. Excavation and disposal of sediment is included in Alternatives 3, 4, & 5.	Any waste considered hazardous must be handled according to Regulations 23 including restrictions for comingling, transport, and deposition. A site accepting hazardous waste must have USEPA identification number and be approved by ADEQ to accept that specific classification of waste. Transporters must have ADEQ permit and meet Regulations 23 standards for permits. EMES will ensure that all requirements of Regulations 23 are met during project implementation.		✓	✓	✓	✓
Water Quality Standards for Surface Water	ADEQ	APCEC Regulation 2 (eff. August 26, 2011)	Applies to alternatives that include surface water quality cleanup. Regulation 2 includes the Arkansas Anti-degradation Policy.	Implementation of the alternative must meet state water quality standards. It is anticipated that state stormwater quality standards will be met by submitting a Notice of Intent (NOI) and preparation of a Stormwater Pollution Prevention Plan (SWPPP).		✓	✓	✓	✓
Regulations For State Administration Of The National Pollutant Discharge Elimination System (NPDES)	ADEQ	APCEC Regulation 6 (eff. February 9, 2013)	Applies to alternatives that require discharge of wastewater (including dewatering water from sediment) to a surface water of the U.S.	Dewatering and discharge to waters of the state (Dawson Cove) will require an individual NPDES permit from ADEQ. Measures will be taken to reduce the potential for water quality impacts including monitoring at discharge point.		✓	✓	✓	✓
Solid Waste Management	ADEQ	APCEC Regulation 22 (eff. April 26, 2008)	Applies to alternatives that require disposal of solid waste. Excavation and disposal of sediment is included in Alternatives 3, 4, & 5.	Solid waste removed from the project site must be deposited at a landfill permitted to access the waste. EMES will ensure that all requirements of Regulations 22 are met during project implementation.		✓	✓	✓	✓

**Table N-2
Applicable Permits and Authorizations**

**Downstream Areas Data Assessment Report
ExxonMobil Environmental Services Company
Mayflower Pipeline Incident Response, Mayflower, Arkansas**

Regulation	Agency	Citation	Requirement	Compliance	Applicable to Alternative				
					Alternative 1 (No Action)	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Federal Regulations									
Clean Water Act Section 404	USACE	40 CFR Sections 230 and 231; and 33 CFR 320- 330	Placement of dredged or fill material into waters of the U.S., including wetlands.	Application (4345 form) and project description information submitted to the USACE Little Rock District. If greater than ½ acre of impacts on waters of the U.S. are expected, an Individual Permit would be required including preparation of 404(b)(1) Alternatives Analysis.			✓	✓	✓
Rivers and Harbors Act of 1899	USACE	33 CFR 322	Placement of dredged or fill material into waters of the U.S. Prohibits the unauthorized obstruction or alteration of navigable waters of the U.S.	Application (4345 form) and project description information submitted to the USACE Little Rock District. If greater than ½ acre of impacts on waters of the U.S. are expected, an Individual Permit would be required including preparation of 404(b)(1) Alternatives Analysis. The USACE can only issue a permit for the Least Environmentally Damaging Practicable Alternative.			✓	✓	✓
Clean Water Act Section 401	ADEQ	40 CFR 131	ADEQ must certify the permits issued by USACE meet state water quality objectives.	Application submitted to ADEQ in coordination with CWA 404 application. Project must comply with state water quality objectives including anti-degradation analysis describing how the preferred alternative will not degrade water quality.			✓	✓	✓
Section 7 Federal Endangered Species Act (ESA)	USFWS/ NOAA Fisheries	ESA, Section 7, As Amended, 50 CFR § 402 (2000).	Under Section 7 of the ESA, an action by a federal agency cannot result in 'take' or jeopardize the continued existence of a listed or candidate species. Where potential for take exists, conservation measures to reduce the potential for take must be implemented. USACE must comply with Section 7 by ensuring the permitting action does not result in the jeopardy of a listed species.	Information regarding the potential for federally listed endangered or threatened species must be included in permit application package to USACE. Information will include list of species with potential to occur within the project vicinity and potential effects on species as a result of project implementation.			✓	✓	✓
Section 106 of the National Historic Preservation Act (NHPA)	SHPO	Public Law 89- 665 and amendments there to 16 USC 470 et seq.	Section 106 of the NHPA requires that all federal agencies provide the Advisory Council on Historic Preservation, an opportunity to comment on any undertaking for which an agency has direct or indirect jurisdiction when the undertaking has the potential for adverse effects on a historic property listed or eligible for listing on the National Register of Historic Places. USACE must comply with Section 106 of NHPA by ensuring the permitting action does not result in adverse effects on historic resources.	Information regarding known historical and cultural resources within the project vicinity will be included in the permit application to the USACE, which includes a description of any cultural resources and the potential adverse effects on resources as a result of project implementation.			✓	✓	✓
NPDES	ADEQ	Section 402 CWA 33 USC 1251- 1387"	Substantive requirements of NPDES permit for point source and non-point source discharges of pollutants into waters of the U.S. from onsite dewatering during construction.	Preparation of a SWPPP and submittal of NOI submitted to ADEQ at least 30 days prior the start of construction. The SWPPP would include best management practices (BMPs) to protect water quality during implementation of the preferred alternative.			✓	✓	✓

Table N-2
Applicable Permits and Authorizations

Downstream Areas Data Assessment Report
ExxonMobil Environmental Services Company
Mayflower Pipeline Incident Response, Mayflower, Arkansas

Regulation	Agency	Citation	Requirement	Compliance	Applicable to Alternative				
					Alternative 1 (No Action)	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Federal Regulations									
Migratory Bird Treaty Act	USFWS	16 USC 703-712	It is prohibited, unless permitted by regulations, to "pursue, hunt, take, capture, kill, attempt to take, capture or kill, possess, offer for sale, sell, offer to purchase, purchase, deliver for shipment, ship, cause to be shipped, deliver for transportation, transport, cause to be transported, carry, or cause to be carried by any means whatever, receive for shipment, transportation or carriage, or export, at any time, or in any manner, any migratory bird, included in the terms of this Convention . . . for the protection of migratory birds . . . or any part, nest, or egg of any such bird".	Because the project is located in the Mississippi Flyway, if work were to occur during the nesting and breeding season, pre-construction surveys for nesting and breeding birds would occur. An avoidance plan would be prepared outlining the specific protocols required for work during the nesting and breeding season.			✓	✓	✓

Notes:
ADEQ = Arkansas Department of Environmental Quality
AGFC = Arkansas Game and Fish Commission
APCEC = Arkansas Pollution Control & Ecology Commission
BMPs = Best Management Practices
CAR = Code of Arkansas Regulation
COPC = Constituents of Potential Concern
CWA = Clean Water Act
EMES = ExxonMobil Environmental Services Company
ESA = Endangered Species Act
NHPA = National Historic Preservation Act
NOAA = National Oceanic and Atmospheric Administration
NOI = Notice of Intent
NPDES = National Pollutant Discharge Elimination System
SHPO = State Historic Preservation Office
SWPPP = Stormwater Pollution Prevention Plan
USACE = U.S. Army Corps of Engineers
USC = U.S. Code
USEPA = U.S. Environmental Protection Agency
USFWS = U.S. Fish and Wildlife Service

¹ APCEC Regulation 22.708 (a) Applicability - Petroleum contaminated soils may be disposed of in a Class 1 landfill provided the contaminated soils meet the requirements established in the Hazardous and Unauthorized Waste Exclusion Plan developed by each Class 1 facility, as required by Reg.22.412, unless otherwise specified in the facility disposal permit. The facility operator shall be responsible for complying with all applicable waste determination protocols. (b) Petroleum contaminated soils that comply with the facility Hazardous and Unauthorized Waste Exclusion Plan may be used as daily cover on interior working faces that drain directly into the facility leachate collection system.

Table N-3
Detailed Evaluation of Retained Remedial Technologies

Downstream Areas Data Assessment Report
ExxonMobil Environmental Services Company
Mayflower Pipeline Incident Response, Mayflower, Arkansas

General Response Action	Retained Remedial Technology	Description	Overall Protection of Ecological Receptors	Compliance with Applicable Rules and Regulations	<u>Short-Term Effectiveness</u> (1) Potential adverse impacts during the construction and implementation. (2) Ability to provide protection of ecological receptors in the short term until the RAO is achieved.	<u>Long-Term Effectiveness</u> Ability to reduce mobility of any residual crude oil, mitigate surface water sheens, and provide reliable protection of ecological receptors in the long term.	<u>Implementability</u> (1) Technical feasibility of designing and constructing the technology to meet the RAO, given the site conditions. (2) Availability of specific equipment, materials, services, and technical specialists to design, install, operate, and maintain the remedy.	Relative Cost ¹
No Action	No Action	- No further action would be completed to address sheen-bearing material. - Serves as baseline for comparison to the other technologies.	- Could not be demonstrated to achieve the RAO, as no monitoring would be conducted.	- Not applicable as remedial actions would not be taken.	(1) No construction-related impacts to human health or the environment. (2) Potential exposure to ecological receptors in the short term. Would not reduce surface water sheens or the mobility or volume of sheen-bearing material in the short term.	- May reduce surface water sheens in the long term through recovery processes (although no monitoring would be conducted to document).	(1) Technically feasible. (2) No specific requirements.	Low.
Natural Recovery	Monitored Natural Recovery	- Includes physical, chemical, and biological recovery processes that act in combination to reduce the mass and volume of crude oil residuals. - Requires periodic sampling and monitoring to assess the natural recovery of constituents over time.	- Would provide protection of ecological receptors as the RAO would be expected to be achieved in the long term.	- Not applicable in the short term as remedial actions would not be taken. - Applicable rules and regulations would be met in the long term.	(1) No construction-related impacts to human health or the environment. (2) Potential exposure to ecological receptors in the short term. Would not reduce surface water sheens or the mobility or volume of sheen-bearing material in the short term.	- Would mitigate the potential for surface water sheens and the potential for exposure to ecological receptors in the long term, assuming natural recovery of sheens over time. - Long-term monitoring would be required to assess long-term effectiveness.	(1) Technically feasible to implement site-wide. (2) Would not require equipment, materials, services, or technical specialists other than those needed to conduct monitoring.	Low construction and O&M costs.
Containment	Reactive Capping	- Application of a mixture of sand/organoclay layer over sheen-bearing material to provide a physical and chemical barrier while simultaneously providing sequestration of constituents and sheens via the addition of organoclay. - Reactive cap would be installed in the wet. - Monitoring during construction would be required to assess achievement of cap thickness and settling.	- Would provide protection of ecological receptors as the RAO would be achieved.	- Applicable rules and regulations would be met.	(1) Low potential for exposure to ecological receptors during construction and implementation. Environmental impacts during construction potentially include removing vegetation, disturbing biota/habitats, creating turbidity in the location of cap installation, and altering the hydrology/water depth of the site. Environmental benefits include creation of a clean surface for use by benthic organisms, limited disturbance of sediments and odor generation during cap construction, and the removal and off-site disposal of sheen-bearing material would not be required. (2) Would mitigate the potential for surface water sheens in the short term. Would reduce the mobility of constituents in sheen-bearing material (via sorption and the presence of a physical barrier). However, would not remove constituents from the site (although they may degrade over time below the cap).	- Would reduce mobility of any residual crude oil, mitigate the potential for surface water sheens, and provide protection of ecological receptors in the long term by physically and chemically reducing the mobility of constituents. - Monitoring during construction would be required to maintain cap integrity/effectiveness in the long term. - Any future intrusive activities at the site, such as excavation, may reduce the long-term effectiveness of this technology; however, such activities are unlikely. - Natural recovery may reduce the potential mobility and volume of sheen-bearing material beneath the reactive cap in the long term.	(1) Technically feasible to install. The ratio of organoclay to sand would be selected to provide adequate cap effectiveness. Additional investigation activities may be required to design the cap. Shallow water, irregular surface from roots, stumps or other causes present installation challenges that can be addressed through proper selection of remedial approach and equipment. (2) Equipment, materials, services, and the technical specialists necessary to construct a reactive cap amended with organoclay are available.	Moderate construction and O&M costs.
Removal	Targeted Removal (in the Dry or Wet)	- Excavate sheen-bearing material from targeted areas consistently producing sheen related to Pegasus crude oil, and/or presenting constituent exposures deemed to cause ecological risk. - If in the wet, mechanical dredges would be used, and the equipment either would operate from shore or a floating barge (due to presence of extensive woody debris, hydraulic dredging is likely not an effective option). - If in the dry, conventional excavation equipment would be used, and the area would be dewatered using pumps and a bypass pipeline to pump the creek flow around the work area prior to excavation. - Estimated depth of excavation is up to 1 foot below sediment surface based on previous sampling performed at the site. - Water generated during processing would be treated and discharged back to the water body, and would be subject to the appropriate permits. - Dewatered, excavated material would be transported to a permitted off-site disposal facility. - Following excavation, a clean backfill layer would be installed, if needed, for seeding and restoration.	- Would provide protection of ecological receptors as the RAO would be achieved.	- Applicable rules and regulations would be met.	(1) Moderate to high potential for exposure to ecological receptors during implementation. Community impacts during implementation include truck traffic and elevated levels of noise, dust, and odors. Environmental impacts during implementation include turbidity generation, re-suspension of sediments, an increased area of inundation due to the lowering of topographic elevations, removing vegetation, disturbing biota/habitat, high energy use, and the generation of sheen-bearing waste for off-site disposal. (2) Would mitigate the potential for surface water sheens in the short term. Would reduce the mobility and volume of crude oil residuals by permanently removing sheen-bearing material. However, residuals may remain after excavation.	- Would remove residual crude oil, mitigate the potential for surface water sheens, and provide protection of ecological receptors in the long term by permanently removing sheen-bearing material. - Natural recovery may reduce potential mobility and volume of residuals in the long term.	(1) Technically feasible to implement. It would take an estimated 1 to 2 months to implement for localized removal in sheen areas. The duration of implementation is dependent on the extent of media requiring excavation (estimated to be 1,500 cubic yards of material removed per day). Excavated material would need to be transported off site for disposal and would require dewatering prior to transporting off site. (2) Equipment, materials, services, and the technical specialists needed are readily available.	High construction and moderate O&M costs.

Notes:

O&M = operation & maintenance

RAO = remedial action objective

¹ Relative cost estimates are based on the available information regarding the site investigation and the anticipated scope of the remedial technology. Changes in cost elements are likely to occur as a result of new information and data collected during the engineering design of the remedial technology. Utilization of this comparative cost estimate information beyond the stated purpose is not recommended. ARCADIS is not licensed to provide financial or legal consulting services; as such, this relative cost estimate information is not intended to be utilized for complying with financial reporting requirements associated with liability services.

Table N-4
Evaluation and Screening of Site-Wide Remedial Alternatives

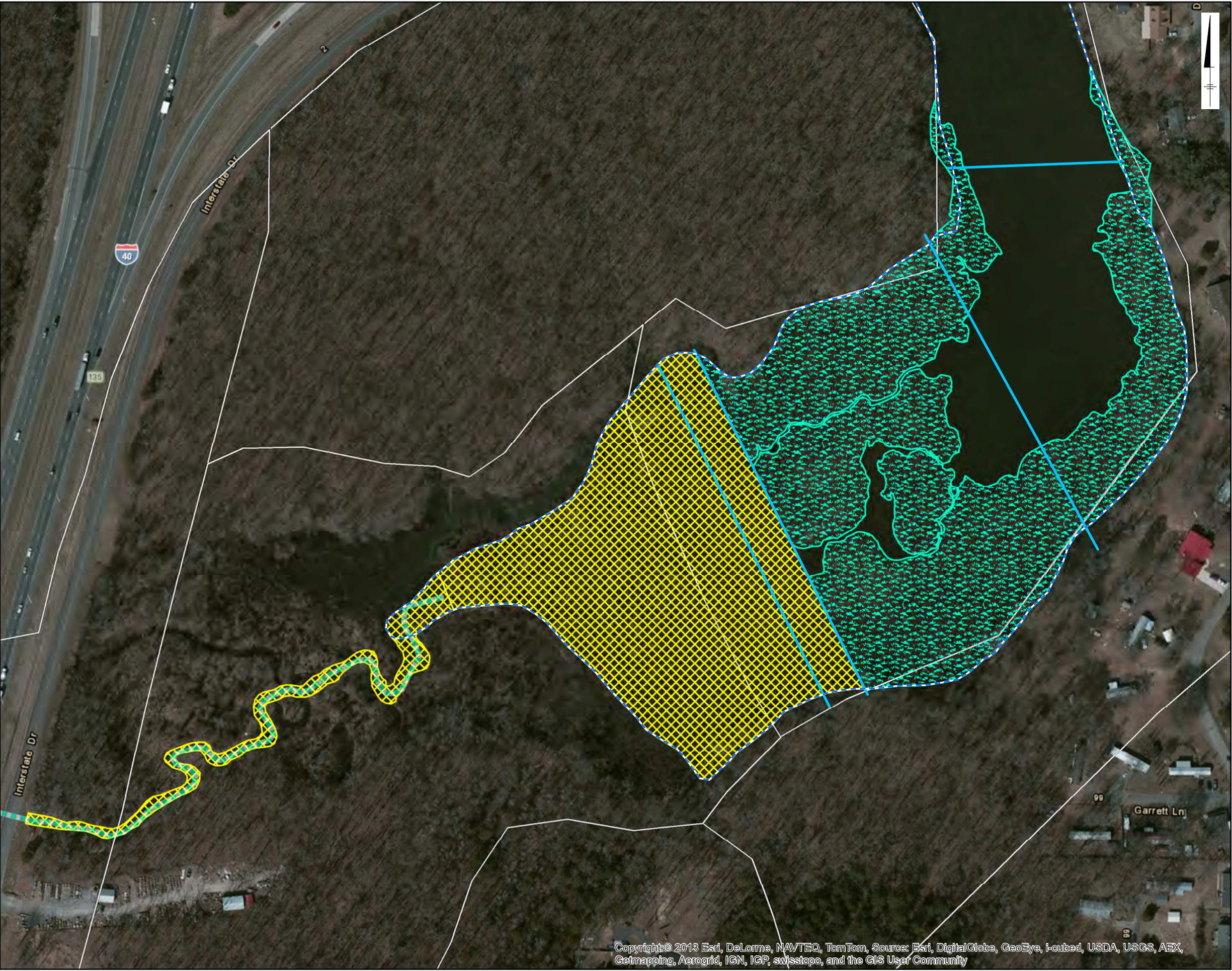
Downstream Areas Data Assessment Report
ExxonMobil Environmental Services Company
Mayflower Pipeline Incident Response, Mayflower, Arkansas

Remedial Alternatives	Threshold Criteria		Balancing Criteria				Screening Score		
	Overall Protection of Ecological Receptors	Compliance with Applicable Rules and Regulations	Short-term Effectiveness	Long-term Effectiveness	Implementability	Relative Cost	Threshold Criteria	Balancing Criteria	Total Score
Alternative 1: No Action	1	1	1	N/A	5	5	2	11	13
Alternative 2: MNR in Inlet Channel MNR in Open Water Area	3	2	1	2	4	4	5	11	16
Alternative 3: Reactive Capping in Inlet Channel Reactive Capping in Open Water Area	4	5	4	3	3	3	9	13	22
Alternative 4: Targeted Removal in Inlet Channel Reactive Capping in Open Water Area	5	5	3	5	3	3	10	14	24
Alternative 5: Targeted Removal in Inlet Channel Targeted Removal in Open Water Area	4	5	2	5	2	1	9	10	19

Screening Key	Overall Protection, Compliance, Effectiveness, Implementability, Screening Score	Relative Cost
1	Lowest	Highest
2	Low	High
3	Medium	Medium
4	High	Low
5	Highest	Lowest

Notes:
MNR = monitored natural recovery
N/A = not applicable

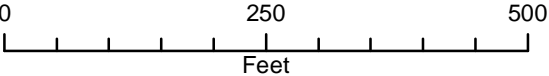
Figures



Legend

- Approximate Areas for Sheen Mitigation
- Areas with Heavy Vegetation
- Drainage Path
- Water's Edge
- Containment Boom
- Operations Areas

NOTE:
1. Areas for mitigation are approximate, and based on daily sheen monitoring activities initiated on October 21, 2013 and results from 10 sheen samples collected on November 4, 2013. Pre-design study will be conducted to confirm and refine the mitigation area.

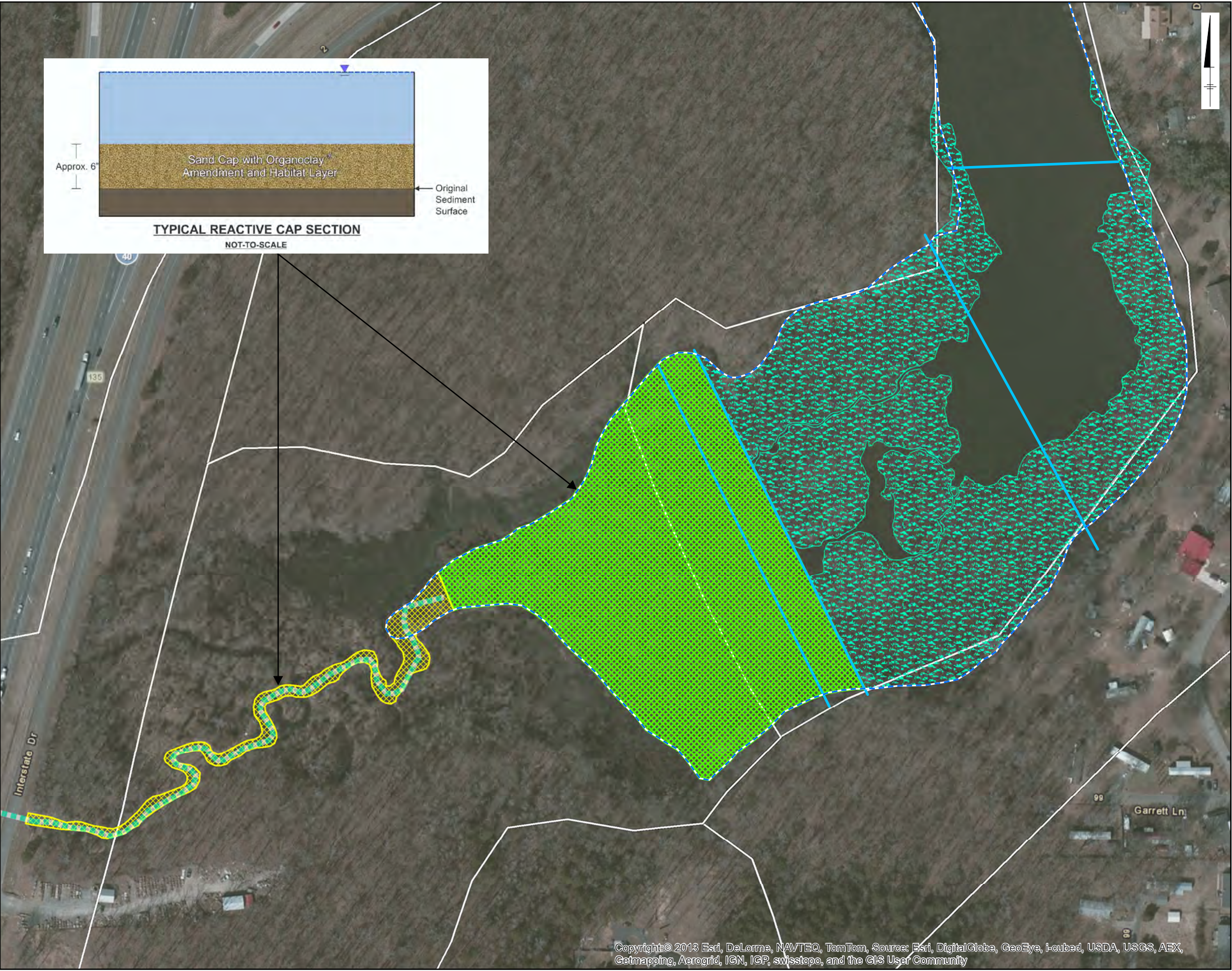


MAYFLOWER PIPELINE INCIDENT RESPONSE
EXXONMOBIL ENVIRONMENTAL SERVICES COMPANY
DOWNSTREAM AREAS DATA ASSESSMENT REPORT

APPROXIMATE AREAS FOR SHEEN MITIGATION

ARCADIS

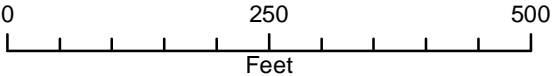
FIGURE
N-1



Legend

- Approximate Inlet Channel Cap Placement Area
- Approximate Open Water Cap Placement Area
- Areas with Heavy Vegetation
- Drainage Path
- Water's Edge
- Containment Boom
- Operations Areas

NOTE:
1. Potential cap placement areas are approximate, and based on daily sheen monitoring activities initiated on October 21, 2013 and on forensic results from 10 sheen samples collected on November 4, 2013. Pre-design study will be conducted to confirm the mitigation area.

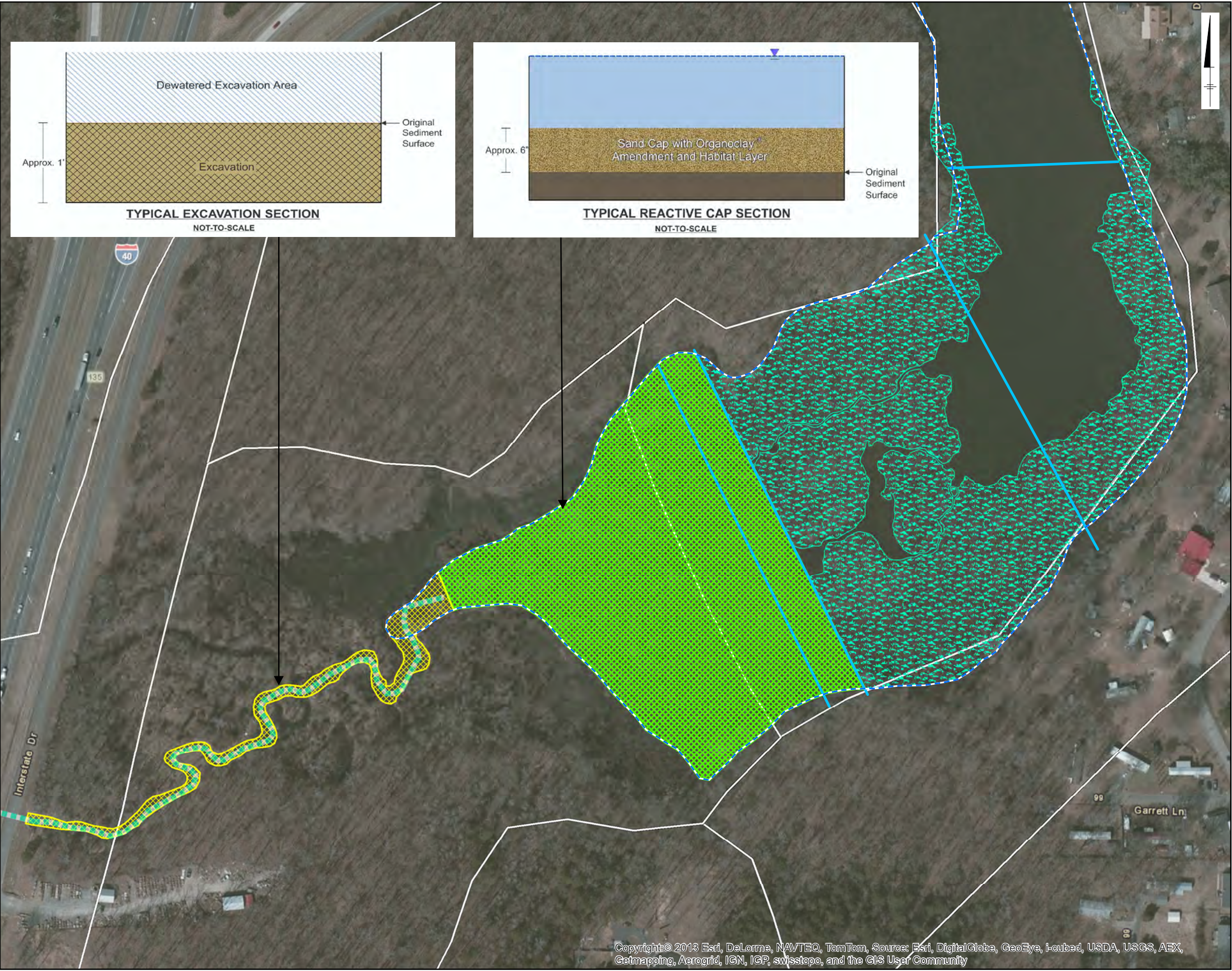


MAYFLOWER PIPELINE INCIDENT RESPONSE
EXXONMOBIL ENVIRONMENTAL SERVICES COMPANY
DOWNSTREAM AREAS DATA ASSESSMENT REPORT

ALTERNATIVE 3 -
REACTIVE CAPPING IN THE INLET CHANNEL
AND IN THE OPEN WATER AREA



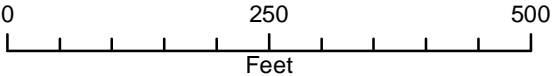
FIGURE
N-2



Legend

- Approximate Inlet Channel Targeted Removal Area
- Approximate Open Water Cap Placement Area
- Areas with Heavy Vegetation
- Drainage Path
- Water's Edge
- Containment Boom
- Operations Areas

NOTE:
1. Potential targeted removal area and cap placement areas are approximate, and based on daily sheen monitoring activities initiated on October 21, 2013 and results from 10 sheen samples collected on November 4, 2013. Pre-design study will be conducted to confirm the mitigation area.

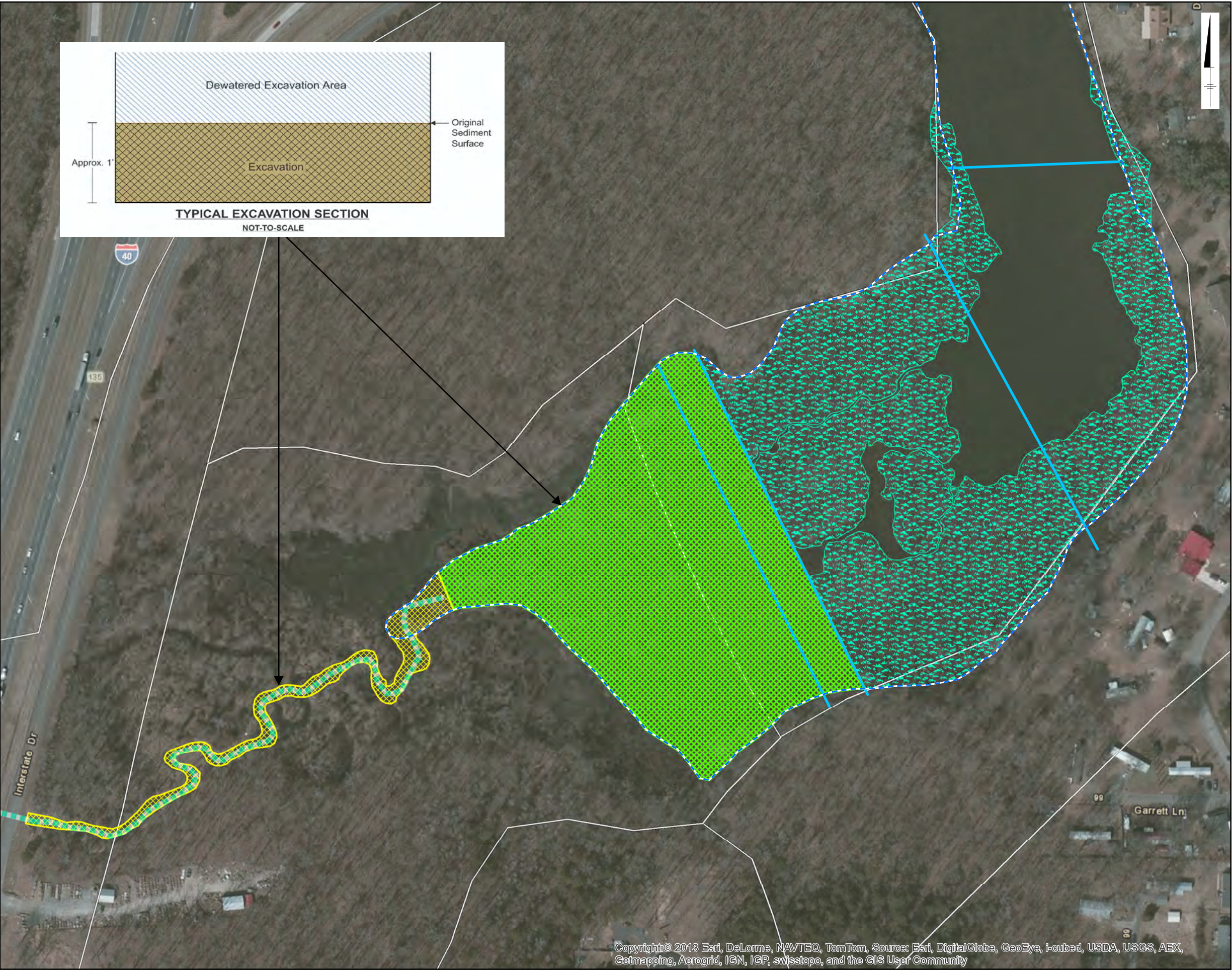


**MAYFLOWER PIPELINE INCIDENT RESPONSE
EXXONMOBIL ENVIRONMENTAL SERVICES COMPANY
DOWNSTREAM AREAS DATA ASSESSMENT REPORT**

**ALTERNATIVE 4 - TARGETED REMOVAL
IN THE INLET CHANNEL AND REACTIVE
CAPPING IN THE OPEN WATER AREA**

ARCADIS

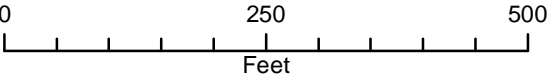
**FIGURE
N-3**



Legend

- Approximate Inlet Channel Targeted Removal Area
- Approximate Open Water Targeted Removal Area
- Areas with Heavy Vegetation
- Drainage Path
- Water's Edge
- Containment Boom
- Operations Areas

NOTE:
1. Potential targeted removal areas are approximate, and based on daily sheen monitoring activities initiated on October 21, 2013 and on forensic results from 10 sheen samples collected on November 4, 2013. Pre-design study will be conducted to confirm the mitigation area.



MAYFLOWER PIPELINE INCIDENT RESPONSE
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DOWNSTREAM AREAS DATA ASSESSMENT REPORT

ALTERNATIVE 5 - TARGETED REMOVAL
IN THE INLET CHANNEL AND IN
THE OPEN WATER AREA



FIGURE
N-4



Attachment N-1

Cost Estimates

**Attachment N-1
Summary of Estimated Costs**

**Downstream Areas Data Assessment Report
ExxonMobil Environmental Services Company
Mayflower Pipeline Incident Response**

Alternative	Description	Cost
Alt 2	MNR in the Inlet Channel and in the Open Water Area	\$ 346,000
Alt 3	Reactive Capping in the Inlet Channel and in the Open Water Area	\$ 3,818,000
Alt 4	Targeted Removal in the Inlet Channel and Reactive Capping in the Open Water Area	\$ 4,496,000
Alt 5	Targeted Removal in the Inlet Channel and in the Open Water Area	\$ 5,369,000

General Notes:

1. Cost estimate is based on ARCADIS U.S.'s (ARCADIS') past experience and vendor estimates using 2013 dollars.
2. This estimate has been prepared for the purposes of comparing potential remedial alternatives. The information in this cost estimate is based on the available information regarding the site investigation and the anticipated scope of the remedial alternative. Changes in cost elements are likely to occur as a result of new information and data collected during the engineering design of the remedial alternative. This cost estimate is expected to be within -30% to +50% of the actual projected cost. Utilization of this cost estimate information beyond the stated purpose is not recommended. ARCADIS is not licensed to provide financial or legal consulting services; as such, this cost estimate information is not intended to be utilized for complying with financial reporting requirements associated with liability services.
3. All costs assume field work to be conducted by non-union labor.
4. All costs presented are based on the current understanding of site-specific conditions and stated remediation goals. Design details are limited to conceptual approaches to remediation and include a number of assumptions that are subject to change. Actual construction specifications and technologies will be determined during the design phase, and as a result, actual construction costs may vary from the costs presented here.

Attachment N-1
Cost Estimate for Alternative 2
MNR in the Inlet Channel and in the Open Water Area

Downstream Areas Data Assessment Report
ExxonMobil Environmental Services Company
Mayflower Pipeline Incident Response

Item #	Description	Estimated Quantity	Unit	Unit Price	Estimated Cost
Capital Costs					
1	Establish Institutional Controls	1	LS	\$50,000	\$50,000
	Subtotal Capital Cost				\$50,000
2	Administration & Engineering (15%)				\$7,500
	Total Capital Cost				\$57,500
Operation and Maintenance (O&M) Costs					
3	Sheen Monitoring Visit	6	LS	\$25,000	\$150,000
4	Annual Monitoring Report	3	LS	\$20,000	\$60,000
5	Annual Verification and Certification of Institutional	3	LS	\$10,000	\$30,000
	Subtotal O&M Cost				\$240,000
	Contingency (20%)				\$48,000
	Total 3-Year O&M Cost				\$288,000
	Total Estimated Cost:				\$345,500
	Rounded To:				\$346,000

LS = lump sum

General Notes:

1. Cost estimate is based on ARCADIS U.S.'s (ARCADIS') past experience and vendor estimates using 2013 dollars.
2. This estimate has been prepared for the purposes of comparing potential remedial alternatives. The information in this cost estimate is based on the available information regarding the site investigation and the anticipated scope of the remedial alternative. Changes in cost elements are likely to occur as a result of new information and data collected during the engineering design of the remedial alternative. This cost estimate is expected to be within -30% to +50% of the actual projected cost. Utilization of this cost estimate information beyond the stated purpose is not recommended. ARCADIS is not licensed to provide financial or legal consulting services; as such, this cost estimate information is not intended to be utilized for complying with financial reporting requirements associated with liability services.
3. All costs assume field work to be conducted by non-union labor.
4. All costs presented are based on the current understanding of site-specific conditions and stated remediation goals. Design details are limited to conceptual approaches to remediation and include a number of assumptions that are subject to change. Actual construction specifications and technologies will be determined during the design phase, and as a result, actual construction costs may vary from the costs presented here.

Assumptions:

1. Establish institutional controls cost estimate includes legal expenses to institute environmental easements and deed restrictions to control the future development adjacent to river and use of the river, as well as limit future activities that could damage the river bottom.
2. Administration and engineering cost is equal to 15% of the total capital costs.
3. Sheen monitoring cost estimate includes all labor, equipment, subsistence and materials necessary to conduct a site-wide sheen monitoring visit. Estimate includes a two-person team (with associated travel costs), and provision of appropriate water vessel to inspect the site and make note of any sheen
4. Annual Monitoring Report cost estimate includes labor necessary to prepare an annual report for agency approval summarizing the results of the sheen observation and O&M activities completed throughout the year (i.e., the verification and certification activities for the institutional controls).
5. Annual costs associated with institutional controls include verifying the status of institutional controls and preparing/submitting notification to demonstrate that the institutional controls are being maintained and remain effective.

Attachment N-1
Cost Estimate for Alternative 3
Reactive Capping in the Inlet Channel and in the Open Water Area

Downstream Areas Data Assessment Report
ExxonMobil Environmental Services Company
Mayflower Pipeline Incident Response

Item #	Description	Estimated Quantity	Unit	Unit Price	Estimated Cost
Capital Costs					
1	Permits and Approvals	1	LS	\$50,000	\$50,000
2	Establish Institutional Controls	1	LS	\$50,000	\$50,000
3	Mobilization/Demobilization	1	LS	\$109,000	\$109,000
4	Construct and Maintain Staging Area	1	LS	\$26,000	\$26,000
5	Construct and Maintain Access Roadway	1	LS	\$95,000	\$95,000
6	Turbidity/Sheen Mitigation				
	Absorbent Booms	2,500	LF	\$10	\$25,000
	Absorbent Pads	4	WEEKS	\$600	\$2,200
	Turbidity Control System	725	LF	\$25	\$18,200
	Water Column Monitoring	0.9	MONTH	\$3,520	\$3,200
7	Woody Debris Removal	6.6	AC	\$17,000	\$112,200
8	Transportation and Disposal				
	Off-site Disposal Debris/Vegetation	1,000	TON	\$35	\$35,000
9	Capping of Inlet Channel and Open Water Area				
	Clean Sand	400	CY	\$24	\$9,600
	Organoclay Amendment	600	CY	\$2,600	\$1,560,000
	Habitat Layer Cover	4,400	CY	\$30	\$132,000
	Cap Placement	5,400	CY	\$40	\$216,000
10	Restoration	6.8	AC	\$15,000	\$102,000
Subtotal Capital Cost					\$2,545,400
11	Administration & Engineering (15%)				\$381,810
12	Construction Management (15%)				\$381,810
Contingency (20%)					\$509,080
Total Estimated Cost:					\$3,818,100
Rounded To:					\$3,818,000

AC = acres; CY = cubic yard; LF = linear feet; LS = lump sum

General Notes:

1. Cost estimate is based on ARCADIS U.S.'s (ARCADIS') past experience and vendor estimates using 2013 dollars.
2. This estimate has been prepared for the purposes of comparing potential remedial alternatives. The information in this cost estimate is based on the available information regarding the site investigation and the anticipated scope of the remedial alternative. Changes in cost elements are likely to occur as a result of new information and data collected during the engineering design of the remedial alternative. This cost estimate is expected to be within -30% to +50% of the actual projected cost. Utilization of this cost estimate information beyond the stated purpose is not recommended. ARCADIS is not licensed to provide financial or legal consulting services; as such, this cost estimate information is not intended to be utilized for complying with financial reporting requirements associated with liability services.
3. All costs assume field work to be conducted by non-union labor.
4. All costs presented are based on the current understanding of site-specific conditions and stated remediation goals. Design details are limited to conceptual approaches to remediation and include a number of assumptions that are subject to change. Actual construction specifications and technologies will be determined during the design phase, and as a result, actual construction costs may vary from the costs presented here.

Attachment N-1
Cost Estimate for Alternative 3
Reactive Capping in the Inlet Channel and in the Open Water Area

Downstream Areas Data Assessment Report
ExxonMobil Environmental Services Company
Mayflower Pipeline Incident Response

Assumptions:

1. Permits and approvals cost estimate includes preparation and procurement of the required permits and approvals from Federal, state and local agencies for one construction season. Access agreement costs not included.
2. Establish institutional controls cost estimate includes legal expenses to institute environmental easements and deed restrictions to control the future development adjacent to river and use of the river, as well as limit future activities that could damage the river bottom.
3. Mobilization/demobilization cost estimate includes mobilization and demobilization of labor, equipment, and materials necessary to complete the remediation. For cost estimating purposes, mobilization/demobilization costs are assumed to be 10% of the capital costs, not including permits and approvals, pre-design investigations, or transportation and disposal.
4. Pre-design investigation costs assumed to be labor, equipment, and materials necessary to conduct any required pre-design investigations. Estimated cost is based on 5% of the total capital cost, including an increased percentage to represent the need for materials handling and stabilization/treatability studies.
5. In addition, the cost estimate includes labor, equipment, and materials necessary to construct a 100-foot by 100-foot material staging area constructed of a 12-inch gravel fill layer over geotextile. Maintenance includes inspecting and repairing staging area as necessary.
6. Construct and maintain access roadway cost estimate includes labor, equipment, and material necessary to construct a construction vehicle access roadway. Cost estimate assumes roadway is 500 feet long, 15 feet wide, and 1 foot thick, constructed of graded and compacted run-of-crusher material. In addition, cost estimate includes approximately 400 20'x48"x12" swamp mats. Road construction cost estimate assumes total roadway area is cleared of vegetation.
7. Turbidity/sheen mitigation cost estimate includes labor, equipment, and materials necessary to purchase, install, and remove turbidity control system (e.g., turbidity curtains) and absorbent booms for use during implementation of the remedy. Turbidity control system and absorbent booms will be replaced on an as needed basis. Additional weekly costs for provision of sorbent pads based on the assumed use of 100 30" v 30" sorbent pads per day. Additionally, cost estimate includes labor, equipment, and materials necessary to perform monitoring of the water column twice per day for turbidity.
8. Woody debris removal cost estimate includes labor, materials, equipment, disposal and services necessary for or incidental to handling/removing vegetation, obstacles, debris (e.g., boulders, wood pilings, etc.) from the inlet channel and open water capping area.
9. Transportation and disposal cost estimate includes labor, equipment, materials, and services required for the transportation and disposal of the removed vegetation/debris. Unit cost used for this estimate was provided by EMES in 2013.
10. Open water capping cost estimate includes labor, materials, equipment, transport, and services necessary for, or incidental to, the placement of capping material over the approximate 6.6 acre inlet channel and open water area. The cap will be comprised of a 2-3-inches layer of clean sand material with bulk Organoclay blended in at 65% by volume, as well as a 3-4-inches layer of Habitat Layer Cover. Quantities shown are for cost estimate purpose only. Quantities will be determined after pre-design study. Backfill placement is assumed to be completed in the wet utilizing standard mechanical construction equipment or via a slurry applied to the water surface. Capping approach and related estimated cost does not include considerations related to the potential need for compensatory material removal or the potential for flood storage losses.
11. Restoration cost estimate includes labor, equipment, and materials necessary to seed and install erosion protection materials (e.g., erosion control fabric, straw/mulch) for the areas disturbed from the staging area, access road, and bank area. Restoration costs also include aquatic plantings in near-shore areas.
12. Administration and engineering cost is equal to 15% of the total capital costs. Cost includes Final Report.
13. Construction management cost is based on an assumed 15% of the total capital costs.

Attachment N-1
Cost Estimate for Alternative 4
Targeted Removal in the Inlet Channel and Reactive Capping in the Open Water Area

Downstream Areas Data Assessment Report
ExxonMobil Environmental Services Company
Mayflower Pipeline Incident Response

Item #	Description	Estimated Quantity	Unit	Unit Price	Estimated Cost
Capital Costs					
1	Permits and Approvals	1	LS	\$50,000	\$50,000
2	Establish Institutional Controls	1	LS	\$50,000	\$50,000
3	Mobilization/Demobilization	1	LS	\$134,000	\$134,000
4	Construct and Maintain Staging Area	1	LS	\$52,000	\$52,000
5	Construct and Maintain Access Roadway	1	LS	\$95,000	\$95,000
6	Turbidity/Sheen Mitigation				
	Absorbent Booms	2,500	LF	\$10	\$25,000
	Absorbent Pads	4	WEEKS	\$600	\$2,700
	Turbidity Control System	725	LF	\$25	\$18,200
	Water Column Monitoring	1.1	MONTH	\$3,520	\$3,900
7	Woody Debris Removal	6.0	AC	\$17,000	\$102,000
8	Water Diversion System				
	Water Tube Dam	100	LF	\$85	\$8,500
	Bypass Piping	1500	LF	\$50	\$75,000
	Maintain Bypass Pumping	5	DAY	\$1,200	\$6,000
9	Temporary Water Treatment System	1.6	MONTH	\$50,000	\$80,000
10	Inlet Channel Sediment Excavation and Handling				
	Material Excavation and Handling	1,000	CY	\$90	\$90,000
11	Sediment Dewatering and Stabilization				
	Blending Operations	1,330	CY	\$15	\$20,000
	Stabilization Admixture	170	TON	\$115	\$19,600
12	Capping of Open Water Area				
	Clean Sand	300	CY	\$24	\$7,200
	Organoclay Amendment	600	CY	\$2,600	\$1,560,000
	Habitat Layer Cover	4,000	CY	\$30	\$120,000
	Cap Placement	4,900	CY	\$40	\$196,000
13	Transportation and Disposal				
	Off-site Disposal Debris/Vegetation	1,000	TON	\$35	\$35,000
	Off-site Disposal Sediment	3,937	TON	\$35	\$137,900
14	Solid Waste Characterization	10	EACH	\$750	\$7,500
15	Restoration	6.8	AC	\$15,000	\$102,000
Subtotal Capital Cost					\$2,997,500
16	Administration & Engineering (15%)				\$449,625
17	Construction Management (15%)				\$449,625
Contingency (20%)					\$599,500
Total Estimated Cost:					\$4,496,250
Rounded To:					\$4,496,000

AC = acres; CY = cubic yard; LF = linear feet; LS = lump sum

General Notes:

- Cost estimate is based on ARCADIS U.S.'s (ARCADIS') past experience and vendor estimates using 2013 dollars.
- This estimate has been prepared for the purposes of comparing potential remedial alternatives. The information in this cost estimate is based on the available information regarding the site investigation and the anticipated scope of the remedial alternative. Changes in cost elements are likely to occur as a result of new information and data collected during the engineering design of the remedial alternative. This cost estimate is expected to be within -30% to +50% of the actual projected cost. Utilization of this cost estimate information beyond the stated purpose is not recommended. ARCADIS is not licensed to provide financial or legal consulting services; as such, this cost estimate information is not intended to be utilized for complying with financial reporting requirements associated with liability services.

Attachment N-1
Cost Estimate for Alternative 4
Targeted Removal in the Inlet Channel and Reactive Capping in the Open Water Area

Downstream Areas Data Assessment Report
ExxonMobil Environmental Services Company
Mayflower Pipeline Incident Response

3. All costs assume field work to be conducted by non-union labor.
4. All costs presented are based on the current understanding of site-specific conditions and stated remediation goals. Design details are limited to conceptual approaches to remediation and include a number of assumptions that are subject to change. Actual construction specifications and technologies will be determined during the design phase, and as a result, actual construction costs may vary from the costs presented here.

Assumptions:

1. Permits and approvals cost estimate includes preparation and procurement of the required permits and approvals from Federal, state and local agencies for one construction season. Access agreement costs not included.
2. Establish institutional controls cost estimate includes legal expenses to institute environmental easements and deed restrictions to control the future development adjacent to river and use of the river, as well as limit future activities that could damage the river bottom.
3. Mobilization/demobilization cost estimate includes mobilization and demobilization of labor, equipment, and materials necessary to complete the remediation. For cost estimating purposes, mobilization/demobilization costs are assumed to be 10% of the capital costs, not including permits and approvals, pre-design investigations, or transportation and disposal.
4. Pre-design investigation costs assumed to be labor, equipment, and materials necessary to conduct any required pre-design investigations. Estimated cost is based on 5% of the total capital cost, including an increased percentage to represent the need for materials handling and stabilization/treatability studies.
5. Construct and maintain staging area costs include labor, equipment, and materials necessary to construct and remove a 60-foot by 30-foot decontamination pad and appurtenances. The decontamination pad would consist of a 12-inch gravel fill layer bermed and sloped to a sump and covered with impermeable liner and a 6-inch layer of gravel. In addition, the cost estimate includes labor, equipment, and materials necessary to construct a 100-foot by 100-foot material staging area constructed of a 12-inch gravel fill layer over geotextile. Maintenance includes inspecting and repairing staging area as necessary.
6. Construct and maintain access roadway cost estimate includes labor, equipment, and material necessary to construct a construction vehicle access roadway. Cost estimate assumes roadway is 500 feet long, 15 feet wide, and 1 foot thick, constructed of graded and compacted run-of-crusher material. In addition, cost estimate includes approximately 400 20'x48"x12" swamp mats. Road construction cost estimate assumes total roadway area is cleared of vegetation.
7. Turbidity/sheen mitigation cost estimate includes labor, equipment, and materials necessary to purchase, install, and remove turbidity control system (e.g., turbidity curtains) and absorbent booms for use during implementation of the remedy. Turbidity control system and absorbent booms will be replaced on an as needed basis. Additional weekly costs for provision of sorbent pads based on the assumed use of 100 30" v 30" sorbent pads per day. Additionally, cost estimate includes labor, equipment, and materials necessary to perform monitoring of the water column twice per day for turbidity.
8. Woody debris removal cost estimate includes labor, materials, equipment, disposal and services necessary for or incidental to handling/removing vegetation, obstacles, debris (e.g., boulders, wood pilings, etc.) from the inlet channel and open water capping area.
9. Water diversion system cost estimate includes labor, equipment, and materials to construct a temporary diversion dam upstream and downstream of the inlet channel remediation area, as well as bypass piping and daily bypass pumping to facilitate performance of excavation and backfill operations in the dry. Assumes diversion dams will consist of water filled geotubes (e.g., Aquadam) and that upstream water will be pumped through the bypass piping around Dawsons Cove. Laydown area for diversion dams will be cleared of vegetation and covered with 1 foot of fill to aid in creating water seal with existing surface. Dewatering costs assumes provision of pump/conveyance piping to initially dewater the cove, and the maintenance of small sump pumps, as necessary, for any water that collects within the bypassed portion of the cove.

Attachment N-1
Cost Estimate for Alternative 4
Targeted Removal in the Inlet Channel and Reactive Capping in the Open Water Area

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10. Temporary water treatment system cost estimate based on vendor specific quote and includes installation and operation of a temporary water treatment system sufficient to handle anticipated decant water associated with materials removed in the dry. Cost estimate assumes water treatment system includes pumps, influent piping and hoses, frac tanks, carbon filters, bag filters, discharge piping and hoses, and flow meter. Cost estimate assumes bag filters will require change out approximately once per day of operation, and that treatment vessels will be refreshed monthly. Estimate assumes treated water would be discharged to Dawson Cove under a SPDES permit at no additional cost. Duration based on assumed vegetation removal, excavation, and backfill rates. Duration also includes an additional 0.5 months for a system startup and testing period and demobilization of the system.
11. Excavation cost estimate includes labor, equipment, and materials necessary to excavate approximately one foot of material in the dry from the inlet channel via mechanical means. Volume estimate assumes 1,300 feet of channel length and an average channel width of 20 feet. Removal volume is based on a neat-line assessment and does not account for potential sloughing of adjacent materials or over-dredging. Backfill cost associated with this removal include the placement (via mechanical means) of sufficient backfill to restore the excavated areas. In-situ removal volume is assumed to be bulked by 20% to estimate required backfill volumes. Quantities shown are for cost estimate purpose only. Quantities will be determined after pre-design study.
12. Sediment dewatering and stabilization activities includes the dewatering and stabilization of material following excavation activities. Blending operations volume includes a factor of 1.2 to account for bulking of material upon excavation and transport to the material staging area. Dewatering will occur passively at the material staging area. Stabilization admixture (Portland cement) will be added at ratio of 10% of the weight of material to be stabilized. It is assumed that any water generated in association with sediment management will be treated onsite through the temporary water treatment system.
13. Open water capping cost estimate includes labor, materials, equipment, transport, and services necessary for, or incidental to, the placement of capping material over the approximate 6 acre open water area. The cap will be comprised of a 2-3-inches layer of clean sand material with bulk Organoclay blended in at 65% by volume, as well as a 3-4-inches layer of Habitat Layer Cover. Quantities shown are for cost estimate purpose only. Quantities will be determined after pre-design study. Backfill placement is assumed to be completed in the wet utilizing standard mechanical construction equipment or via a slurry applied to the water surface. Capping approach and related estimated cost does not include considerations related to the potential need for compensatory material removal or the potential for flood storage losses.
14. Transportation and disposal cost estimate includes labor, equipment, materials, and services required for the transportation and disposal of the removed vegetation/debris, dewatered and stabilized sediments, as well as access/staging materials. Unit cost assumed for this estimate was provided by EMES in 2013.
15. Solid waste characterization cost estimate includes the analysis of samples (including, but not limited to, TCLP metals, PCBs, VOCs, SVOCs, ignitability, reactivity, and corrosivity), however waste characterization analyses are subject to change based on the selection of final disposal facility. Costs assumes that waste characterization samples would be collected at a frequency of one sample per every 500 tons of material destined for off-site treatment/ disposal.
16. Restoration cost estimate includes labor, equipment, and materials necessary to seed and install erosion protection materials (e.g., erosion control fabric, straw/mulch) for the areas disturbed from the staging area, access road, and bank area. Restoration costs also include aquatic plantings in near-shore areas.
17. Administration and engineering cost is equal to 15% of the total capital costs. Cost includes Final Report.
18. Construction management cost is based on an assumed 15% of the total capital costs.

Attachment N-1
Cost Estimate for Alternative 5
Targeted Removal in the Inlet Channel and in the Open Water Area

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Item #	Description	Estimated Quantity	Unit	Unit Price	Estimated Cost
Capital Costs					
1	Permits and Approvals	1	LS	\$50,000	\$50,000
2	Establish Institutional Controls	1	LS	\$50,000	\$50,000
3	Mobilization/Demobilization	1	LS	\$241,000	\$241,000
4	Construct and Maintain Staging Area	1	LS	\$78,000	\$78,000
5	Construct and Maintain Access Roadway	1	LS	\$95,000	\$95,000
6	Turbidity/Sheen Mitigation				
	Absorbent Booms	2,500	LF	\$10	\$25,000
	Absorbent Pads	4	WEEKS	\$600	\$2,700
	Turbidity Control System	725	LF	\$25	\$18,200
	Water Column Monitoring	1.1	MONTH	\$3,520	\$3,900
7	Woody Debris Removal	6.0	AC	\$17,000	\$102,000
8	Water Diversion System				
	Water Tube Dam	860	LF	\$85	\$73,100
	Bypass Piping	3000	LF	\$75	\$225,000
	Maintain Bypass Pumping	54	DAY	\$2,000	\$107,000
9	Temporary Water Treatment System	3.8	MONTH	\$50,000	\$190,000
10	Inlet Channel and Open Water Sediment Excavation and Handling				
	Material Excavation and Handling	10,700	CY	\$90	\$963,000
11	Sediment Dewatering and Stabilization				
	Blending Operations	14,200	CY	\$15	\$213,000
	Stabilization Admixture	1,800	TON	\$115	\$207,000
12	Transportation and Disposal				
	Off-site Disposal Debris/Vegetation	1,000	TON	\$35	\$35,000
	Off-site Disposal Sediment	21,826	TON	\$35	\$764,000
13	Solid Waste Characterization	46	EACH	\$750	\$34,500
14	Restoration	6.8	AC	\$15,000	\$102,000
Subtotal Capital Cost					\$3,579,400
15	Administration & Engineering (15%)				\$536,910
16	Construction Management (15%)				\$536,910
Contingency (20%)					\$715,880
Total Estimated Cost:					\$5,369,100
Rounded To:					\$5,369,000

AC = acres; CY = cubic yard; LF = linear feet; LS = lump sum

General Notes:

- Cost estimate is based on ARCADIS U.S.'s (ARCADIS') past experience and vendor estimates using 2013 dollars.
- This estimate has been prepared for the purposes of comparing potential remedial alternatives. The information in this cost estimate is based on the available information regarding the site investigation and the anticipated scope of the remedial alternative. Changes in cost elements are likely to occur as a result of new information and data collected during the engineering design of the remedial alternative. This cost estimate is expected to be within -30% to +50% of the actual projected cost. Utilization of this cost estimate information beyond the stated purpose is not recommended. ARCADIS is not licensed to provide financial or legal consulting services; as such, this cost estimate information is not intended to be utilized for complying with financial reporting requirements associated with liability services.
- All costs assume field work to be conducted by non-union labor.

Attachment N-1
Cost Estimate for Alternative 5
Targeted Removal in the Inlet Channel and in the Open Water Area

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4. All costs presented are based on the current understanding of site-specific conditions and stated remediation goals. Design details are limited to conceptual approaches to remediation and include a number of assumptions that are subject to change. Actual construction specifications and technologies will be determined during the design phase, and as a result, actual construction costs may vary from the costs presented here.

Assumptions:

1. Permits and approvals cost estimate includes preparation and procurement of the required permits and approvals from Federal, state and local agencies for one construction season. Access agreement costs not included.
2. Establish institutional controls cost estimate includes legal expenses to institute environmental easements and deed restrictions to control the future development adjacent to river and use of the river, as well as limit future activities that could damage the river bottom.
3. Mobilization/demobilization cost estimate includes mobilization and demobilization of labor, equipment, and materials necessary to complete the remediation. For cost estimating purposes, mobilization/demobilization costs are assumed to be 10% of the capital costs, not including permits and approvals, pre-design investigations, or transportation and disposal.
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