Table 4.1
Detailed Evaluation of Remedial Alternatives – Upper Vadose Soil and Perched Groundwater Remediation Zone (3 to 35 feet bgs)
Pemaco Superfund Site, Maywood, California

Criterion	REMEDIAL ALTERNATIVES					
	SP1 - No Action	**SP2a – High-Vacuum Dual-Phase Extraction/ Ultraviolet Oxidation/Flameless Thermal Oxidation/Granular Activated Carbon**	**SP2b – High-Vacuum Dual-Phase Extraction/ Ultraviolet Oxidation/ Granular Activated Carbon**	**SP3 – *In-Situ* Chemical Oxidation**	**SP4 – Enhanced *In-Situ* Bioremediation**	**SP5 – Monitored Natural Attenuation**
1. Overall Protection of Human Health and the Environment	• The no action alternative is a baseline for comparing other alternatives, per the NCP. • Upper vadose zone soils (3 to 35 ft bgs) and perched groundwater contain chlorinated VOCs, PAHs and BTEX at concentrations above the EPA Region IX PRGs (soil) and California MCLs, (groundwater). • The COCs are characteristically persistent in the environment and are not expected to naturally attenuate in a reasonable timeframe. • Under no action, pathways for human exposure to contaminated soil via inhalation, ingestion, or dermal contact would exist during site redevelopment activities (e.g., construction workers, fugitive dust to neighboring residences). • Pathway for human exposure to contaminated groundwater may eventually exist if groundwater contamination spreads towards domestic production wells. • Because no remedial activities would be implemented, human health and environmental risks would remain the same as those identified in Section 1.8 – Baseline Risk Assessment.	• HVDPE in the upper vadose/perched groundwater zone would effectively eliminate potential exposure to contaminated soils (via inhalation, ingestion, or dermal contact to future construction workers) and contaminated groundwater (via migration of COCs in groundwater to domestic production wells) through a reduction in COCs over time. • A fenced and covered treatment compound would eliminate public access to the treatment system. • Extracted groundwater would require *ex-situ* treatment via UV oxidation. A properly designed UV oxidation treatment system is protective of human health and the environment for the removal of all VOC COCs. • Extracted soil vapor would require *ex-situ* treatment via FTO for the first year of operation followed by GAC. FTO is the most effective thermal treatment technology available and is capable of handling the initial high mass loading expected from the HVDPE. • Assumes that prior to implementing GAC, low molecular weight VOCs (vinyl chloride) and/or COCs with low adsorptive capacity (1,4-dioxane), which cannot be effectively treated by GAC, will be significantly reduced during the first year. • Properly designed FTO and GAC treatment systems are protective of human health and the environment for the destruction of most organic contaminants. • Treatment compound must be adequately secured, maintained, and monitored to prevent leaks and creation of exposure pathways. • All treatment systems require routine monitoring and maintenance to assure effective capture of contaminants in accordance with discharge permits. • All used carbon eventually needs to be disposed in landfills.	• HVDPE in the upper vadose/ perched groundwater zone would effectively eliminate potential exposure to contaminated soils (via inhalation, ingestion, or dermal contact to future construction workers) and contaminated groundwater (via migration of COCs in groundwater to domestic production wells) through a reduction in COCs over time. • A fenced and covered treatment compound would eliminate public access to the treatment system. • Extracted groundwater would require *ex-situ* treatment via UV oxidation. A properly designed UV oxidation treatment system is protective of human health and the environment for the removal of all VOC COCs. • Extracted soil vapor would be treated at the surface via GAC. A properly designed GAC treatment system is protective of human health and the environment for the removal of most organic contaminants from the effluent stream. • Close monitoring of GAC system influent and effluent, especially with respect to low molecular weight VOCs (vinyl chloride) and/or COCs with low adsorptive capacity (1,4-dioxane) is required to ensure the system is protective of human health and the environment. • Treatment compound must be adequately secured, maintained, and monitored to prevent leaks and creation of exposure pathways. • Both treatment systems require routine monitoring and maintenance to assure effective capture of contaminants in accordance with discharge permits. • All used carbon eventually needs to be disposed in landfills.	• The *in-situ* chemical oxidation alternative would reduce contaminant toxicity in groundwater, reducing the potential exposure pathway of COCs in groundwater via migration to domestic production wells. • ISCO would only provide a partial treatment solution to the upper vadose zone soil and perched groundwater zone, because ISCO is not recommended for *in-situ* treatment of soil (difficulty in dispersing oxidants). As such, potential pathways for exposure via inhalation, ingestion, or dermal contact to future construction workers are not eliminated.	• The enhanced *in-situ* bioremediation alternative would reduce contaminant toxicity in groundwater, reducing the potential exposure pathway of COCs in groundwater via migration to domestic production wells. • EISB is not recommended for *in-situ* treatment of soil since the mechanics of substrate delivery are unproven and groundwater is required to assist with dispersion. EISB would provide only a partial treatment solution to the upper vadose zone soil and perched groundwater zone. As such, the potential pathways for exposure via inhalation, ingestion, or dermal contact to future construction workers are not eliminated.	• MNA may result in reduced contamination; however, remediation of this zone through attenuation and degradation processes would be expected to take 50+ years. • In conjunction with an effective source treatment alternative, MNA is protective of human health and the environment by restoring groundwater quality along plume fringes towards that of drinking water standards over time.

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2. Compliance With ARARs and TBCs	• Would not meet remedial action objectives. • Potential exposure pathways would exist for future excavation workers (via dermal contact, inhalation, and ingestion) and for community residents (via migration of COCs to viable aquifers).	• Directly addresses groundwater and soil contamination, and hence, is expected to achieve remedial objectives and would be generally compliant with ARARs and TBCs. • Monitoring of remediation area required to assure compliance with ARARs and TBCs. • The treatment processes would have to comply with water discharge and air emission standards. • *Ex-situ* treatment of groundwater via UV Oxidation would comply with all ARARs and TBCs discharge requirements. • *Ex-situ* treatment of vapor via FTO and GAC is capable of exceeding all ARARs and TBCs discharge requirements. • Engineering controls would be established to manage any residuals associated with the FTO and GAC treatment systems in accordance with requirements for treatment, storage, and disposal of solid wastes/used carbon. • A discharge gas scrubber would most likely be required to reduce acid gas emissions from the FTO.	• Directly addresses groundwater and soil contamination, and hence, is expected to achieve remedial objectives and would be generally compliant with ARARs and TBCs. • Monitoring of remediation area required to assure compliance with ARARs and TBCs. • The treatment processes would have to comply with water discharge and air emission standards. • *Ex-situ* treatment of groundwater via UV Oxidation would comply with all ARARs and TBCs discharge requirements. • *Ex-situ* treatment of vapor via GAC capacity would likely result in non-compliance with ARARs and/or TBCs (i.e., discharge requirements) due to the presence of low molecular weight VOCs such as vinyl chloride or COCs with low adsorptive capacity such as 1,4 dioxane. These compounds have been detected at elevated concentrations within this zone. Consequently they must be monitored carefully; or if in high enough concentrations, a treatment alternative other than GAC should be used in order to be protective of the environment. • Engineering controls would be established to meet associated requirements for treatment, storage, and disposal of used carbon.	• Reduction of COCs would eliminate groundwater exposure pathways, thereby complying with groundwater ARARs and TBCs. • Will not achieve subsurface soil TBCs. • Monitoring of remediation area required to assure compliance with chemical-based ARARs and TBCs.	• Degradation of chlorinated VOCs would eliminate groundwater exposure pathways, thereby complying with groundwater ARARs and TBCs. • Will not achieve subsurface soil TBCs. • Monitoring of bioremediation area required to assure compliance with ARARs and TBCs.	• MNA would not actively address upper vadose soil zone/perched groundwater zone, although natural attenuation may eventually result in general compliance with groundwater ARARs/TBCs (although this could take many years). • Would not address subsurface soil remedial objectives. Subsurface soil ARARs and TBCs would not be met because subsurface soil contaminants would not be mitigated.

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3. Long-Term Effectiveness And Permanence	• Because no remedial activities would be implemented, there would be no reduction in risk. The potential pathways for human exposure would remain.	• Long-term effectiveness (for meeting RAOs) would be achieved because HVDPE proactively removes and treats COCs. • Removal of contaminants within the perched groundwater zone and upper vadose zone from the Site would be permanent. • HVDPE process consists of generally conventional and well- proven technologies and is expected to be highly reliable when adequately operated and maintained. • UV oxidation is a well proven and effective method of treatment over time when adequately operated and maintained. • The effectiveness of UV oxidation is dependent on the aqueous stream being able to transmit UV light; i.e., low turbidity and metal ions < 10 mg/L. • Pretreatment of the influent can minimize cleaning and maintenance of the UV reactor and ensure an effective method of treatment over time. • FTO is a highly effective treatment process for the destruction of all VOCs. Contaminants are permanently destroyed on-site through FTO. • Carbon adsorption is a well-proven and effective method of treatment over time when adequately operated and maintained; however, permanent destruction of the COCs would take place at an off-site approved facility. Assumes that prior to implementing GAC, low molecular weight VOCs (vinyl chloride) and/or COCs with low adsorptive capacity (1,4-dioxane), which cannot be effectively treated by GAC, will be significantly reduced during the first year. • Routine monitoring of the treatment process would be performed to assure effectiveness over time.	• Long-term effectiveness (for meeting RAOs) would be achieved because HVDPE proactively removes and treats COCs. • Removal of contaminants within the perched groundwater zone and upper vadose zone from the Site would be permanent. • HVDPE process consists of generally conventional and well- proven technologies and is expected to be highly reliable when adequately operated and maintained. • UV oxidation is a well proven and effective method of treatment over time when adequately operated and maintained. • The effectiveness of UV oxidation is dependent on the aqueous stream being able to transmit UV light; i.e., low turbidity and metal ions < 10 mg/L. • Pretreatment of the influent can minimize cleaning and maintenance of the UV reactor and ensure an effective method of treatment over time. • Carbon adsorption is a well proven and effective method of treatment over time when adequately operated and maintained. • COCs are adsorbed by the carbon; however, permanent destruction of the COCs would take place at an off-site approved facility. • Carbon adsorption is not as effective on low molecular weight VOCs such as vinyl chloride or COCs with low adsorptive capacity such as 1,4 dioxane. • Routine monitoring of the treatment process would be performed to assure effectiveness over time.	• *In-situ* chemical oxidation would permanently remove COCs and expedite natural attenuation of remaining site contaminants. • Monitoring of the remediation area required to assure long-term effectiveness over time. • Long-term effectiveness dependent on success of each injection event (3 injection events proposed with a 1 month period between events). • Pilot test recommended to confirm site characteristics. • Chemical oxidation is a well-developed, increasingly used process that has proven effective for the destruction of many of the VOCs present in the perched groundwater.	• Enhanced *in-situ* bioremediation would expedite natural attenuation of chlorinated VOCs. • Not effective for treating compounds (e.g., benzene, toluene) that biodegrade under aerobic conditions; would have to address these compounds aerobically before or after reductive dechlorination. • Monitoring of the remediation area required to assure effectiveness over time. ▪ Design is for one-time application of HRC; the need for reapplication will depend on actual site-specific biodegradation performance. ▪ Pilot test recommended to confirm site characteristics.	• Effectiveness of natural attenuation in restoring subsurface soil and groundwater quality to RAOs in a reasonable timeframe without a pro-active technology is not likely. • Long-term effectiveness and permanence of other alternatives, however, may be documented by monitored natural attenuation.

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4. Reduction of Toxicity, Mobility or Volume (TMV) through Treatment	• There would be no treatment and thus no reduction in TMV.	• HVDPE allows for good control over contaminant mobility and a reduction in contaminant volume for both soil and groundwater. • UV oxidation required during treatment process, because it is effective in treatment of 1,4-dioxane. • Estimated volume of soil exceeding TBCs is approximately 80,000 to 95,000 cubic yards; estimated volume of groundwater exceeding ARARs is approximately 1.4 million gallons. • Extracted water and vapor would require treatment via *ex-situ* treatment alternatives UV Ox, FTO, and GAC. • UV oxidation is a very effective treatment method for reducing the TMV of almost all organic contaminants. All COCs would be completely destroyed on-site with no residual wastes to manage. • FTO locally destroys contaminants resulting in a permanent reduction in TMV of COCs. The generation of acid gasses in the effluent stream of the FTO can be controlled through the operation of a scrubber. • The mobility and volume of COCs are greatly reduced as they become adsorbed to the GAC. Toxicity is not reduced on-site but is typically performed at the disposal facility via thermal oxidation. Carbon that has exceeded its useful lifespan would be transported for off-site regeneration or landfilling. • Some degradation products, such as vinyl chloride and smaller molecules (e.g., 1,4 dioxane) are not adsorbed well. Consequently they must be monitored carefully to be sure the TMV of these contaminants are being addressed.	• HVDPE allows for good control over contaminant mobility and a reduction in contaminant volume for both soil and groundwater. • UV oxidation required during treatment process, because it is effective in treatment of 1,4-dioxane. • Estimated volume of soil exceeding TBCs is approximately 80,000 to 95,000 cubic yards; estimated volume of groundwater exceeding ARARs is approximately 1.4 million gallons. • Extracted water and vapor would require treatment via *ex-situ* treatment alternatives UV Ox and GAC. • UV oxidation is a very effective treatment method for reducing the TMV of almost all organic contaminants. All COCs would be completely destroyed on-site with no residual wastes to manage. • The mobility and volume of COCs are greatly reduced as they become adsorbed to the GAC. • Toxicity is not reduced on-site but is typically performed at the disposal facility via thermal oxidation. • Carbon that has exceeded its useful lifespan would be transported for off-site regeneration or landfilling. • Some degradation products, such as vinyl chloride and smaller molecules (e.g., 1,4 dioxane) are not adsorbed well. Consequently they must be monitored carefully to be sure the TMV of these contaminants are being addressed.	• Fenton's reagent (most aggressive oxidant available) is expected to reduce toxicity of contaminants in groundwater. The mobility and volume of contamination will also be reduced by this alternative. • The TMV of upper vadose zone soils would not be reduced by *in-situ* chemical oxidation because there is no conventional method available to adequately distribute the oxidation reagent though the soil. • Estimated treatment area is 168,000 square feet; approximate thickness would include entire perched groundwater zone (2 to 3 ft). • Because of physical limitations of delivery of electron donors in the heterogeneous subsurface, there will likely be areas of contamination that remain.	• HRC has proven to reduce toxicity of chlorinated VOCs into harmless compounds over time. The mobility and volume of chlorinated VOCs will also be reduced by this alternative. • Not effective for treating compounds (e.g., benzene, toluene) that biodegrade under aerobic conditions; would have to address these compounds aerobically before or after reductive dechlorination. • The TMV of upper vadose zone soils would not be reduced by *in-situ* bioremediation. • Estimated treatment area is 168,000 square feet; approximate thickness would include perched groundwater zone (2 to 3 ft). • Because of physical limitations of delivery of substrates in the heterogeneous subsurface, there will likely be areas of contamination that remain. • Incomplete dechlorination may result in proliferation of daughter products (e.g., vinyl chloride, DCE).	• MNA is a not an *active* treatment alternative and is therefore not considered effective in reduction of TMV. • MNA may result in reduced TMV in both media of this remediation zone through attenuation and degradation processes, but not within a reasonable timeframe. • Purge water from semiannual monitoring events would be produced that would require treatment prior to disposal. • Estimated volume of soil exceeding TBCs is approximately 80,000 to 95,000 cubic yards; estimated volume of groundwater exceeding ARARs is approximately 1.4 million gallons.

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5. Short-term Effectiveness	• There would be no treatment and thus no short-term effectiveness. • Since there would be no remedial activities, there would be no resulting short-term risks to remedial construction workers, the community, or the environment.	• Air emissions from vapor treatment would comply with air emission standards. • Risks to workers performing remedial and monitoring activities can be controlled and mitigated with proper health and safety measures (e.g. air monitoring, PPE). • Estimated project duration is 5 years + 5 additional years of monitoring; RAOs will likely be met. • The UV oxidation requires that caustic oxidants be stored at the treatment facility. Risks to workers from oxidant storage and handling and from monitoring activities can be controlled and mitigated with proper health and safety measures; e.g., air monitoring and PPE. • Due to the high effectives of FTO, the production of combustion by-products (e.g. dioxin) above background concentrations is unlikely. • Evaluation of the air emissions may be required to demonstrate no significant impact to the community from combustion by-products. • Transportation of used carbon to an off-site facility for regeneration or disposal would encounter hazardous waste manifesting issues and increase local traffic. • Risks to workers performing monitoring activities of both treatment systems can be controlled and mitigated with proper health and safety measures; e.g., air monitoring and PPE.	• Air emissions from vapor treatment would comply with air emission standards. • Risks to workers performing remedial and monitoring activities can be controlled and mitigated with proper health and safety measures (e.g. air monitoring, PPE). • Estimated project duration is 5 years + 5 additional years of monitoring; RAOs will likely be met. • The UV oxidation requires that caustic oxidants be stored at the treatment facility. Risks to workers from oxidant storage and handling and from monitoring activities can be controlled and mitigated with proper health and safety measures; e.g., air monitoring and PPE. • Transportation of used carbon to an off-site facility for regeneration or disposal would encounter hazardous waste manifesting issues and increase local traffic. • Risks to workers performing monitoring activities of both treatment systems can be controlled and mitigated with proper health and safety measures; e.g., air monitoring and PPE.	• Nature of alternative does not require *ex-situ* engineering controls or treatment options. • Risks to workers performing remedial and monitoring activities can be controlled and mitigated with proper health and safety measures (e.g. air monitoring, PPE). • Estimated project duration is 1 year plus a minimum of 5 years of monitoring; RAOs may not be met in all subsurface areas (delivery of electron donors).	• Nature of alternative does not require *ex-situ* engineering controls or treatment options. • Risks to workers performing remedial and monitoring activities can be controlled and mitigated with proper health and safety measures (e.g. air monitoring, PPE). • Estimated project duration is 1 year plus a minimum of 5 years of monitoring; RAOs may not be met (delivery of oxidants).	• No additional risks beyond those posed by current conditions. • Risks to workers performing monitoring activities are relatively minimal and can be controlled and mitigated with proper health and safety measures (e.g. PPE). • Estimated project duration is 50+ years, RAOs will likely not be met.

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6. Implementability	• There would be no technical, administrative, or other impediments to implementability.	• HVDPE process consists of generally conventional, well proven, and implementable technologies and is expected to be highly reliable when adequately operated and maintained. Personnel, equipment, and materials generally available for implementation/operation of HVDPE. • Groundwater monitoring would indicate effectiveness of HVDPE as well as the status of the contaminant plume. System modifications may be added if warranted based on performance/monitoring data. • Administrative requirements, such as discharge permits for treated vapor and groundwater are all feasible. • Disruption of portion of MRP for approximate 2-month period during implementation. • UV oxidation is an established technology with sufficient vendors and no unusual technical problems anticipated. Consideration should be given to the turbidity and hardness of the aqueous stream, which can interfere with the oxidation process. This alternative is administratively feasible since state and local agency permits are routinely issued. The system can be modified or improved based on treatment results; e.g., prefiltration to combat fouling of the quartz sleeves, which transmit UV light • FTO is a relatively new technology with few vendors; however, use of the technology is well documented and no unusual technical problems would be expected. The technology is anticipated to be administratively feasible since similar systems have been operating in the SCAQMD since 1998 and the system does not have measurable emissions of dioxin – a by-product of combustion. No modifications are anticipated. • Carbon treatment is a mature and very reliable technology with many vendors. No unusual technical problems are anticipated. • The UV, FTO, and GAC systems require occupation of a small area of the MRP until the cleanup objectives are reached. Operation and maintenance personnel, materials, and utilities are readily available or in place for ex situ treatment systems since they have been previously operated at the site.	• HVDPE process consists of generally conventional, well proven, and implementable technologies and is expected to be highly reliable when adequately operated and maintained. • Personnel, equipment, and materials generally available for implementation/operation of HVDPE. • Groundwater monitoring would indicate effectiveness of extraction and treatment as well as the status of the contaminant plume. System modifications may be added if warranted based on performance/monitoring data. • Administrative requirements, such as discharge permits for treated vapor and groundwater are all feasible. • Disruption of portion of MRP for approximate 2-month period during implementation. • UV oxidation is an established technology with sufficient vendors and no unusual technical problems anticipated. Consideration should be given to the turbidity and hardness of the aqueous stream, which can interfere with the oxidation process. This alternative is administratively feasible since state and local agency permits are routinely issued. The system can be modified or improved based on treatment results; e.g., prefiltration to combat fouling of the quartz sleeves, which transmit UV light. • Carbon treatment is a mature and very reliable technology with many vendors. No unusual technical problems are anticipated. Operation and maintenance personnel, materials, and utilities are readily available. This alternative is administratively feasible since state and local agency permits are routinely issued. The system can be modified or improved based on treatment results. • The UV and GAC systems require occupation of a small area of the MRP until the cleanup objectives are reached. Operation and maintenance personnel, materials, and utilities are readily available or in place for ex situ treatment systems since they have been previously operated at the site.	• Modifications to the system may be warranted based on system performance/monitoring data (e.g., additional injection events). • Groundwater monitoring would provide indication of effectiveness of groundwater treatment and status of contaminant plume. • Personnel, equipment, and materials generally available for implementation/operation of *in-situ* chemical oxidation. • Pilot test needed to establish suitability of method and to obtain additional design information. • Administratively feasible; injection permits required from appropriate state and local agencies. • Disruption of portion of MRP for approximate 2-month period.	• Modifications to the system may be warranted based on system performance/monitoring data (e.g., additional injection events). • Groundwater monitoring would provide indication of effectiveness of groundwater treatment and status of contaminant plume. • Personnel, equipment, and materials generally available for implementation/operation of *in-situ* bioremediation. • Pilot test needed to establish suitability of method and to obtain additional design information. • Administratively feasible; injection permits required from appropriate state and local agencies. • Disruption of portion of MRP for approximate 2-month period.	• Technically feasible. Modifications, such as additional monitoring wells, can be easily implemented with a minimal amount of disturbance to the MRP. • Groundwater monitoring would provide indication of status of contaminant plume. • Personnel, equipment, and materials generally available for implementation/operation of MNA. • Administratively feasible.

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7. Estimated Cost[1]						
Direct Capital Cost	$0	$1,431,000	$906,000	$1,850,000	$1,010,000	$131,000
Annual O&M Cost	$0	$488,000	$595,000	$133,000	$140,000	$112,000
O&M Present Worth	$0	$2,230,000 (5 yr term at 4.25% interest for O&M; 5 yr. term at 5.0% for additional monitoring)	$2,700,000 (5 yr term at 4.25% interest for O&M; 5 yr. term at 5.0% for additional monitoring)	$691,000 (6 yr term at 4.25% interest)	$726,000 (6 yr term at 4.25% interest)	$2,301,000 (50 yr term at 4.25% interest)
Total Present Worth	$0	$3,659,000	$3,608,000	$2,540,000	$1,735,000	$2,432,000
8. State and Support Agency Acceptance	• U.S. EPA representatives have indicated that remedial action is favored and No Action would not meet state acceptance.	• Statewide acceptance under CalEPA on numerous projects. • SCAQMD approval of discharge permits would be required. • Further comments will be addressed in the ROD after public comment period.	• Statewide acceptance under CalEPA on numerous projects. • SCAQMD approval of discharge permits would be required. • Further comments will be addressed in the ROD after public comment period.	• Statewide acceptance under CalEPA on numerous projects. • Further comments will be addressed in the ROD after public comment period.	• Statewide acceptance under CalEPA on numerous projects. • Further comments will be addressed in the ROD after public comment period.	• Statewide acceptance under CalEPA on numerous projects if combined with source treatment. • Generally accepted as a “containment alternative”. • Further comments will be addressed in the ROD after public comment period.
9. Community Acceptance	• The City of Maywood representatives have indicated that remedial action is favored and No Action would not meet community acceptance.	• To be determined during public comment period. • Certain members of public opposed thermal vapor abatement associated with operation of SVE system in 1999. • System would be operated aboveground leading to potential conflicts with future park activities. • Further comments will be addressed in the during the public comment period.	• To be determined during public comment period. • Certain members of public opposed thermal vapor abatement associated with operation of SVE system in 1999. • System would be operated aboveground leading to potential conflicts with future park activities. • Further comments will be addressed in the during the public comment period.	• To be determined during public comment period.	• To be determined during public comment period.	• To be determined during public comment period.

1. Cost estimates and present worth values are rounded to three significant figures. Refer to Appendix H for a detailed analysis of capital estimates, operation and maintenance cost estimates, and present worth assumptions. Cost estimates are considered order-of-magnitude with an expected accuracy of plus 50 to minus 30 percent.