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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 for the Mayflower Pipeline Incident Response located in Mayflower, Arkansas (the site). This document was prepared at the request of the Arkansas Department of Environmental Quality (ADEQ 2013) to 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 is based on results of the refined ecological risk evaluation provided in Section 10 of the DADAR, and on the sheen monitoring and characterization results discussed in Section 11 of the DADAR.

The purpose of this Remedial Alternatives Evaluation is to propose an appropriate mitigation plan for ADEQ approval that achieves the remedial action objectives (RAOs) presented in Section 2. The objectives of this Remedial Alternatives Evaluation are to:

- Develop RAOs specific to the site.
- Screen various remedial technologies to identify those that can reliably and effectively achieve the RAOs.
- Based on these technologies, identify potential remedial alternatives to address the RAOs and evaluate the alternatives against the evaluation factors requested by ADEQ.
- Describe an appropriate plan, based on the evaluated alternatives, to mitigate potentially remaining adverse impacts in the downstream areas related to the Pegasus Pipeline Incident.

For the purposes of this document, the site consists of the following three areas located downstream from the residential neighborhood:

- 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.

- Dawson Cove Heavily Vegetated Area (Heavily Vegetated Area): Vegetated area with residual sheen-bearing material located between the existing floatation boom along the edge of the Open Water Area to the west and extending approximately 200 feet toward Highway 89, including the natural channels between the vegetation in this area. This area serves as a buffer between the lower portions of Dawson Cove, helping to retain sediment delivered by runoff flows, provides habitat for wetland species, and buffers peak event runoff flows into Lake Conway.

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 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 because there are no unacceptable risks to ecological receptors associated with soil and sediment exposures expected based on the site-specific ecological risk evaluation presented in the DADAR. However, sheen-bearing materials remaining in portions of the site and mitigation of these residual sheens are identified as a remediation need.

One RAO has been identified for the entire site – mitigate surface water sheens resulting from the Wabasca heavy crude oil (hereinafter referred to as crude oil) release from the Pegasus Pipeline, to the extent practicable. Based on the sheen sampling and monitoring results described in DADAR Appendix M, no sheens observed in the drainage ways were related to the crude oil from the Pegasus Pipeline and therefore, no mitigation action is necessary in the drainage ways. The evaluation and screening of remedial technologies and remedial alternatives to control sheens in this document focuses on the Dawson Cove Inlet Channel, Open Water Area, and Heavily Vegetated Area.

Approximate areas where sheen mitigation is needed are shown on Figure N-1. The extent of the Open Water Area is based on the approximate edge-of-water position shown on Figure N-1, which corresponds approximately to the normal high-water level in Dawson Cove of 262.87 feet (North American Vertical Datum of 1988) during summer. The extent of the area identified for sheen mitigation is based on observations of sheens following the response action, and it is believed that not all parts of the Heavily Vegetated Area contain sheen-bearing material. However, additional data are needed to determine the extent within the Heavily Vegetated Area that requires mitigation. The approximate sheen mitigation area will be refined as part of the pre-design study proposed in Appendix O of this DADAR.

3. Technology Screening and Development of Remedial Alternatives

This section describes the process through which potential remedial technologies for achieving the 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.
- Evaluating and 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. Habitat protection was included as an additional evaluation factor for the Heavily Vegetated Area during the technology screening process to account for the intrinsic habitat value of the remaining wetlands vegetation in this area.
- Remedial technologies were evaluated and screened for the Inlet Channel, Open Water Area, and the Heavily Vegetated Area.

3.1 Identification and Description of Remedial Technologies

GRAs are general types of remedial technologies that can be used individually or in combination to achieve the RAO. GRAs and associated remedial technologies were identified as an initial step, and then remedial technologies were evaluated and screened for the Inlet Channel, Open Water Area, and the Heavily Vegetated Area, accounting for area-specific conditions.

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

GRA	Technology	Area
Natural Recovery	Monitored Natural Recovery	Inlet Channel Open Water Area Heavily Vegetated Area
	Enhanced Natural Recovery	Inlet Channel Open Water Area Heavily Vegetated Area
	Dewatering/Enhanced Aerobic Bioremediation	Inlet Channel Open Water Area Heavily Vegetated Area
In-Situ Treatment	Sediment Amendments	Inlet Channel Open Water Area Heavily Vegetated Area
	Enhanced Bioremediation via Agitation	Inlet Channel Open Water Area
	Enhanced Bioremediation via Air Sparging	Inlet Channel Open Water Area Heavily Vegetated Area
Containment	Non-Reactive Capping	Inlet Channel Open Water Area
	Reactive Capping	Inlet Channel Open Water Area Heavily Vegetated Area
Removal	Targeted Removal with Off-Site Disposal	Inlet Channel Open Water Area
	Removal with Ex-Situ On-Site Treatment and Reuse	Inlet Channel Open Water Area

3.1.1 Natural Recovery

Monitored Natural Recovery (MNR)

MNR is implementable in the Inlet Channel, Open Water Area, and the Heavily Vegetated Area, and 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 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/wetland environment or benthic community (American Petroleum Institute 2013). MNR requires periodic monitoring and/or sampling to assess the degree to which natural recovery has mitigated sheens and sheen-bearing material over time.

Enhanced Natural Recovery (ENR)

ENR consists of placing a thin layer of clean sediment material over crude oil-affected areas to create a new surface layer with lower sheen-bearing material. Natural recovery is enhanced through several processes, principally bioturbation over time, which reduces sheen-bearing material in the surface sediments through the mixing of the clean layer with underlying, existing sediments. This mixing eventually creates a new biologically active surface layer once the clean layer is integrated with existing sediments. The clean material is usually composed of a few inches of sand or clean sediment, 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). ENR required periodic monitoring and/or sampling to assess the degree to which natural recovery has mitigated sheens and sheen-bearing material over time. This technology is most applicable to the Inlet Channel and Open Water Area. The technology could be applied to the Heavily Vegetated Area; however, placing a thin-layer of clean material over wetland vegetation would be difficult to do in a controlled manner and could have a potential short-term adverse impact on vegetation that could result in temporary vegetation loss, increased invasive species growth and decreased habitat diversity.

Dewatering/Enhanced Aerobic Bioremediation

Dewatering and enhanced aerobic bioremediation consists of dewatering the affected areas to expose sheen-bearing material to warm air (assuming implementation occurs in the warm season), and thereby enhancing aerobic biodegradation of crude oil constituents. Dewatering would be done using water barriers and pumps. This remedial technology assumes that sheens are associated with residual crude oil in the surficial sediment layer; that the availability of oxygen is limiting biodegradation of residual crude oil compounds in that layer; and therefore, that addition of oxygen will enhance

the biodegradation of the crude oil residuals. In general, biodegradation plays an important role in the weathering and removal of crude oil constituents from the environment (especially non-volatile petroleum-related compounds), but it is a relatively slow process that may take a period of months, or longer, to achieve the elimination of residual sheens (USEPA 2001). The effectiveness of aerobic biodegradation and duration of implementation depend upon the composition of the hydrocarbon-degrading microbial community, the molecular weight of the crude oil constituents (i.e., polycyclic aromatic hydrocarbons), availability of oxygen and nutrients, moisture content, nutrient availability, and temperature (USEPA 2001). The addition of nutrients and management of moisture may be necessary to further enhance biodegradation. Periodic monitoring and/or sampling of sheen-bearing material would be performed to assess the biodegradation of sheen-bearing materials over time. This remedial technology is applicable to the Inlet Channel, Open Water Area, and the Heavily Vegetated Area. Following implementation of the remedial action, seeding of native vegetation and/or wetland re-construction may be necessary due to potential adverse impacts on vegetation during implementation.

3.1.2 In-Situ Treatment

Remedial technologies associated with this GRA consist of those that treat or stabilize sheen-bearing material in place without removal or capping. Technologies evaluated are:

- In-situ mixing of amendments such as mixture of sand/organoclay or pelletized organoclay into the sheen-bearing material to reduce sheen mobility through adsorption/absorption processes.
- In-situ agitation/tilling of sheen-bearing material to enhance aerobic biodegradation of crude oil constituents through a combination of physical, chemical, and biological processes.
- In-situ injection of oxygen into the surficial layer of the sheen-bearing material to enhance aerobic bioremediation of crude oil constituents.

In-Situ Sediment Amendments

The use of in-situ sediment amendments reduces sheen mobility through adsorption/absorption processes and/or enhances the rate of biodegradation of crude oil constituents (USEPA 2013). This remedial technology is applicable to the Inlet Channel, Open Water Area, and the Heavily Vegetated Area. The amendments

considered for this site are a mixture of sand/organoclay (applied as a mixed-in amendment, rather than as a sediment cap) or pelletized organoclay. Organoclay consists of clay that is organically modified to improve its oleophilic sorption capacity as a means of sorbing oils and/or sheen-bearing residuals, thereby eliminating or greatly reducing their transport from sediments to the water column (Reible and Lampert 2008, Reible et al. 2011, Alther 2008). Amendments would act in combination with natural recovery processes to reduce sheens and the mass of residual constituents over time. The application of amendments minimizes the impact to aquatic ecosystems, compared to sediment caps, because amendments are not intended to physically cover sediments (Environmental Security Technology Certification Program 2011).

In-Situ Enhanced Bioremediation via Agitation

In-situ enhanced bioremediation via agitation is applicable to the Inlet Channel and Open Water Area only where the mixing of amendments, as described above, would be limited due to the extensive woody debris and woody vegetation in these areas. Agitation involves mixing the surficial layer of sheen-bearing material “in the wet” to accelerate the biodegradation of crude oil constituents through a combination of physical, chemical, and biological processes. By mixing sheen-bearing sediments, the rate of aerobic biodegradation is enhanced. In addition, physical mixing of sheen-bearing material increases the total surface area available for natural weathering processes of crude oil constituents (USEPA 2001). Large woody vegetation would need to be removed prior to this type of mixing, and/or the mixing would need to be conducted away from the root masses of remaining trees. Traditional tilling machines or construction equipment, such as a backhoe fitted with a mixing head, would be used to mix sheen-bearing sediments (to an estimated minimum depth of 1 foot) approximately every 3 days for 3 to 6 months to provide aeration and physical agitation to promote biodegradation. The duration of mixing and rate of aerobic biodegradation are dependent upon several factors, including the composition of the hydrocarbon-degrading microbial community, the molecular weight of the crude oil constituents (i.e., polycyclic aromatic hydrocarbons), availability of oxygen and nutrients, temperature, and moisture level (USEPA 2001). Periodic monitoring and/or sampling would be performed to assess the biodegradation of constituents over time. Following implementation of the remedial action, seeding of native vegetation may be necessary due to the destruction of some vegetation during implementation.

In-Situ Enhanced Bioremediation via Air Sparging

In-situ enhanced bioremediation via air sparging is applicable to the Inlet Channel, Open Water Area, and the Heavily Vegetated Area. This remedial technology consists of injecting air "in the wet" into the surficial layer of the sheen-bearing material to enhance aerobic biodegradation of crude oil constituents. This technique is well established for accelerating the bioremediation of petroleum hydrocarbons in subsurface soil and groundwater, but has a limited history of use in submerged sediments; therefore, field tests would be necessary to verify the effectiveness of this remedial technology in sediments (USEPA 2001). In addition, the rate of aerobic biodegradation (and, therefore, the duration of implementation) depends on the composition of the hydrocarbon-degrading microbial community, the molecular weight of the crude oil constituents (i.e., polycyclic aromatic hydrocarbons), availability of oxygen and nutrients, moisture content, and temperature, some of which may need to be adjusted during implementation (USEPA 2001). Periodic monitoring and/or sampling would be necessary to assess the biodegradation of constituents over time.

Accessing the sheen-bearing material in the Heavily Vegetated Area and distributing a sufficient amount of oxygen throughout the targeted areas would likely require some de-vegetation; thus, seeding and/or wetland re-construction may be required following the remedial action.

3.1.3 Containment Technologies

Remedial technologies associated with this GRA would mitigate surface water sheens without sediment removal or treatment. The remedial technology applicable to the Inlet Channel, Open Water Area, and Heavily Vegetated Area is capping, which primarily involves chemically and/or physically isolating underlying sediments from ecological receptors and, therefore, reducing exposure (USEPA 2013). 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 a layer of sand, and potentially overlying armor and/or habitat layers to isolate underlying sediments from ecological exposure in the new surficial sediment biologically active zone that will develop on the surface of a cap layer. This type of cap can reduce the release of chemicals to water when diffusion and or resuspension are important transport mechanisms, but they may not be effective at mitigating sheens as sand does not sorb sheen-bearing crude-oil residuals to any appreciable degree. Low-permeability barrier layers can be incorporated in such caps; however, these layers have a disadvantage of potentially obstructing the release of gasses produced by microbial processes in sediment and they may also impede natural groundwater discharge to surface water (USEPA 2013). Non-reactive capping is applicable to the Inlet Channel and Open Water Area. This technology is not applicable to the Heavily Vegetated Area because a thick cap would have to be placed over wetland vegetation (to avoid complete de-vegetation), which would result in adverse impacts to the wetlands vegetation.

Reactive Capping

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

Typical reactive media used in reactive caps include granular activated carbon, organoclay, and AquaGate™. Organoclay consists of clay that is organically modified to improve its oleophilic sorption capacity as a means of sorbing oils and/or sheen-bearing residuals, thereby eliminating or greatly reducing their 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 permeable but sorptive medium to sorb constituents and sheen-bearing materials. 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 (Electric Power Research Institute 2011, Oregon Department of Environmental Quality and USEPA 2011, USEPA 2013). Sand would be mixed with organoclay to facilitate cap deployment.

Reactive capping is applicable to the Inlet Channel, Open Water Area, and Heavily Vegetated Area. The placement of a thin cap (nominally 2 to 3 inches) in the Heavily Vegetated Area may have temporary impacts on wetland vegetation as a result of covering the sediment surface; however, it is likely that the existing wetland vegetation would not experience any long-term degradation.

3.1.4 Removal Technologies

Removal consists of targeted excavation of sheen-bearing material. This remedial technology is applicable to the Inlet Channel and Open Water Area. This technology would result in significant adverse impact to the ecological function and habitat value in the Heavily Vegetated Area. Removal is highly invasive and would result in significant alteration of the wetlands during implementation, as occurred during the emergency response phase. In this remediation phase; the ecological value and function of the vegetated area is recognized, and the alternatives evaluation seeks to preserve this area. For those reasons, the technologies considered in the Heavily Vegetated Area do not include removal.

Targeted Removal (in the Dry or Wet) with Off-Site Disposal

Removal may be performed either “in the wet” or “in the dry”. Removal “in the dry” is conducted after removing standing water, which reduces excavated material dewatering requirements and reduces the redistribution of constituents in surface water during dredging; it may also reduce material handling and stabilization costs for transport and disposal. Removal “in the dry” would first involve dewatering the submerged area via the construction of a temporary diversion dam or berm, pumps and bypass pipelines. Following dewatering, conventional excavation equipment would be used to excavate a shallow layer of sheen-bearing surface sediment. 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 using mechanical dredges to remove the sheen-bearing material, and using turbidity curtains and absorbent booms during implementation of the mitigation action to control and recover any generated sheens.

Auxiliary technologies such as placing backfill, dewatering of saturated soil/sediment, and transport of excavated/removed material to a permitted off-site disposal facility would also be necessary. The water generated during sediment processing and/or dewatering would be treated by appropriate methods and discharged back to the water body in accordance with applicable rules, regulations, and any required permits. Restorative seeding may be necessary in some areas following excavation.

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

Ex-situ on-site treatment and reuse is applicable to the Inlet Channel and Open Water Area. This remedial technology consists of excavation followed by ex-situ enhanced biodegradation of sheen-bearing material in a constructed temporary land treatment cell 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 temporary placement in the treatment cell to enhance biodegradation in a controlled setting. If applied in submerged areas, sediments would require dewatering following excavation and prior to treatment. Water generated may need to be treated and discharged back to the water body, and discharges would be subject to the appropriate permits. Excavated areas would be backfilled and re-graded with the treated soils or sediments after treatment. Restorative seeding may be necessary in some areas following soil or sediment replacement.

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.

The four 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 of mitigating surface water sheens and providing protection of ecological receptors by reducing the mobility, volume, and toxicity of crude oil constituents. This criterion also considers the degree of ecological protection during construction and implementation of a remedial technology.
    - Short-term effectiveness refers to the ability of a remedial technology to protect ecological receptors and the environment in the short term considering the amount of time required until the RAO is achieved.

- Long-term effectiveness refers to the ability of a remedial technology to meet the RAO of mitigating surface water sheens and protect ecological receptors.

- *Habitat and Ecological Protection* – The criterion refers to the ability of a remedial technology to retain the existing ecological function and habitat value of the Heavily Vegetated Area, and to protect against the potential adverse impacts to ecological receptors (i.e., human health and the environment) that may occur during the construction and implementation period.

- *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 a remedial technology.
- *Relative Cost* – This criterion evaluates the overall relative cost required to implement a 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 professional experience in the industry.

Based on the criteria described above, technologies were ranked using a scoring system from less preferable (score = 1) to more preferable (score = 3) as shown in the table below. The technology ranking for the Inlet Channel and Open Water Area is provided separately from the ranking for the Heavily Vegetated Area to account for differences in site conditions.

Remedial Technology Screening for the Inlet Channel and Open Water Area

Remedial Technology	Effective-ness	Habitat and Ecological Protection	Implement-ability	Relative Cost	Screening	
					Total Score	Retained?
Monitored Natural Recovery	1	**2**	**3**	**3**	**9**	**YES**
Enhanced Natural Recovery	2	1	2	2	7	NO
Dewatering/ Enhanced Bioremediation	2	1	1	2	6	NO
In-Situ Sediment Amendments	2	1	2	2	7	NO
In-Situ Enhanced Bioremediation via Agitation	2	1	1	2	6	NO
In-Situ Enhanced Bioremediation via Air Sparging	1	1	1	2	5	NO
Non-Reactive Capping	2	1	1	2	6	NO
Reactive Capping	**3**	**2**	**2**	**2**	**9**	**YES**
Targeted Removal	**3**	**2**	**2**	**2**	**9**	**YES**
Ex-Situ On-Site Treatment/Reuse	3	1	1	1	6	NO

Note: Retained technology scorings are shaded

Remedial Technology Screening for Heavily Vegetated Area

Remedial Technology	Effective-ness	Habitat and Ecological Protection	Implement-ability	Relative Cost	Screening	
					Total Score	Retained?
Monitored Natural Recovery	1	**3**	**3**	**3**	**10**	**YES**
Enhanced Natural Recovery	2	2	2	2	8	NO
Dewatering/Enhanced Bioremediation	1	2	2	2	7	NO
In-Situ Sediment Amendments	**2**	**3**	**2**	**2**	**9**	**YES**
In-Situ Bioremediation via Air Sparging	1	2	1	2	6	NO
Reactive Capping	**3**	**2**	**2**	**2**	**9**	**YES**

Note: Retained technology scorings are shaded

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.

- *MNR* - Although MNR may not meet the RAO for the site in the short term, this remedial technology was retained for all site areas as it may meet the RAO in the long term, assuming the physical, chemical, and biological recovery processes reduce the mass and volume of crude oil residuals over time, and periodic monitoring would be conducted to verify that the RAO is achieved. As there would be no construction required, MNR is readily implementable at a low cost with no construction-related impacts to ecological receptors during implementation. This technology would retain the ecological function and habitat value of the Heavily Vegetated Area.
- *Reactive Capping* – Reactive capping was retained for all site areas, as it would achieve the RAO of mitigating surface water sheens in the short and long term by functioning as a reactive barrier between sheen-bearing material and the water column. Reactive capping would provide a mechanism for the interception and sorption of sheens via organoclay, which is an effective oleophilic sorptive medium. Although this technology would not remove sheen-bearing materials, it would reduce their mobility and they would continue to naturally degrade below the cap over time. During construction and implementation, some short-term ecological impacts would likely occur, such as disturbance to biota and vegetation/habitat loss, and the placement of cap materials may result in some sheen release. In addition, some adverse impact on wetland vegetation may occur. 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 surfaces 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.
- *In-Situ Sediment Amendments* – In-situ delivery of amendments has been retained for the Heavily Vegetated Area as it has been successfully implemented in marsh areas at other sites, and applying a thin layer of amendments without active mixing is expected to have low adverse impacts on wetland vegetation. Although this

technology would not provide a barrier between sheen-bearing material and the water column, it would reduce the mobility and bioavailability of constituents in through adsorption/absorption in the short term and/or enhanced rate of natural biodegradation in the long term.

- *Targeted Removal* – Removal would meet the site RAO and reduce the mobility and volume of crude oil constituents in the short and long term by permanently removing sheen-bearing material (i.e., not necessarily all sheen-bearing material would be removed) from targeted areas of the site. Although some crude oil residuals may remain after the removal action, natural recovery processes would degrade residuals over time. During implementation, particularly in the Open Water Area, there is moderate to high potential for exposure to ecological receptors, as the disturbance of sheen-bearing material would likely result in some sheen release. Short-term ecological impacts would also be likely, such as adverse impacts on the vegetation, biota and habitats. This technology has been retained for the Inlet Channel and the Open Water Area. This remedial technology is implementable, but dewatering, off-site disposal, and habitat impacts are significant considerations associated 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 may not 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 to an unacceptable degree by significantly raising the bottom elevation.
- *In-Situ Enhanced Bioremediation via Agitation* – This technology may not mitigate surface water sheens in an adequate time frame, as aerobic biodegradation is anticipated to occur over a longer period of time (even with mixing). Attempts have been made to use agitation techniques at other parts of the site and inadequate performance in controlling sheens was observed. Mixing would adversely disturb biota/habitat resulting in a high level of habitat destruction.
- *In-Situ Enhanced Bioremediation via Air Sparging* – Air sparging would likely not mitigate sheens nor reduce the long-term potential for exposure to ecological

receptors. In the short term, sparging would likely increase sheens because the air phase would likely transport sheen-bearing materials upward as the air rises through the sediments into the water column. In addition, accelerating aerobic bioremediation via oxygen injection is only effective if an adequate supply of oxygen is distributed to the microbial community within the surface layer of the sheen-bearing material. Oxygen distribution would likely be limited to select pathways within the sediment, limiting its effectiveness. Accessing the targeted areas and installing the aeration system would adversely impact wetland vegetation through de-vegetation resulting in habitat destruction, an increase in invasive species and decrease in habitat diversity.

- *Ex-Situ On-Site Treatment and Reuse* – 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 for the site have been assembled into five remedial alternatives presented in Section 3.3. The "No Action" alternative, which includes no mitigation activities, and is included as a baseline for comparison purposes only.

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 for the Inlet Channel, Open Water Area and the Heavily Vegetated Area. This section provides an overview of the remedial alternatives that were retained for detailed evaluation, each of which is potentially capable of meeting the site RAO in the Inlet Channel, Open Water Area and the Heavily Vegetated Area. A pre-design study will be conducted to confirm and design the preferred remedy. The pre-design study will also confirm and refine the boundaries for sheen mitigation.

Descriptions of the remedial alternatives provided in this section are conceptual, with details developed to a level supportive of 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 may 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, Open Water Area, and Heavily Vegetated Area

The main components of Alternative 2 include:

- Conducting periodic sheen monitoring in the Inlet Channel, Open Water Area, and Heavily Vegetated Area to evaluate the rate of natural recovery of crude-oil-related sheens.
- It is assumed that sheen monitoring would be conducted weekly and following rainfall events for at least 6 months, 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, and Targeted Reactive Capping in the Heavily Vegetated Area

The main components of Alternative 3 include the following:

- Installing a reactive cap over sediment where sheen-bearing materials are present in the Inlet Channel, Open Water Area, and Heavily Vegetated 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 in the Inlet Channel and Open Water Area 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 or organoclay would be determined during remedial design.
  - Cap materials would be placed via mechanical broadcasting methods either using dry particle or slurry methods in accessible areas. 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.

- Monitoring will be performed to evaluate the presence of sheens over time. If monitoring shows a need for further mitigation in other areas, the cap area would be extended, as needed, to mitigate sheens.

- Additional measures may also be taken after the monitoring period, such as enhancement of the cap layers via placement of additional material if, upon inspection, target conditions (thickness and reactive media dosage) are not maintained.

Alternative 4: Targeted Removal in the Inlet Channel, Reactive Capping in the Open Water Area, and Targeted In-Situ Amendment Placement in the Heavily Vegetated Area

The main components of Alternative 4 include the following:

- Excavating up to 1 foot of localized sheen-bearing soils and sediments resulting from 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 more than 1 foot below the top of sediment. Pre-design sampling would be conducted to determine the horizontal boundaries of sheen-bearing material to be targeted for 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 to the extent 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 based on extent of sheen-bearing material. 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.

- Placing in-situ amendments at targeted locations where sheens have been observed within the Heavily Vegetated Area (see Figure N-3). Pre-design sampling would be conducted to identify target areas. Additional elements of this remedial alternative are as follows:

  - In-situ amendments (organoclay) would be placed in accessible areas, such as the existing, relatively open surface water channels, using slurry placement methods working from barges or boats. In more difficult to access areas (due to dense vegetation), amendments would be applied manually, to the extent practical, from air boats.

  - An initial dose of amendments would be applied and then monitored for sheens for approximately 6 months. If monitoring shows additional sheen mitigation efforts are warranted and needed in this area, additional application of the in-situ amendments would be conducted using similar and/or enhanced

methods of broadcasting additional doses of amendments into areas of remaining sheens.

- Additional measures may also be taken after the monitoring and amendment reapplication period, such as the use of alternative equipment to broadcast and apply the amendment materials and/or partial cutting of vegetation to improve access.

Alternative 5: Targeted Removal in the Inlet Channel and the Open Water Area, and Targeted In-Situ Amendment Placement in the Heavily Vegetated Area

The main components of Alternative 5 include the following:

- Excavating up to 1 foot of localized sheen-bearing soils and sediments resulting from the Mayflower Pipeline Incident in the Inlet Channel and Open Water Area (see Figure N-4 for potential excavation area). The excavation depth is based on sampling results presented in the DADAR that indicated no sheen-bearing material more than 1 foot below the top of sediment. Pre-design sampling would be conducted to determine the horizontal boundaries of sheen-bearing material to be targeted for 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 to the extent needed for restoration.
  - Restoring the excavated areas by re-grading and re-planting with native species.

- Placing in-situ amendments at targeted locations where sheens have been observed within the Heavily Vegetated Area (see Figure N-4). Pre-design sampling would be conducted to identify target areas. Additional elements of this remedial alternative are as follows:
  - In-situ amendments (organoclay) would be placed in accessible areas, such as the existing, relatively open surface water channels, using slurry placement methods working from barges or boats. In more difficult to access areas (due to dense vegetation), amendments would be applied, to the extent practical, working manually from air boats.
  - An initial dose of amendments will be applied and then monitored for sheens for approximately 6 months. If monitoring shows additional sheen mitigation efforts are warranted and needed in this area, additional application of the in-situ amendments would be conducted using similar and/or enhanced methods of broadcasting additional doses of amendments into areas of remaining sheens.
  - Additional measures may also be taken after the monitoring and amendment reapplication period, such as the use of alternative equipment to broadcast and apply the amendment materials and/or partial cutting of vegetation to improve access.

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 regulation Arkansas Pollution Control & Ecology Commission (APC&EC) Regulation No. 2 (effective August 26, 2011) applies to this alternative. Performing “No Action” in the site would be viewed by ADEQ as a violation of APC&EC Regulation No. 2. This technology is not the recommended alternative for the site, and it is included as a baseline for comparing the potential overall effectiveness, implementability, and cost of the other technologies.

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 seven evaluation criteria, as requested by ADEQ, to select a preferred alternative:

- Overall protection of ecological receptors
- Compliance with applicable rules and regulations
- Short-term effectiveness
- Long-term effectiveness
- Protection of existing habitat
- 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 among 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 five 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.
- *Habitat Protection* – This criterion refers to existing the ecological function and habitat value of the wetlands vegetation. It evaluates the feasibility of application remedial alternative in the Heavily Vegetated Area considering the spatially varying density, height, and maturity of the existing vegetation.
- *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 comparative screening of the remedial alternatives was performed and is presented in Table N-3. Each remedial alternative was evaluated against the seven evaluation criteria (two threshold criteria and five balancing criteria), which was 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, reactive capping in the Open Water Area, targeted in-situ amendment in the Heavily Vegetated 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 26.
- Alternative 3 (*Reactive Capping in the Inlet Channel and in the Open Water Area, targeted reactive capping in the Heavily Vegetated 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 23.
- Alternative 5 (*Targeted removal in the Inlet Channel and the Open Water Area, targeted in-situ amendment in the Heavily Vegetated 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: 20. 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, Open Water Area, and Heavily Vegetated 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 20. MNR may not meet the RAO in all areas of the site in the short term, and therefore MNR is not the recommended alternative.
- Alternative 1 (*No Action*): Lowest ranking on the threshold criteria, with the lowest total screening score of 17. No Action may not meet the RAO in all 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, reactive capping in the Open Water Area, and targeted in-situ amendments in the Heavily Vegetated 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; the scope for the pre-design study is provided in Appendix O of the DADAR. Subsequent to the pre-design study, the design will be completed and then implemented. If additional sheen mitigation measures are identified during design, then they will be proposed as part of the design documents. The additional mitigation action may include a combination of targeted removal, reactive capping and/or targeted in-situ amendment placement in areas of remaining sheens.

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; however, this will be confirmed with the USACE at the beginning of the permitting process.

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 an estimated 120 days, or more, 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 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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Tables

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ARCADIS

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 (Downstream Area)	Description	Effectiveness		Implementability	Relative Cost [1]
			Short-Term & Long-Term Effectiveness **(1) Short-term effectiveness: Ability to protect ecological receptors in the short term until the RAO of mitigating surface water sheens is achieved.** **(2) Long-term effectiveness: Ability to meet the RAO of mitigating surface water sheens and provide reliable protection of ecological receptors.**	**Habitat and Ecological Protection** **(1) Inlet Channel & Open Water Area: Potential adverse impacts to the ecological receptors and habitat during construction and implementation.** **(2) Heavily Vegetated Area: Ability to retain the existing ecological function and habitat value during construction and implementation.**	**Technical Feasibility** **(1) Inlet Channel & Open Water Area: Technical feasibility of designing and constructing the technology to meet the RAO given the site conditions.** **(2) Heavily Vegetated Area: Technical feasibility of designing and constructing the technology to meet the RAO given the existing site conditions.** **(3) Availability of specific equipment, materials, services, and technical specialists to design, install, operate, and maintain the remedy.**	
Natural Recovery	Monitored Natural Recovery	- Applicable to the Inlet Channel, Open Water Area and Heavily Vegetated Area. - Includes physical, chemical, and biological recovery processes that act in combination to reduce the mass and volume of sheen bearing-material. - Requires periodic sampling and/or monitoring to assess the natural recovery of crude oil residuals over time.	(1) Would not reduce surface water sheens or the mobility and volume of sheen-bearing material in the short term as natural recovery is anticipated to occur over a longer period of time assuming suitable environmental conditions; potential for exposure to ecological receptors in the short term. (2) Expected to achieve the RAO of mitigating surface water sheens and reduce exposure to ecological receptors in the long term, assuming natural recovery of constituents over time. Monitoring would be required to assess long-term effectiveness.	(1) Inlet Channel & Open Water Area: No construction or implementation-related impacts. (2) Heavily Vegetated Area: Would retain the ecological function and habitat value as periodic monitoring would not adversely impact vegetation.	(1) Inlet Channel & Open Water Area: Technically feasible. (2) Heavily Vegetated Area: Technically feasible. (3) 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	- Applicable to the Inlet Channel, Open Water Area and Heavily Vegetated Area. - 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 mixing of the clean layer through bioturbation with underlying sediments, that act in combination to reduce the mass and volume of sheen-bearing material. - Thin-layer materials would be installed in the wet. - Requires periodic sampling and/or monitoring to assess the natural recovery of sheen-bearing material over time.	(1) Would not reduce surface water sheens or the mobility or volume of sheen-bearing material in the short term as natural recovery is anticipated to occur over a longer period of time assuming suitable environmental conditions; potential for exposure to ecological receptors in the short term. (2) Would likely achieve the RAO and reduce exposure to ecological receptors in the long term, although the anticipated amount of time until the RAO is met is uncertain. Would not remove constituents from the site, although the volume, mass, and toxicity of constituents would be reduced over time via accelerated natural recovery through several processes, including mixing of the clean layer through bioturbation with underlying sediments. Monitoring would be required to assess long-term effectiveness.	(1) Inlet Channel & Open Water Area: Low to moderate potential for adverse impacts to ecological receptors during construction and implementation. Environmental impacts during thin-layer placement 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. (2) Heavily Vegetated Area: Applying a thin layer of amendments without active mixing is expected to have a low to moderate adverse impact on wetland vegetation. However, assessing densely vegetated areas could have a moderate adverse impact on wetland vegetation.	(1) Inlet Channel & Open Water Area: 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) Heavily Vegetated Area: Implementability is questionable due to challenges accessing the densely vegetated areas and evenly placing a thin layer of clean material. (3) Equipment, materials, services, and the technical specialists necessary to install a thin-layer of clean material are available.	Moderate construction and low O&M costs.
	Dewatering/ Enhanced Aerobic Bioremediation	- Applicable to the Inlet Channel, Open Water Area and Heavily Vegetated Area. - Dewater using a berm or wall, pumps and a bypass pipeline to pump water out of and around the work area. - Water may need to be treated and discharged back to the water body, and would be subject to the appropriate permits. - Assumes oxygen is limiting biodegradation rate of sheen generating crude oil residuals; vegetation and sediments would be exposed to air under high temperatures, which would enhance degradation rates of residual crude oil. - Addition of nutrients and moisture may facilitate biodegradation. - Seeding or wetland re-construction may be required especially if performed during spring or summer exposing wetlands to high temperatures and low moisture during plant growth seasons. - Requires periodic sampling and/or monitoring to assess the natural biodegradation of constituents over time.	(1) Short-term effectiveness is unknown because the timeframe to achieve sufficient biodegradation and to mitigate surface water sheens, reduce the mobility, volume, or toxicity of sheen-bearing material is uncertain. (2) Would likely achieve the RAO and reduce exposure to ecological receptors in the long term, although the anticipated amount of time until the RAO is met is uncertain. Would not remove constituents from the site, although the volume, mass, and toxicity of constituents would be reduced over time via natural recovery processes given suitable environmental conditions. Monitoring would be required to assess long-term effectiveness.	(1) Inlet Channel & Open Water Area: Not applicable. (2) Heavily Vegetated Area: Dewatering for long periods of time may adversely impact wetland vegetation if there is enough time for an increase in invasive species in the vegetative cover and decrease in habitat diversity. Some degree of wetland re-construction may be necessary.	(1) Inlet Channel & Open Water Area: Not applicable. (2) Heavily Vegetated Area: Technically feasible to implement. The duration of implementation (dewatering) is dependent on the rate of aerobic biodegradation. Biodegradation is estimated to occur within 6 or more months depending on availability of oxygen, optimum temperature, and moisture. Depending on the duration of dewatering, challenges associated with dewatering include managing stormwater and groundwater inputs and supplying a consistent power source and adequate monitoring/maintenance to operate the dewatering system. Accessing the densely vegetated areas to dewater presents additional implementation challenges. (3) Equipment, materials, services, and the technical specialists necessary for dewatering are available.	High construction and moderate O&M costs.

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			Short-Term & Long-Term Effectiveness **(1) Short-term effectiveness: Ability to protect ecological receptors in the short term until the RAO of mitigating surface water sheens is achieved.** **(2) Long-term effectiveness: Ability to meet the RAO of mitigating surface water sheens and provide reliable protection of ecological receptors.**	**Habitat and Ecological Protection** **(1) Inlet Channel & Open Water Area: Potential adverse impacts to the ecological receptors and habitat during construction and implementation.** **(2) Heavily Vegetated Area: Ability to retain the existing ecological function and habitat value during construction and implementation.**	**Technical Feasibility** **(1) Inlet Channel & Open Water Area: Technical feasibility of designing and constructing the technology to meet the RAO given the site conditions.** **(2) Heavily Vegetated Area: Technical feasibility of designing and constructing the technology to meet the RAO given the existing site conditions.** **(3) Availability of specific equipment, materials, services, and technical specialists to design, install, operate, and maintain the remedy.**	
In-Situ Treatment	Sediment Amendments	- Applicable to the Inlet Channel, Open Water Area and Heavily Vegetated Area. - In-situ delivery 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 a mixture of sand/organoclay or pelletized organoclay. Mixing into the bioactive zone would occur through natural sediment mixing processes such as bioturbation. - Would require periodic sampling and/or monitoring to assess effectiveness and need for additional doses.	(1) Would reduce the mobility of constituents (via adsorption/absorption) in the short term and reduce future adverse exposures, assuming the proper dosage of amendment is applied and comes into direct contact with crude oil constituents. Not expected to reduce the volume of sheen-bearing material in the short term as natural biodegradation is anticipated to occur over a long period of time, assuming suitable environmental conditions. (2) Would reduce the long-term potential for exposure to ecological receptors and the volume of sheen-bearing material via natural biodegradation, assuming suitable environmental conditions and adequate contact between amendments and crude oil constituents. Additional amendments might have to be applied in the future. Monitoring would be required to assess long-term effectiveness. Future intrusive activities at the site may reduce the long-term effectiveness of this technology; however, such activities are unlikely.	(1) Inlet Channel & Open Water Area: Low potential for adverse impacts to ecological receptors during implementation. Environmental impacts during implementation include disturbing vegetation/biota and creating some degree of turbidity during implementation. Environmental benefit includes removal and off-site disposal of sheen-bearing material is not required (assuming amendments can be left in place after application). (2) Heavily Vegetated Area: Applying a thin layer of amendments without active mixing is expected to have a low potential for temporary adverse impact on wetland vegetation. However, accessing the densely vegetated areas may have a moderate adverse impact on wetland vegetation.	(1) Inlet Channel & Open Water Area: Technically feasible to implement, although the amount of amendments applied to the site would have to be determined during implementation to achieve proper dosage. Amendments may need to be mixed into the subsurface to maximize absorptive/adsorptive capacity. In near-shore accessible areas, amendments could be applied mechanically. In accessible open water areas, amendments could be applied using slurry placement methods working from barges or boats. (2) Heavily Vegetated Area: Technically feasible to implement (same as Inlet Channel & Open Water Area). Accessing the densely vegetated areas to adequately apply/disperse amendments over sheen-bearing material presents additional implementation challenges. In difficult to access (densely vegetated) areas, amendment could be applied manually, to the extent practicable. (3) Equipment, materials, services, and technical specialists necessary to apply amendments are available. Field testing is suggested to select and optimize the amendment dosage and method of applying/dispersing amendments in the various parts of the site.	Moderate to high capital and O&M costs.
	Enhanced Bioremediation via Agitation	- Applicable to the Inlet Channel and Open Water Area. - Accelerate biodegradation of residual crude oil by in-situ mixing of surface layer, sheen-bearing sediment. - Remove large woody vegetation prior to mixing. - Assumes oxygen is limiting biodegradation rate; mixing will introduce oxygen under warm temperatures and enhance biodegradation of residual crude oil in surface sediment layer. - Estimated depth of mixing would be a minimum of 1 foot below sediment surface and mixing would occur every 3 days. - Requires periodic sampling and/or monitoring to assess the biodegradation of constituents over time.	(1) Would not mitigate surface water sheens, reduce the mobility, volume, or toxicity of sheen-bearing material, and may not provide protection of ecological receptors in the short term as aerobic biodegradation is anticipated to occur over a longer period of time (even with agitation). On-site field crews utilized agitation techniques in the Open Water Area in summer 2013 and did not observe noticeable decrease of sheens. (2) Would likely not reduce the long-term potential for exposure to ecological exposure given the limited success of this remedial option to mitigate sheens at other parts of the site. Would not remove constituents from the site, although some natural degradation of crude oil might occur given suitable environmental conditions. Mixing in the wet may potentially disperse crude oil constituents into the anaerobic subsurface, which would decrease the rate of natural biodegradation. Monitoring would be required to assess long-term effectiveness.	(1) Open Water Area: Moderate to high potential for adverse impacts to ecological receptors during implementation. Environmental impacts during implementation include removing vegetation, high level of habitat destruction, disturbing biota, and high energy use. Environmental benefit includes minimal removal and off-site disposal of sheen-bearing material. (2) Heavily Vegetated Area: Not applicable because sediment agitation would require wetland de-vegetation.	(1) Open Water Area: Technically feasible to implement. The duration of implementation is dependent on the rate of aerobic biodegradation. Frequent mixing is anticipated to occur for 3 to 6 months depending on availability of oxygen, optimum temperature, and moisture level. (2) Heavily Vegetated Area: Not applicable. (3) Equipment, materials, services, and technical specialists necessary to till the surface sediment layer are available. Field testing is suggested to select and optimize mixing equipment.	Highest capital and O&M costs.

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Mayflower Pipeline Incident Response, Mayflower, Arkansas

General Response Action	Remedial Technology (Downstream Area)	Description	Effectiveness		Implementability	Relative Cost [1]
			Short-Term & Long-Term Effectiveness **(1) Short-term effectiveness: Ability to protect ecological receptors in the short term until the RAO of mitigating surface water sheens is achieved.** **(2) Long-term effectiveness: Ability to meet the RAO of mitigating surface water sheens and provide reliable protection of ecological receptors.**	**Habitat and Ecological Protection** **(1) Inlet Channel & Open Water Area: Potential adverse impacts to the ecological receptors and habitat during construction and implementation.** **(2) Heavily Vegetated Area: Ability to retain the existing ecological function and habitat value during construction and implementation.**	**Technical Feasibility** **(1) Inlet Channel & Open Water Area: Technical feasibility of designing and constructing the technology to meet the RAO given the site conditions.** **(2) Heavily Vegetated Area: Technical feasibility of designing and constructing the technology to meet the RAO given the existing site conditions.** **(3) Availability of specific equipment, materials, services, and technical specialists to design, install, operate, and maintain the remedy.**	
In-Situ Treatment	Enhanced Bioremediation via Air Sparging	- Applicable to the Inlet Channel, Open Water Area and Heavily Vegetated Area. - Accelerate biodegradation of residual crude oil by aerating the surface layer of sediments and loosening the sediments. - Assumes oxygen is limiting biodegradation rate; air sparging will introduce oxygen and enhance biodegradation of residual crude oil. - Sheen management and removal would be required during air injection to recover sheens released from the sediment. - Following remedial action, restoration may be required, especially if performed in the dry during spring or summer. - Requires periodic sampling and monitoring to assess the biodegradation of constituents over time.	(1) Would not mitigate surface water sheens, reduce the mobility, volume, or toxicity of sheen-bearing material, and may not provide protection of ecological receptors in the short term as aerobic biodegradation is anticipated to occur over a longer period of time (even with oxygen amendments). (2) Would likely not mitigate sheens nor reduce the long-term potential for exposure to ecological receptors. Accelerating aerobic bioremediation via oxygen amendments is only effective if an adequate supply of oxygen is distributed to the microbial community within the surface layer of the sheen-bearing material. Oxygen distribution in a shallow water column will likely limit the effectiveness of this remedial technology to mitigate sheens. Would not remove constituents from the site, although some natural degradation of crude oil might occur given suitable environmental conditions. Monitoring would be required to assess long-term effectiveness.	(1) Inlet Channel & Open Water Area: Moderate to high potential for adverse impacts to ecological receptors during construction and implementation. Environmental impacts during construction/implementation include disturbing biota/habitats, partial removal of vegetation, noise associated with aeration system, odor generation, and high energy use. Environmental benefit includes minimal removal and off-site disposal of sheen-bearing material. (2) Heavily Vegetated Area: Gaining access to the targeted areas and installing the aeration system is expected to adversely impact wetland vegetation through de-vegetation resulting in habitat destruction, increased invasive species growth and decreased habitat diversity.	(1) Inlet Channel & Open Water Area: Implementability is questionable due to lack of successful large field-scale trials in this type of setting. Air injection would be provided using compressor, air lance, and/or mud cat excavator. The duration of implementation is dependent on the rate of aerobic biodegradation. Biodegradation is anticipated to occur within 3 to 6 months depending on dissolved oxygen concentrations, optimum temperature, and moisture level. Power requirements associated with aeration system may present additional implementation challenges. (2) Heavily Vegetated Area: Implementability is questionable because accessing the densely vegetated areas to install the aeration system and supply power presents additional implementation challenges. (3) Equipment, materials, services, and the technical specialists necessary for air sparging the surface sediment layer are available. Field testing is suggested to select and optimize air sparging equipment.	Moderate to high capital and O&M costs.
Containment	Non-Reactive Capping	- Applicable to the Inlet Channel and Open Water Area. - 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 reduce the mobility of crude oil constituents in sheen-bearing material (via a physical barrier) and reduce the potential for exposure to constituents in the short term. However, sand does not provide sorption of constituents, so sheens may occur if cap does not sufficiently isolate sheen-bearing material or if the cap is damaged. (2) Would mitigate sheens and reduce the potential for exposure to ecological receptors in the long term, assuming sheen-bearing materials are physically isolated, the cap is not damaged, and constituents naturally degrade below the cap over time. Would not remove constituents from the site. 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) Inlet Channel & Open Water Area: Low potential for adverse impacts 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. (2) Not applicable to the Heavily Vegetated Area because a thick cap would result in adverse impact to the wetlands vegetation.	(1) Inlet Channel & Open Water Area: 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. Monitoring during construction would be required to assess achievement of cap thickness and settling. (2) Heavily Vegetated Area: Not applicable. (3) Equipment, materials, services, and the technical specialists necessary to construct a non-reactive cap are available.	Moderate construction and O&M costs.
	Reactive Capping	- Applicable to the Inlet Channel, Open Water Area and Heavily Vegetated Area. - 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. - Seeding may be needed to prevent non-native species growth. A thin cap would have some impact on wetlands. - 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) Would mitigate sheens and reduce the potential for exposure to ecological receptors in the long term. Would not remove constituents from the site, although they may naturally degrade over time below the cap. 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) Inlet Channel & Open Water Area: Low potential for adverse impacts to ecological receptors during construction and implementation. Environmental impacts during construction include some impact on the 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) Heavily Vegetated Area: Applying a cap over wetland areas is expected to have some temporary impact on wetland vegetation, resulting in increased invasive species growth and decreased habitat diversity. Dense vegetation may need to be removed to gain access/install the cap.	(1) Inlet Channel & Open Water Area: Technically feasible to install. The ratio of organoclay to sand would be selected to provide adequate adsorptive capacity. 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. Monitoring during construction would be required to assess achievement of cap thickness and settling. Thickness of the cap required to mitigate sheens may present installation challenges in shallow water. (2) Heavily Vegetated Area: Accessing the densely vegetated areas to install the cap and designing/installing a cap over densely vegetated areas (to provide sufficient isolation of sheen-bearing material) presents implementation challenges. A uniform reactive cap layer may not be feasible without vegetation removal. (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 (Downstream Area)	Description	Effectiveness		Implementability	Relative Cost [1]
			Short-Term & Long-Term Effectiveness **(1) Short-term effectiveness: Ability to protect ecological receptors in the short term until the RAO of mitigating surface water sheens is achieved.** **(2) Long-term effectiveness: Ability to meet the RAO of mitigating surface water sheens and provide reliable protection of ecological receptors.**	**Habitat and Ecological Protection** **(1) Inlet Channel & Open Water Area: Potential adverse impacts to the ecological receptors and habitat during construction and implementation.** **(2) Heavily Vegetated Area: Ability to retain the existing ecological function and habitat value during construction and implementation.**	**Technical Feasibility** **(1) Inlet Channel & Open Water Area: Technical feasibility of designing and constructing the technology to meet the RAO given the site conditions.** **(2) Heavily Vegetated Area: Technical feasibility of designing and constructing the technology to meet the RAO given the existing site conditions.** **(3) Availability of specific equipment, materials, services, and technical specialists to design, install, operate, and maintain the remedy.**	
Removal	Targeted Removal with Off-Site Disposal	- Applicable to the Inlet Channel and Open Water Area. - Excavation of sheen-bearing material from targeted areas consistently producing sheen related to 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 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 mitigate sheens, reduce the mobility, volume, and toxicity of constituents, and reduce the potential for exposure to ecological receptors in the short term by permanently removing sheen-bearing material. However, residuals may remain after excavation. (2) Would mitigate sheens and 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) Inlet Channel & Open Water Area: Moderate to high potential for adverse impacts to ecological receptors during implementation. Environmental impacts during implementation potentially include odor and 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 generation of sheen-bearing waste for off-site disposal. (2) Heavily Vegetated Area: Not applicable because removal would require wetland de-vegetation.	(1) Inlet Channel & Open Water Area: 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) Heavily Vegetated Area: Not applicable. (3) Equipment, materials, services, and the technical specialists needed for targeted removal are readily available.	Highest construction and low O&M costs.
	Removal followed by Ex-Situ On-Site Treatment and Reuse	- Applicable to the Inlet Channel and Open Water Area. - 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. - Requires excavation of submerged sediments and dewatering prior to treatment. - Water generated may need to be treated and discharged back to the water body, and would be subject to the appropriate permits. - 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 mitigate sheens, reduce the mobility, volume, and toxicity of constituents, and reduce the potential for exposure to ecological receptors in the short term by removing and treating sheen-bearing material. However, residuals may remain after removal and treatment. (2) Would mitigate sheens and reduce the long-term potential for exposure to ecological 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) Inlet Channel & Open Water Area: Moderate to high potential for adverse impacts to ecological receptors during implementation. Environmental impacts during implementation potentially include odor and turbidity generation, 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. Environmental benefit includes minimal off-site disposal of sheen-bearing material (however, removed vegetation would have to be transported and disposed off-site). (2) Heavily Vegetated Area: Not applicable because removal would require wetland de-vegetation.	(1) Inlet Channel & Open Water Area: 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) Heavily Vegetated Area: Not applicable. (3) Equipment, materials, services, and technical specialists necessary to excavate and treat impacted media are available. There are two types of mixing options generally available: - 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.	Highest 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 NOI and preparation of a SWPPP.	✓	✓	✓	✓	✓
Regulations For State Administration of the 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 United States.	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									
CWA Section 404	USACE	40 CFR Sections 230 and 231; and 33 CFR 320-330	Placement of dredged or fill material into waters of the United States, 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 United States 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 United States.	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 United States 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.			✓	✓	✓
CWA 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 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 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 United States from on-site 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 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
APCEC = Arkansas Pollution Control & Ecology Commission
CFR = Code of Federal Regulations
CWA = Clean Water Act
Eff. = effective
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
Evaluation and Screening of 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	Habitat Protection	Implementability	Relative Cost	Threshold Criteria	Balancing Criteria	Total Score
Alternative 1: **- No Action**	1	1	1	N/A	4	5	5	2	15	17
Alternative 2: **- MNR in Inlet Channel** **- MNR in Open Water Area** **- MNR in Heavily Vegetated Area**	3	2	1	2	4	4	4	5	15	20
Alternative 3: **- Reactive Capping in Inlet Channel** **- Reactive Capping in Open Water Area** **- Targeted Reactive Capping in Heavily Vegetated Area**	4	5	4	4	2	2	2	9	14	23
Alternative 4: **- Targeted Removal in Inlet Channel** **- Reactive Capping in Open Water Area** **- Targeted In-Situ Amendments in Heavily Vegetated Area**	5	5	3	4	3	3	3	10	16	26
Alternative 5: **- Targeted Removal in Inlet Channel** **- Targeted Removal in Open Water Area** **- Targeted In-Situ Amendments in Heavily Vegetated Area**	4	5	3	5	1	1	1	9	11	20

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

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Figures

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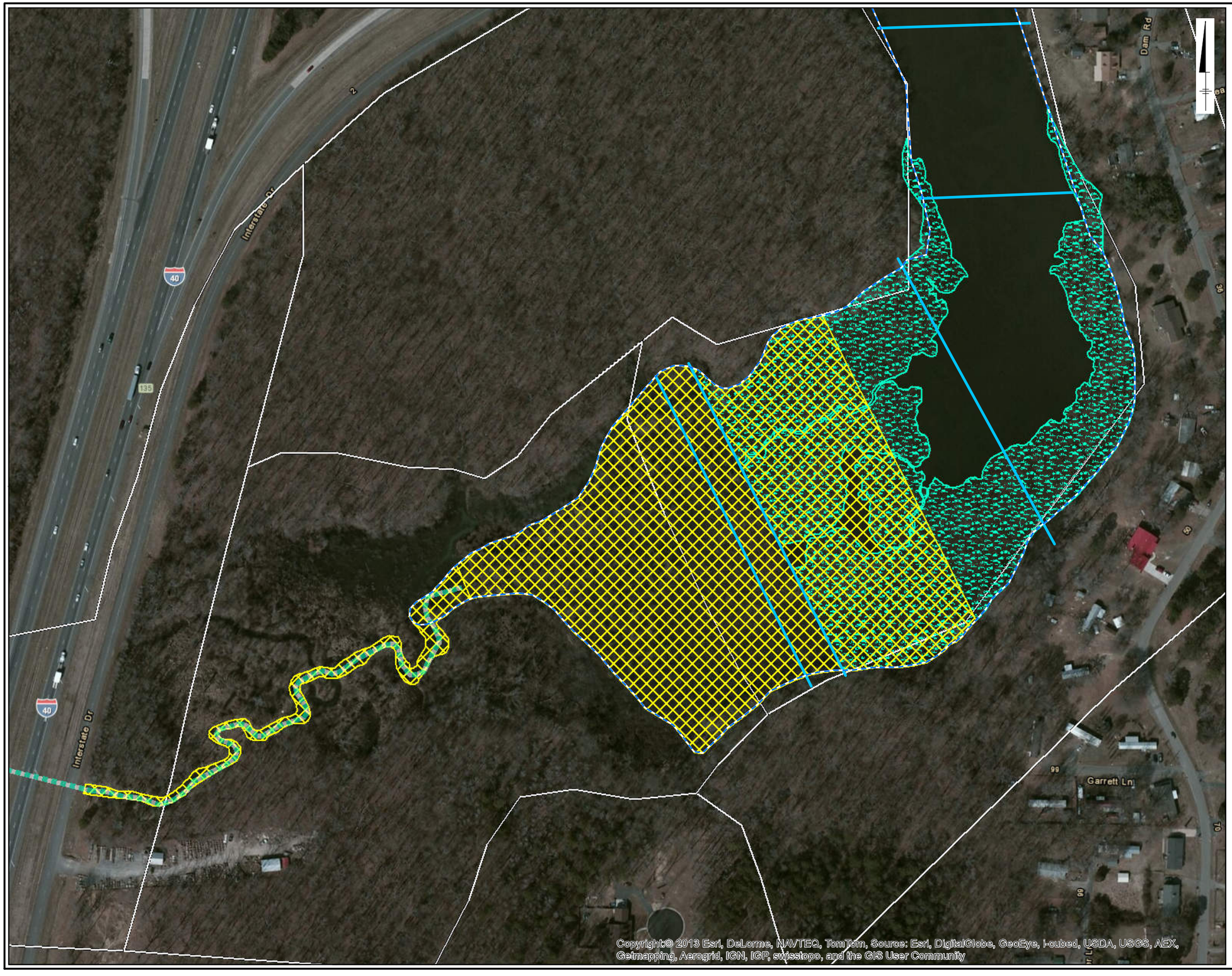

Legend

- 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 12 sheen samples collected in November 2013 and January 2014. Pre-design study will be conducted to confirm and refine the mitigation area.

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DOWNSTREAM AREAS DATA ASSESSMENT REPORT

APPROXIMATE AREAS FOR SHEEN MITIGATION

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FIGURE
N-1

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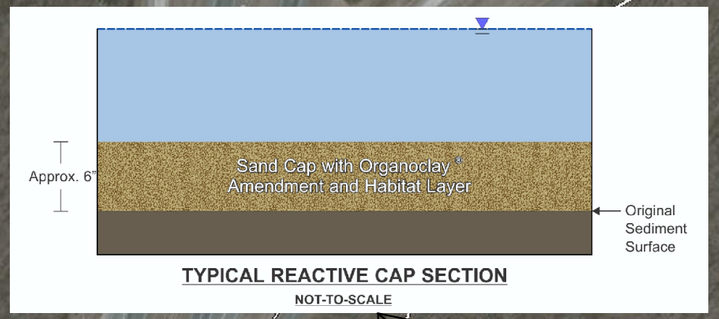

TYPICAL REACTIVE CAP SECTION

NOT-TO-SCALE

Legend

- Approximate Inlet Channel Cap Placement Area
- Approximate Open Water Cap Placement Area
- Areas with Heavy Vegetation
- Approximate Heavily Vegetated Targeted Cap Placement Area
- 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 12 sheen samples collected in November 2013 and Janauary 2014. Pre-design study will be conducted to confirm the mitigation area.

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MAYFLOWER PIPELINE INCIDENT RESPONSE
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DOWNSTREAM AREAS DATA ASSESSMENT REPORT

ALTERNATIVE 3 -
REACTIVE CAPPING IN THE INLET CHANNEL AND OPEN WATER AREA, TARGETED REACTIVE CAPPING IN THE HEAVILY VEGETATED AREA

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FIGURE N-2

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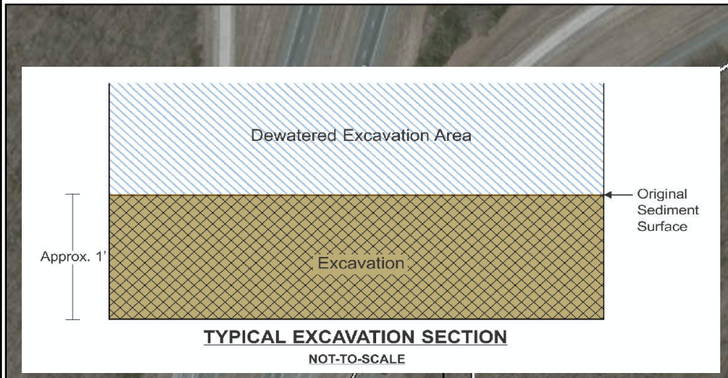
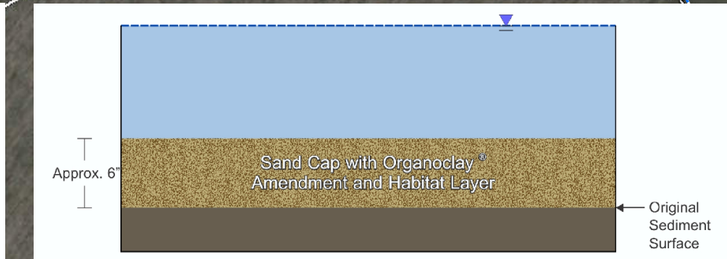


TYPICAL EXCAVATION SECTION
NOT-TO-SCALE



TYPICAL REACTIVE CAP SECTION
NOT-TO-SCALE

TYPICAL TARGETED IN-SITU SEDIMENT AMENDMENT SECTION
NOT-TO-SCALE

Legend

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

NOTE:
1. Potential mitigation areas are approximate, and based on daily sheen monitoring activities initiated on October 21, 2013 and results from 12 sheen samples collected in November 2013 and January 2014. Pre-design study will be conducted to confirm the mitigation area.

0 200 400
Feet

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

ALTERNATIVE 4 - TARGETED REMOVAL IN THE INLET CHANNEL,REACTIVE CAPPING IN THE OPEN WATER AREA, TARGETED IN-SITU AMENDMENT PLACEMENT IN THE HEAVILY VEGETATED AREA

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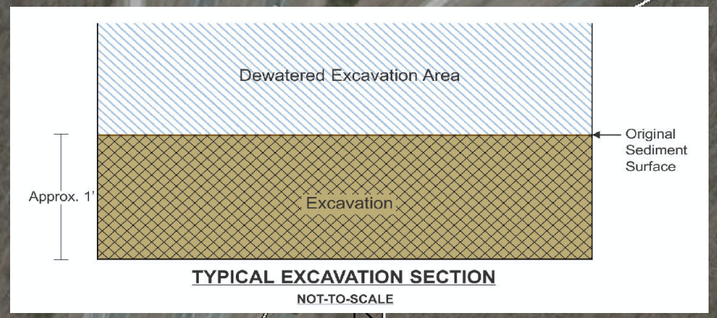
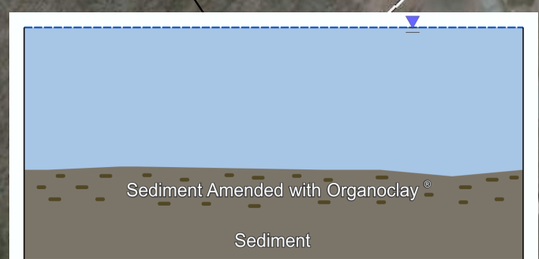
FIGURE
N-3



TYPICAL EXCAVATION SECTION
NOT-TO-SCALE

Legend

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



TYPICAL TARGETED IN-SITU SEDIMENT AMENDMENT SECTION
NOT-TO-SCALE

NOTE:
1. Potential mitigation areas are approximate, and based on daily sheen monitoring activities initiated on October 21, 2013 and on forensic results from 12 sheen samples collected in November 2013 and January 2014. Pre-design study will be conducted to confirm the mitigation area.

0 200 400
Feet

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

ALTERNATIVE 5 -
TARGETED REMOVAL IN THE INLET CHANNEL AND OPEN WATER AREA, TARGETED IN-SITU AMENDMENT PLACEMENT IN THE HEAVILY VEGETATED AREA

ARCADIS

FIGURE
N-4

ARCADIS

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, Open Water Area, and Heavily Vegetated Area	$ 2,035,000
Alt 3	Reactive Capping in the Inlet Channel and Open Water Area, Targeted Reactive Capping in the Heavily Vegetated Area	$ 7,629,000
Alt 4	Targeted Removal in the Inlet Channel, Reactive Capping in the Open Water Area, Targeted In-Situ Amendment Placement in the Heavily Vegetated Area	$ 6,838,000
Alt 5	Targeted Removal in the Inlet Channel and Open Water Area, Targeted In-Situ Amendment Placement in the Heavily Vegetated Area	$ 7,165,000

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, Open Water Area, and Heavily Vegetated 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	76	LS	$20,000	$1,520,000
4	Weekly Monitoring Update	76	LS	$500	$38,000
5	Semi-Annual Monitoring Report	6	LS	$10,000	$60,000
6	Annual Verification and Certification of Institutional	3	LS	$10,000	$30,000
				Subtotal O&M Cost	$1,648,000
				Contingency (20%)	$329,600
				Total 3-Year O&M Cost	$1,977,600
				Total Estimated Cost:	**$2,035,100**
				Rounded To:	**$2,035,000**

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 consists of weekly visits and weekly updates for the first year of MNR to ensure mitigation goals are achieved. Monitoring and reporting will be performed monthly for the following two (2) years for a total of three (3) years of MNR performance monitoring. Semi-annual reports will be prepared for three years of MNR monitoring.
4. 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 observations.
5. Weekly Monitoring Update cost estimate includes all labor, equipment, subsistence and materials necessary to complete a basic form for agency approval documenting the results of the weekly sheen monitoring visit.

6. Semi-Annual Monitoring Report cost estimate includes labor necessary to prepare a semi-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).
7. 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 Open Water Area, Targeted Reactive Capping in the Heavily Vegetated 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	$128,000	$128,000
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	$2,400
	Turbidity Control System	725	LF	$25	$18,200
	Water Column Monitoring	1.0	MONTH	$3,520	$3,600
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	700	CY	$2,600	$1,820,000
	Habitat Layer Cover	5,100	CY	$30	$153,000
	Cap Placement	6,200	CY	$50	$310,000
10	Capping of Heavily Vegetated Area				
	Clean Sand	200	CY	$24	$4,800
	Organoclay Amendment	400	CY	$2,600	$1,040,000
	Cap Placement	600	CY	$120	$72,000
11	Restoration	7.8	AC	$15,000	$117,000
				Subtotal Capital Cost	$4,071,800
12				Administration & Engineering (15%)	$610,770
13				Construction Management (15%)	$610,770
				Contingency (20%)	$814,360
				Total Capital Cost	$6,107,700
Operation and Maintenance (O&M) Costs					
14	Sheen Monitoring Visit	76	LS	$15,000	$1,140,000
15	Weekly Monitoring Update	76	LS	$500	$38,000
16	Semi-Annual Monitoring Report	6	LS	$10,000	$60,000
17	Annual Verification and Certification of Institutional Controls	3	LS	$10,000	$30,000
				Subtotal O&M Cost	$1,268,000
				Contingency (20%)	$253,600
				Total 3-Year O&M Cost	$1,521,600
				Total Estimated Cost:	**$7,629,300**
				Rounded To:	**$7,629,000**

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

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

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

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. 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. Only 20% of the material costs for the Organoclay amendment were included in the capital costs.
4. Staging area cost 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.
5. 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.
6. 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.

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

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

7 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.

8. 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.

9. Inlet channel and open water area 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 1-inch layer of clean sand material with bulk Organoclay blended in at 65% by volume, as well as a 5-inch layer of Habitat Layer Cover. 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.

10. Heavily vegetated area capping cost estimate includes labor, materials, equipment, transport, and services necessary for, or incidental to, the placement of capping material over an approximate 1 acre area. The cap will be comprised of a 2-3-inch layer of clean sand material with bulk Organoclay blended in at 65% by volume. Quantities shown are for cost estimate purpose only. Quantities will be determined after pre-design study. 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.

14. Sheen monitoring consists of weekly visits and weekly updates for the first year following construction to ensure mitigation goals for heavily vegetated area are achieved. Monitoring and reporting will be performed monthly for the following two (2) years for a total of three (3) years of MNR performance monitoring. Semi-annual reports will be prepared for three years of MNR monitoring.

15. Sheen monitoring cost estimate includes all labor, equipment, subsistence and materials necessary to conduct a sheen monitoring visit in the heavily vegetated areas not identified for capping (approximately 5 acres). 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 observations.

16. Weekly Monitoring Update cost estimate includes all labor, equipment, subsistence and materials necessary to complete a basic form for agency approval documenting the results of the weekly sheen monitoring visit.

17. Semi-Annual Monitoring Report cost estimate includes labor necessary to prepare a semi-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).

18. 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 4
Targeted Removal in the Inlet Channel, Reactive Capping in the Open Water Area, Targeted In-Situ Amendment Placement in the Heavily Vegetated 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	$152,000	$152,000
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	5	WEEKS	$600	$2,900
	Turbidity Control System	725	LF	$25	$18,200
	Water Column Monitoring	1.2	MONTH	$3,520	$4,300
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	1.7	MONTH	$50,000	$85,000
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	400	CY	$24	$9,600
	Organoclay Amendment	700	CY	$2,600	$1,820,000
	Habitat Layer Cover	4,600	CY	$30	$138,000
	Cap Placement	5,700	CY	$50	$285,000
13	In-Situ Amendment in Heavily Vegetated Area				
	Amendment	1	AC	$78,500	$78,500
	Amendment Placement	1	AC	$60,000	$60,000
14	Transportation and Disposal				
	Off-site Disposal Debris/Vegetation	1,000	TON	$35	$35,000
	Off-site Disposal Sediment	3,937	TON	$35	$137,900
15	Solid Waste Characterization	10	EACH	$750	$7,500
16	Restoration	7.8	AC	$15,000	$117,000
				Subtotal Capital Cost	$3,544,000
17				Administration & Engineering (15%)	$531,600
18				Construction Management (15%)	$531,600
				Contingency (20%)	$708,800
				Total Capital Cost	$5,316,000
Operation and Maintenance (O&M) Costs					
19	Sheen Monitoring Visit	76	LS	$15,000	$1,140,000
20	Weekly Monitoring Update	76	LS	$500	$38,000
21	Semi-Annual Monitoring Report	6	LS	$10,000	$60,000
22	Annual Verification and Certification of Institutional	3	LS	$10,000	$30,000
				Subtotal O&M Cost	$1,268,000
				Contingency (20%)	$253,600
				Total 3-Year O&M Cost	$1,521,600
				Total Estimated Cost:	**$6,837,600**
				Rounded To:	**$6,838,000**

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

Attachment N-1
Cost Estimate for Alternative 4
Targeted Removal in the Inlet Channel, Reactive Capping in the Open Water Area, Targeted In-Situ Amendment Placement in the Heavily Vegetated Area

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

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. 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 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 Dawson 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.
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. In-Situ amendment cost estimate includes labor, materials, equipment, transport, and services necessary for, or incidental to, the placement of amendment material over an approximate 1 acre area. Amendment will be placed at a rate of 1 pound per square foot. Amendment placement costs assume manual placement from a small boat. Specific placement methods will be evaluated further in design. Quantities shown are for cost estimate purpose only. Quantities will be determined after pre-design study.
15. 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.

16. 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.
17. 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.
18. Administration and engineering cost is equal to 15% of the total capital costs. Cost includes Final Report.
19. Construction management cost is based on an assumed 15% of the total capital costs.
20. Sheen monitoring consists of weekly visits and weekly updates for the first year following construction to ensure mitigation goals for heavily vegetated area are achieved. Monitoring and reporting will be performed monthly for the following two (2) years for a total of three (3) years of MNR performance monitoring. Semi-annual reports will be prepared for three years of MNR monitoring.
21. Sheen monitoring cost estimate includes all labor, equipment, subsistence and materials necessary to conduct a sheen monitoring visit in the heavily vegetated area (approximately 6 acres). 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 observations.
22. Weekly Monitoring Update cost estimate includes all labor, equipment, subsistence and materials necessary to complete a basic form for agency approval documenting the results of the weekly sheen monitoring visit.
23. Semi-Annual Monitoring Report cost estimate includes labor necessary to prepare a semi-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).
24. 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 5
Targeted Removal in the Inlet Channel and Open Water Area, Targeted In-Situ Amendment Placement in the Heavily Vegetated 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	$245,000	$245,000
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	5	WEEKS	$600	$2,900
	Turbidity Control System	725	LF	$25	$18,200
	Water Column Monitoring	1.2	MONTH	$3,520	$4,300
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	4.3	MONTH	$50,000	$215,000
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	In-Situ Amendment in Heavily Vegetated Area				
	Amendment	1	AC	$78,500	$78,500
	Amendment Placement	1	AC	$60,000	$60,000
13	Transportation and Disposal				
	Off-site Disposal Debris/Vegetation	1,000	TON	$35	$35,000
	Off-site Disposal Sediment	21,826	TON	$35	$764,000
14	Solid Waste Characterization	46	EACH	$750	$34,500
15	Restoration	7.8	AC	$15,000	$117,000
				Subtotal Capital Cost	$3,762,500
16				Administration & Engineering (15%)	$564,375
17				Construction Management (15%)	$564,375
				Contingency (20%)	$752,500
				Total Capital Cost	$5,643,750
Operation and Maintenance (O&M) Costs					
18	Sheen Monitoring Visit	76	LS	$15,000	$1,140,000
19	Weekly Monitoring Update	76	LS	$500	$38,000
20	Semi-Annual Monitoring Report	6	LS	$10,000	$60,000
21	Annual Verification and Certification of Institutional	3	LS	$10,000	$30,000
				Subtotal O&M Cost	$1,268,000
				Contingency (20%)	$253,600
				Total 3-Year O&M Cost	$1,521,600
				Total Estimated Cost:	**$7,165,350**
				Rounded To:	**$7,165,000**

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

Attachment N-1
Cost Estimate for Alternative 5
Targeted Removal in the Inlet Channel and Open Water Area, Targeted In-Situ Amendment Placement in the Heavily Vegetated Area

Downstream Areas Data Assessment Report
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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. 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 90-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 Dawson 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.
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 and open water areas via mechanical means. Volume estimate assumes 1,300 feet of channel length and an average channel width of 20 feet, and approximately 6 acres of open water area. 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. Transportation and disposal cost estimate includes labor, equipment, materials, and services required for the transportation and disposal of the removed vegetation/debris, as well as access/staging materials.

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14. 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.
15. In-Situ amendment cost estimate includes labor, materials, equipment, transport, and services necessary for, or incidental to, the placement of amendment material over an approximate 1 acre area. Amendment will be placed at a rate of 1 pound per square foot. Amendment placement costs assume manual placement from a small boat. Specific placement methods will be evaluated further in design. Quantities shown are for cost estimate purpose only. Quantities will be determined after pre-design study.
16. 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.
17. 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.
18. Administration and engineering cost is equal to 15% of the total capital costs. Cost includes Final Report.
19. Construction management cost is based on an assumed 15% of the total capital costs.
20. Sheen monitoring consists of weekly visits and weekly updates for the first year following construction to ensure mitigation goals for heavily vegetated area are achieved. Monitoring and reporting will be performed monthly for the following two (2) years for a total of three (3) years of MNR performance monitoring. Semi-annual reports will be prepared for three years of MNR monitoring.
21. Sheen monitoring cost estimate includes all labor, equipment, subsistence and materials necessary to conduct a sheen monitoring visit in the heavily vegetated area (approximately 6 acres). 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 observations.
22. Weekly Monitoring Update cost estimate includes all labor, equipment, subsistence and materials necessary to complete a basic form for agency approval documenting the results of the weekly sheen monitoring visit.
23. Semi-Annual Monitoring Report cost estimate includes labor necessary to prepare a semi-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).
24. 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.