REFINING AREAS OF IMPAIRMENT AND ASSESSING DELETERIOUS EFFECTS TO AQUATIC LIFE

DUTCH HARBOR
ILIULIUK HARBOR

Unalaska, Alaska

FINAL
February 2009

Prepared for:

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ACRONYMS AND ABBREVIATIONS

AAC............... Alaska Administrative Code
ADEC .... Alaska Department of Environmental Conservation
BTEX............. benzene, toluene, ethylbenzene, xylenes
CWA.............. Clean Water Act
EC_{50}............... half maximal effective concentration
EPA............... Environmental Protection Agency
IDW............... investigation-derived waste
LC_{50}............... median lethal concentration
µg/kg .... micrograms per kilogram
µg/L............... micrograms per liter
mg/d .... milligrams per day
ml .... milliliter
OASIS .... OASIS Environmental, Inc.
PAHs............. polynuclear aromatic hydrocarbons
PEL .... probable effects level
QC................. quality control
RCRA............ Resource Conservation and Recovery Act
RPD............... relative percent difference
TAH............... total aromatic hydrocarbons
TAqH............. total aqueous hydrocarbons
TBT .... tributyltin
TEL................ threshold effects level
TMDL .... total maximum daily load
TOC............... total organic carbon

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EXECUTIVE SUMMARY

OASIS Environmental, Inc. performed an assessment for the Alaska Department of Environmental Conservation (ADEC) in September 2008 to refine areas of impairment and assess deleterious effects to aquatic life for Dutch Harbor and Iliuliuk Harbor. The assessment included collection of four surface water samples, three storm water samples, 47 surface sediment samples, 11 sediment core samples, and three bulk sediment samples. Analytical results show that surface water and subtidal sediment in Margaret Bay are not impacted with petroleum hydrocarbons. Storm water does not appear to be a contributing factor to sediment contamination near the Former Submarine Base/Ship Repair Facility and UniSea, but it may be influencing sediment contamination at the top of Dutch Harbor. The surface sediment samples confirmed and provided further delineation for the six priority areas of impairment, which tend to be located near active docks and harbors. The core sediment samples showed that for most locations in Dutch Harbor and Iliuliuk Harbor the impact from polycyclic aromatic hydrocarbons (PAHs) is limited to the first few inches of surface sediment. Bioassay results indicated that survival, development, and growth of aquatic life were not affected at three bulk sediment sample locations, although the three samples represent too small of a data set to draw definitive conclusions regarding sediment toxicity for Iliuliuk Harbor and Dutch Harbor. The bioassay data should be considered as cursory information.

The findings from this assessment, combined with the previous two assessments, provide an adequate baseline of impact from petroleum hydrocarbons in Dutch Harbor and Iliuliuk Harbor. Only two clauses of water quality criteria from 18 Alaska Administrative Code 70 remain in question for attainment of the water bodies: 1) petroleum hydrocarbons, animal fats, or vegetable oils may not cause a film, sheen, or discoloration on the floor of the water body, and 2) there may be no concentrations of petroleum hydrocarbons, animal fats, or vegetable oils in shoreline or bottom sediments that cause deleterious effects to aquatic life. The latter standard appears to have been met during this current assessment based on the results of bioassay tests; however, as previously noted, the sample program was too small to conclude a finding of attainment for this standard based on only three data points. In addition, regardless of the bioassay results, approximately one-half of the sediment samples had visible sheening and thus exceeded the first water quality standard. Therefore, Dutch Harbor and Iliuliuk Harbor are still considered impaired by the ADEC.

The main recommendation for ADEC to consider is development of a Total Maximum Daily Load (TMDL) to address the first standard in question and meet ADEC's legal obligation under the Clean Water Act. Implementation of the TMDL should include a meeting of local stakeholders to develop uniform best management practices for docks and harbors in the impaired water bodies for the purpose of further reducing inputs of petroleum hydrocarbons. Other recommendations to consider include additional bioassay tests, analysis of storm water at the top of Dutch Harbor and other locations that were not assessed during this investigation, and a determination from the

Contaminated Sites program as to whether an additional investigation is needed for the Former Submarine Base/Ship Repair Facility.

ACKNOWLEDGEMENTS

The Alaska Department of Environmental Conservation would like to acknowledge the following individuals and organizations that assisted in the completion of this project.

- Byron Singley for coordinating charter services and commanding the *Nancy Ellen*,
- Paul Wayner for serving as first mate on the *Nancy Ellen*,
- Jeff Hancock for operating the skiff,
- City of Unalaska for discussing project objectives,
- Ounalashka Corporation for discussing project objectives,
- Air Cargo Express for shipping and delivering field gear,
- Pen Air for transporting samples and field personnel,
- Kinnetic Laboratories Inc., for providing technical support and laboratory analysis of toxicity samples, and
- The OASIS sampling team and project manager, Ben Martich.

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1. INTRODUCTION

Under Notice-to-Proceed No. 18-2011-26-9, the Alaska Department of Environmental Conservation (ADEC) tasked OASIS Environmental, Inc. (OASIS) to refine areas of impairment and assess deleterious effects to aquatic life from petroleum hydrocarbon contamination in Dutch Harbor and Iliuliuk Harbor near Unalaska Island and Amaknak Island, Alaska (Figure 1). These water bodies are identified as impaired as a result of contamination from petroleum hydrocarbons. This report presents information regarding water and sediment quality conditions for the impaired water bodies. Figure 2 shows the water bodies under investigation and surrounding features.

1.1. Background

In 1990, ADEC listed Iliuliuk Bay and Iliuliuk Harbor as impaired water bodies under the Federal Clean Water Act (CWA) Section 303(d) for petroleum hydrocarbon pollution exceeding state water quality standards of 18 Alaska Administrative Code (AAC) 70. Dutch Harbor also was added to the 303(d) list in 1994 for petroleum hydrocarbon pollution. The 303(d) listings were based on observed sheens and reports of numerous petroleum spills in the water bodies. The observed sheens caused violations of the water quality standard from 18 AAC 70.020(b)(5), which states in various forms that petroleum hydrocarbons "may not cause a visible sheen on the surface of the water."

Although extensive visible sheens no longer exist in the study area, all three water bodies remain on the 303(d) list as presented in the most recent ADEC water quality report, *Alaska's Final 2008 Integrated Water Quality Monitoring & Assessment Report* (ADEC 2008). By mandate of the CWA, Section 303(d)(1)(C), the Environmental Protection Agency (EPA) or ADEC must enact one of the following actions for an impaired water body:

- Complete a Total Maximum Daily Load (TMDL).
- Provide evidence that a water body is not impaired.
- Demonstrate that other controls are in place that will bring a water body back into compliance with state water quality standards.

ADEC conducted a TMDL study in 2006 and a baseline water quality assessment in April 2007. An additional assessment in September 2007 identified six priority areas of sediment impairment. Based on the findings from these assessments, Iliuliuk Bay does not appear to be impacted by petroleum hydrocarbons. ADEC is addressing the de-listing of Iliuliuk Bay from the 303(d) list separate from this project.

1.2. Previous Investigations

This subsection details the findings from previous assessments of the study area.

1.2.1. TMDL Study

In 2006, ADEC conducted a water quality information analysis of Dutch Harbor, Iliuliuk Bay, and Iliuliuk Harbor (OASIS 2006). The objectives of the study included evaluating available information for petroleum pollution in the study area; defining the current areas of impairment; identifying data gaps in the understanding of the impairment; and recommending a process for development of a TMDL or alternative approach.

The study identified six sources of existing or potential petroleum pollution: contaminated sites, spills, storm water, seafood processors, petroleum bulk storage and transfer facilities, and docks and harbors. In addition, contaminated sediments were identified as a contributing factor to potential water quality impairment. These sources were ranked based on the risk each posed to future water quality. Bulk storage and transfer facilities was the only source ranked as having a high risk, but the risk was identified as a potential one because no documented release of petroleum to water has occurred from this group. The other sources were identified as existing causes of petroleum pollution with contaminated sites, spills, docks and harbors, and contaminated sediments equally ranked as most threatening to future water quality.

Based on this analysis of sources, the study identified three physical areas most at risk in the study area for having potential water quality impairment from dissolved-phase petroleum pollutants and contaminated sediments:

- Rocky Point from the airport past the APL Dock
- The top of Dutch Harbor between Ballyhoo Spit and the coast of Amaknak Island
- The coastline of Iliuliuk Harbor

The study recommended the development of an alternative approach for water quality attainment instead of a TMDL. The development of a TMDL was excluded because the allocation of petroleum loads to contaminated sites, spills, and contaminated sediments was deemed not feasible. The alternative approach outlined in the report was based on the EPA's recommended guidelines for a water body recovery plan and consisted of two main components: water quality monitoring and increased management of petroleum sources in the study area.

The subsequent April 2007 water quality assessment initiated the water quality monitoring component of the alternative approach.

1.2.2. April 2007 Water Quality Assessment

In April 2007, ADEC performed a baseline water quality assessment of Dutch Harbor, Iliuliuk Bay, and Iliuliuk Harbor (OASIS 2007a). The assessment included the collection of 71 water samples at 39 locations, collection of discrete sediment samples at ten locations, and collection of incremental composite sediment samples within five regions. The assessment focused on the three areas identified as most at risk in the TMDL analysis. The assessment also included field observations of personal harvest activities and sources of petroleum pollution within the project's study area. The significant findings from the baseline assessment included the following:

- The waters of Dutch Harbor, Iliuliuk Bay, and Iliuliuk Harbor met numeric water quality standards for total aromatic hydrocarbons (TAH) and total aqueous hydrocarbons (TAqH) in all 71 water samples collected, although concentrations of TAH and TAqH were detected in ten and three samples, respectively.

- The presence of polycyclic aromatic hydrocarbons (PAHs) in the sediments of Dutch Harbor, Iliuliuk Bay, and Iliuliuk Harbor appears to be ubiquitous. All sediment samples had detectable concentrations for a majority of PAHs, many of which were above Threshold Effects Levels (TELs) and Probable Effects Levels (PELs) from Screening Quick Reference Tables (Buchman 1999). However, the ubiquitous presence of PAHs in sediments does not appear to be significantly impacting water quality based on the analytical results of water samples. The most impacted sediments are located in Iliuliuk Harbor and the top of Dutch Harbor.
- Field observations of the potential sources of petroleum pollution in the study area identified three sheens: two near seafood processors and one near a dock.

The report recommended focusing on more narrowly defined priority areas within the three areas identified in the TMDL analysis. The recommendations also included the collection of water samples from the former Submarine Base/Ship Repair Facility, Small Boat Harbor, UniSea, Front Beach, Coastal Transportation Dock, tip of Rocky Point, and top of Dutch Harbor, and the collection of discrete sediment samples from Iliuliuk Harbor, the top of Dutch Harbor, and around the Delta Western dock.

1.2.3. September 2007 Water Quality Assessment

In September 2007, ADEC conducted a second water quality assessment of Dutch Harbor, Iliuliuk Bay, and Iliuliuk Harbor (OASIS 2008a). The assessment included collection of 36 water samples and 51 sediment samples at discrete locations that were collected mostly from priority areas identified during the April 2007 assessment. The assessment also included field observations of personal harvest activities and sources of petroleum pollution within the project's study area. The significant findings of the second assessment included the following:

- The waters of Dutch Harbor, Iliuliuk Bay, and Iliuliuk Harbor again met numeric water quality standards for TAH and TAqH in all 36 water samples collected.
- All but one of the 51 sediment samples had detectable concentrations for multiple PAH compounds. Thirty-seven (37) locations had at least one compound that exceeded a TEL benchmark for sediment quality, and 14 of the samples had at least one compound that exceeded a PEL benchmark. Of the 21 sediment samples that exceeded TEL or PEL benchmarks for total PAHs, 20 of them were locations either in Iliuliuk Harbor or the top of Dutch Harbor.
- One sheen was observed during assessment activities along a vessel that was at the APL Dock.

Report recommendations included excluding additional water sampling because numeric water quality standards for TAH and TAqH have been met for all 107 primary samples collected during the two water quality assessments; increasing sediment sample density in the priority areas of impairment to better understand sources and extent; adding sediment depth sampling to profile concentrations of PAHs; sampling storm water to understand whether this point source is contributing to the impairment; assessing Margaret Bay; and performing bioassays of sediment to better understand whether documented concentrations of PAHs are having a deleterious effect to aquatic life.

1.3. Scope of Work

The objectives of this assessment for Dutch Harbor and Iliuliuk Harbor included the following:

- Evaluate water and sediment quality data for petroleum pollutants in Margaret Bay.
- Evaluate the contribution of petroleum pollutants in storm water to the priority areas of impairment.
- Refine the priority areas of impairment for petroleum pollutants in sediment.
- Profile petroleum pollutants at the surface and a depth of 1 foot for select locations in the priority areas of impairment.
- Evaluate sediment toxicity by analysis of chronic and acute bioassay tests.

The objectives were met by employing the rationale, methodology, and analysis described in Section 2.

1.4. Regulatory Framework

Alaska water quality standards and the degree of degradation that may not be exceeded are contained in 18 AAC 70, *Water Quality Standards*, and its supporting document *Alaska Water Quality Criteria Supporting for Toxic and Other Deleterious Organic and Inorganic Substances*. Table 1 outlines water use classes, subclasses, and petroleum hydrocarbon standards for marine water bodies.

Table 1: Water Use Classes and Standards

Marine Water Use Class and Subclass	Petroleum Hydrocarbon Standard
Water Supply – Aquaculture	TAqH in the water column may not exceed 15 µg/L. TAH in the water column may not exceed 10 µg/L. There may be no concentrations of petroleum hydrocarbons, animal fats, or vegetable oils in shoreline or bottom sediments that cause deleterious effects to aquatic life. Surface waters and adjoining shorelines must be virtually free from floating oil, film, sheen, or discoloration.
Water Supply – Seafood Processing	May not cause a film, sheen, or discoloration on the surface or floor of the water body or adjoining shorelines. Surface waters must be virtually free from floating oils. May not exceed concentrations that individually or in combination impart odor or taste as determined by organoleptic tests.
Water Supply – Industrial	May not make the water unfit or unsafe for the use.
Water Recreation – Contact Recreation and Secondary Recreation	May not cause a film, sheen, or discoloration on the surface or floor of the water body or adjoining shorelines. Surface waters must be virtually free from floating oils.
Growth and Propagation of Fish, Shellfish, Other Aquatic Life, and Wildlife	Same as *Water Supply – Aquaculture*
Harvesting for Consumption of Raw Mollusks or Other Raw Aquatic Life	May not exceed concentrations that individually or in combination impart undesirable odor or taste to organisms as determined by bioassay or organoleptic tests.

ADEC has not promulgated any sediment quality standards; however, the Contaminated Sites Remediation Program has issued the technical memorandum *Sediment Quality Guidelines* (ADEC 2004) in which the use of TELs and PELs from Screening Quick Reference Tables (Buchman 1999) are recommended for evaluating sediment quality. TELs represent the concentration below which adverse effects are expected to occur only rarely. PELs represent the concentration above which adverse effects are expected to occur frequently. Table 2 lists the applicable TELs and PELs for this project.

Table 2: TELs and PELs

Compound	TELs (µg/kg)	PELs (µg/kg)
2-Methylnaphthalene	20.21	201.28
Acenaphthene	6.71	88.9
Acenaphthylene	5.87	127.87
Anthracene	46.85	245
Benzo(a)pyrene	88.81	763.22
Benzo(a)anthracene	74.83	692.53
Chrysene	107.77	845.98
Dibenzo(a,h)anthracene	6.22	134.61
Fluoranthene	112.82	1,493.54
Fluorene	21.17	144.35
Naphthalene	34.57	390.64
Phenanthrene	86.68	543.53
Pyrene	152.66	1,397.6
Total PAHs	1,684.06	16,770.4
Arsenic	7.24	41.6
Cadmium	0.676	4.21
Chromium	52.3	160.4
Lead	30.24	112.18
Mercury	0.130	0.696
Silver	0.730	1.77

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2. ASSESSMENT ACTIVITIES

This section presents a summary of the field activities that occurred to meet the objectives outlined in Section 1.3. Table 3 contains a summary of samples collected during field activities. Appendix A contains a copy of field notes, and Appendix B presents photographs depicting field activities.

2.1. Water Sampling

OASIS field personnel collected surface water and storm water samples during the assessment. The following subsections detail the sample rationale and procedures.

2.1.1. Surface Water

OASIS field personnel collected surface water samples at four discrete locations in Margaret Bay to assess water quality. Figure 3 presents the water sample locations.

A single water sample was collected at each location from a depth of one meter. SGS Environmental Services analyzed the samples for benzene, toluene, ethylbenzene, and xylenes (BTEX) by EPA method 602 for the determination of TAH.

A skiff was used to access sample locations. A GPS unit with stored location data was used to navigate to each sample location. When the sample location was reached, the outboard motor on the skiff was turned off and the sample crew anchored the skiff to maintain sample position. The following sampling methodology was used:

- The YSI 556 water quality meter was lowered to a depth of one meter to measure pH, temperature, specific conductivity, dissolved oxygen, oxygen reduction potential, and salinity. Water quality parameters are included on sample data sheets in Appendix C. GPS locations of each sample are provided in Appendix D.
- After recording field parameters, samples were collected for BTEX by placing three uncapped 40-millilter (ml) amber sample vials in a Wildco® hydrocarbon sampler and lowering the sampler to a depth of one meter. The sampler was tied off at the sample depth to allow sufficient time for the chamber of the sampler to completely fill and flush. At this point, the sampler was retrieved and the immersed sample vials were removed from inside the sampler. The vials were preserved with hydrochloric acid to a pH of less than 2 and capped so that no headspace remained in the vials.

2.1.2. Storm Water

OASIS field personnel initially identified storm water outfalls in Iliuliuk Harbor, Rocky Point, and Dutch Harbor by sailing the entire coastline. Twenty-five (25) outfalls were observed and location data were recorded using GPS. Figure 3 shows the locations of the storm water outfalls. GPS locations of each outfall are provided in Appendix D.

The sample plan called for the collection of storm water samples at six outfalls, one outfall from each priority area of impairment, for the analysis of PAHs (OASIS 2008b). However, no outfalls were observed near Alyeska Seafoods and the Small Boat Harbor, and the proposed outfall for sampling at Delta Western was not accessible because above-ground pipelines blocked access. Therefore, only three outfalls (ST-1 at the Former Submarine Base/Ship Repair Facility, ST-3 at UniSea, and ST-22 at the top of Dutch Harbor) were selected for the collection of storm water samples.

The storm water samples were composite samples with eight increments per sample, except for the sample from ST-22, which only had five increments because of a lack of consistent discharge. The samples from ST-1 and ST-3 were collected over two days with at least one hour elapsing between the collections of increments. The sample from ST-22 was collected during one day, but at least one hour elapsed between the collections of increments.

Increments were collected by filling a dedicated, graduated container with 250 ml of effluent. Field personnel transferred 125 ml from the dedicated, graduated container into two 1-liter amber bottles. Eight increments yielded a complete 1-liter sample. SGS Environmental Services analyzed the samples for PAHs by EPA method 625 for the determination of TAqH.

2.2. Sediment Sampling

OASIS field personnel collected subtidal sediment samples at 47 discrete locations in Dutch Harbor and Iliuliuk Harbor. Surface sediment samples were collected at all 47 locations. In addition, sediment core samples from one foot below the sediment surface were collected at 11 of the 47 locations, and bulk sediment samples were collected at three of the 47 locations. The following subsections detail the types of sediment samples.

2.2.1. Surface Sediment

OASIS field personnel collected 47 discrete sub-tidal surface sediment samples within Dutch Harbor and Iliuliuk Harbor. The following list includes the number and location of samples and rationale by priority area:

- Former Submarine Base/Ship Repair Facility – three samples from new sample locations (SD-59, SD-60, and SD-61) and one sample from an existing sample location (SD-01) to determine the extent of impact from petroleum pollutants near the Former Submarine Base/Ship Repair Facility.
- Small Boat Harbor – five samples from new sample locations (SD-62, SD-63, SD-64, SD-65, and SD-66) and one sample from an existing sample location (SD-02) to determine the extent of impact from petroleum pollutants near the Small Boat Harbor.
- UniSea – five samples from new sample locations (SD-67, SD-68, SD-69, SD-70, and SD-71) and four samples from existing sample locations (SD-03, SD-21, SD-22, and SD-23) to determine the extent of impact from petroleum pollutants near UniSea.
- Alyeska Seafoods – five samples from new sample locations (SD-72, SD-73, SD-74, SD-75, and SD-76) and two samples from existing sample locations (SD-26 and SD-28) to determine the extent of impact from petroleum pollutants near Alyeska Seafoods and the Coastal Transportation dock.

- Delta Western – three samples from new sample locations (SD-77, SD-89, and SD-90) and two samples from existing sample locations (SD-08 and SD-37) to determine the extent of impact from petroleum pollutants near the Delta Western dock.
- Top of Dutch Harbor – six samples from new sample locations (SD-78, SD-79, SD-80, SD-81, SD-82, and SD-83) and four samples from existing sample locations (SD-46, SD-50, SD-53, and SD-56) to determine if the extent of impact from petroleum pollutants spans the area between the shorelines of Amaknak Island and Ballyhoo Spit.

In addition, four sediment samples were collected from Margaret Bay at locations (SD-84, SD-85, SD-86, and SD-87) that corresponded to surface water samples to determine if sediments in Margaret Bay have been impacted by petroleum pollutants, and two sediment samples were collected from locations (SD-45 and SD-88) where bulk sediment samples were collected for the purpose of correlating concentrations of PAHs and bioassay results. Figure 4 shows the sediment sample locations for the Former Submarine Base/Ship Repair Facility, Small Boat Harbor, UniSea, Alyeska Seafoods, and Margaret Bay. Figure 5 shows the sediment sample locations for Delta Western and the top of Dutch Harbor.

OnSite Environmental Inc., analyzed all surface sediment samples for PAHs by EPA method 8270C SIM. In addition, 12 samples were analyzed by a subcontract laboratory for total organic carbon (TOC) by standard method Plumb, 1981. Each priority area of impairment had at least two samples analyzed for TOC so that TOC analysis was distributed throughout the priority areas.

Lastly, sample locations SD-01 and SD-60 at the Former Submarine Base/Ship Repair Facility were sampled and analyzed for Resource Conservation and Recovery (RCRA) metals by EPA method 6010/7471 and tributyltin (TBT) by the Krone method based on concerns of former activities at the Former Submarine Base/Ship Repair Facility. These analyses were performed in cooperation with the ADEC Contaminated Sites program for the purpose of providing data for Contamination Sites to determine potential future actions at this area. OnSite Environmental Inc., analyzed the samples for RCRA metals, and a subcontract laboratory analyzed the samples for TBT.

The surface sediment samples were collected using a Van Veen sampler onboard the commercial fishing vessel, *Nancy Ellen*, except for ten locations that were too shallow or difficult to access for the *Nancy Ellen*. These ten locations (SD-59, SD-60, SD-62, SD-64, SD-84, SD-85, SD-86, SD-87, SD-89, and SD-90) were sampled with a portable Van Veen sampler, or ponar sampler, that was onboard the skiff.

The GPS unit onboard the *Nancy Ellen* and a handheld GPS unit onboard the skiff was used to navigate to the sample locations. GPS locations of each sample are provided in Appendix D. The following activities occurred at each sample location:

- The Van Veen sampler was placed in the open position and lowered over the side of the boat. When the Van Veen sampler tripped closed on the bottom of the water body, the Van Veen sampler was retrieved.

- On the boat, the Van Veen sampler was opened to expose the intact sediment grab. Field personnel determined whether a clean grab of sediment occurred by examining the recovery of the sampler. If a clean grab had not occurred, then the Van Veen sampler was rinsed out and deployed again. On the other hand, if a clean grab had occurred, then field personnel collected a grab sample for PAHs at each location. A dedicated stainless steel spoon was used to fill a 4-ounce amber bottle with sediment from the top 2 inches of the matrix.
- For locations selected to be sampled for TOC also, the same dedicated stainless steel spoon was used to fill another 4-ounce sample bottle with sediment from the top 2 inches of matrix.
- For locations SD-01 and SD-60, the same dedicated stainless steel spoon was used to fill two additional 4-ounce sample bottles with sediment from the top 2 inches of matrix for analysis of RCRA metals and TBT.
- When all sampling was completed at each location, field personnel recorded observations of the sediment material. Appendix E contains field data sheets for sediment samples.

2.2.2. Core Sediment

OASIS field personnel collected subtidal sediment core samples using a gravity core sampler at 11 locations that corresponded with surface sediment samples. The sediment core samples were collected to assess concentrations of PAHs at one foot below the surface of sediment. The plan (OASIS 2008b) was to collect two sediment core samples from each priority area of impairment, except for the Former Submarine Base/Ship Repair Facility, which would have only one sample, but the gravity sampler was unable to adequately penetrate the coarse-grained sands and shellhash that characterize the sediment near Alyeska Seafoods and the Coastal Transportation dock; therefore, the two core samples for Alyeska Seafoods were divided and one was allocated for the top of Dutch Harbor and one for UniSea.

Figure 6 shows the sample locations for sediment core samples. OnSite Environmental Inc., analyzed the samples for PAHs by EPA method 8270C SIM.

OASIS field personnel collected sediment core samples onboard the *Nancy Ellen*. The GPS unit onboard the *Nancy Ellen* was used to navigate to each sample location. GPS locations of each sample are provided in Appendix D. The following activities occurred at each sample location:

- Inserted a sample sleeve inside the gravity sampler core and spooled out adequate line from the hydraulic winch so that the gravity sampler could free-fall to the bottom of the water body.
- Released the gravity core sampler in a free-fall over the side of the boat.
- When the gravity core sampler reached bottom, the attached line was retrieved using the hydraulic winch and davit.

- On the boat, the sample sleeve was extracted from the sampler and field personnel determined whether adequate recovery had occurred to collect a sample from one foot below the surface of the sediment.
- If adequate recovery occurred, field personnel collected a grab sample for PAHs from a depth of approximately one foot in the sample core. A dedicated stainless steel spoon was used to fill a 4-ounce amber sample bottle.
- If adequate recovery did not occur, then the sample process was repeated.
- When sampling was completed, field personnel recorded observations of the sediment material. Appendix E contains field data sheets for sediment samples.

2.2.3. Bulk Sediment

OASIS field personnel collected bulk sediment from three sample locations (SD-01, SD-45, and SD-88) for bioassay tests of chronic and acute toxicity. Figure 6 shows the sample locations. Sample location SD-01 was selected because this location has had the greatest concentrations of total PAHs from the previous assessments. Sample location SD-45 was selected because this location had a concentration of total PAHs in September 2007 that was very similar to the TEL action level. Sample location SD-88 was selected as a site control sample.

Three separate bioassay tests were performed on each sample. The tests are based on recommended procedures as detailed in Washington state sediment standards (WAC 173-204-315). The tests included one chronic and two acute bioassays. The chronic bioassay was a 20-day growth rate analysis of the juvenile polychaete *Neanthes arenaceodentata* by method Puget Sound Water Quality Authority Protocols (PSWQA 1995). The acute bioassays included a 10-day mortality test on the amphipod *Ampelisca abdita* by method EPA/600/R-94/025 and a 48-hour mortality/abnormality test on the blue mussel *Mytilus galloprovincialis* by method EPA/600/R-95/136. ToxScan Inc., a division of our term subcontractor, Kinnetic Laboratories Inc., performed the bioassay tests.

OASIS field personnel collected the bulk sediment samples using a Van Veen sampler onboard the *Nancy Ellen*. The GPS unit onboard the *Nancy Ellen* was used to navigate to the sample locations. GPS locations of each sample are provided in Appendix D. The following activities occurred at each sample location:

- The Van Veen sampler was placed in the open position and lowered over the side of the boat. When the Van Veen sampler tripped closed on the bottom of the water body, the Van Veen sampler was retrieved.
- On the boat, the Van Veen sampler was opened to expose the intact sediment grab. Field personnel determined whether a clean grab of sediment occurred by examining the recovery of the sampler. If a clean grab did not occur, then the Van Veen sampler was rinsed out and re-deployed. On the other hand, if a clean grab did occur, then field personnel transferred bulk sediment from the Van Veen to a dedicated stainless steel bowl with a dedicated stainless steel trowel. The sample

process was repeated so sediment from a second Van Veen grab was added to the stainless steel bowl.

- The combined sediment was homogenized with the dedicated stainless steel trowel and allocated to two 1-gallon polyethylene containers.
- After sample collection was complete, OASIS field personnel recorded observations of the sediment material. Appendix E contains field data sheets for sediment samples.
- A water sample also was collected from the locations of the bulk sediment samples. The water sample was used by the laboratory as makeup water for an elutriate rinse during the 48-hour mortality/abnormality test on the blue mussel *M. galloprovincialis*. OASIS field personnel collected the water sample by lowering a Kemmerer sampler over the side of the boat and allowing the sampler to reach the bottom of the water body. At this point, the sampler's messenger was sent down so that the bottle closes with an intact, representative sample. The Kemmerer sampler was retrieved to the surface and field personnel filled a 2.5-gallon cubitainer. Three deployments of the Kemmerer sampler were required to retrieve the required water volume.
- Lastly, for sample locations SD-45 and SD-88, OASIS field personnel also collected a surface sediment sample for analysis of PAHs for correlation with the bioassay results. The process for collecting samples for analysis of PAHs corresponded to the procedures in Section 2.2.1.

2.3. Sample Plan Deviations

OASIS prepared a sample plan that outlined the strategy and methodology for the collection of water and sediment samples (OASIS 2008b). Some of the executed activities and details deviated from the plan. The list below identifies the deviations:

- Only three storm water samples were collected instead of the proposed six samples. One sample was proposed to be collected from each priority area of impairment, but the assessment documented that no outfalls are present at the Small Boat Harbor and Alyeska Seafoods. In addition, the outfall near the Delta Western dock was inaccessible because above-ground pipelines limited access. Therefore, the ADEC project manager and OASIS project manager decided to only sample outfalls at the Former Submarine Base/Ship Repair Facility (ST-1), UniSea (ST-2), and top of Dutch Harbor (ST-22).
- Storm water sample 08-DH-0926-124-ST from storm water outfall ST-22 at the top of Dutch Harbor only had five increments collected instead of the proposed eight increments. The reason is that limited discharge from the outfall precluded the collection of eight increments. The result is that laboratory reporting limits for PAHs are elevated in the sample because of the reduced sample volume. However, this consequence was of minimal impact to data quality because most PAHs were detected above laboratory reporting limits in the sample.

- Sediment core samples were not collected at proposed locations SD-26 and SD-75 near Alyeska Seafoods. An attempt was made to collect these samples, but the coarse-grained sediment material would wash out of the gravity core during retrieval. Attempts were made to collect core samples at nearby locations SD-72, SD-74, and SD-76, but the sample material also washed out. Therefore, an extra core sample was collected at the top of Dutch Harbor (SD-79) and UniSea (SD-70) to replace the two samples near Alyeska Seafoods.
- Samples for analysis of PAHs by EPA method 8270C SIM were collected with bioassay samples from sample locations SD-45 and SD-88. These samples originally were not proposed, but they were collected so that bioassay results could be correlated with PAH data from the same sample location.

2.4. Investigation-Derived Waste

Water quality assessment field activities generated solid and aqueous investigation-derived waste (IDW). Solid IDW included used PPE, sampling equipment, and unused sediment sample material. The used PPE and sampling equipment, which included disposable nitrile gloves, sample spoons, and paper towels were contained in trash bags and disposed of at the Unalaska landfill. Unused sediment sample material was dumped overboard. Aqueous IDW included unused water matrix from sampling and decontamination rinse water for the Van Veen sampler. Unused water matrix was dumped overboard and decontamination rinse water was drained off the boat.

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3. FINDINGS

This section discusses the results of the assessment and includes tables and figures that show analytical results for water and sediment samples. Appendix F contains a copy of laboratory analytical data reports.

3.1. Water Samples

This subsection presents analytical results for surface water and storm water samples.

3.1.1. Surface Water Results

Table 4 presents the analytical results for surface water samples, and Figure 3 shows TAH concentrations by sample location. Each of the four surface water samples had an estimated concentration of benzene less than the laboratory reporting limit. Although it is not possible to ascertain, these low-level detections of benzene may have been caused by the recent operation of the skiff's engine. Regardless of the cause of the benzene detections, none of the concentrations exceeded the water quality criteria of 10 micrograms per liter (µg/L) for TAH; therefore, their significance is minimal.

3.1.2. Storm Water Results

Table 5 presents the analytical results for storm water composite samples, and Figure 3 shows TAqH concentrations by outfall location. Outfall ST-1 had estimated concentrations of phenanthrene, fluoranthene, and pyrene, and outfall ST-3 had estimated concentrations of naphthalene, fluoranthene, and pyrene. The resulting TAqH concentrations for ST-1 and ST-3, however, were significantly less than the water quality criteria of 15 µg/L.

The analytical result for ST-22 at the top of Dutch Harbor had detectable concentrations for most PAHs. The resulting TAqH concentration for ST-22 was 6.00 µg/L, which is less than the water quality criteria of 15 µg/L.

3.2. Sediment Samples

This subsection presents analytical results for surface, core, and bulk sediment samples. The discussion also includes an analysis of TOC concentrations and how that data affect the raw laboratory data for PAHs.

3.2.1. Surface Sediment Results

As with previous assessments of sediment quality, many of the samples had sheening visible in the sample material. Twenty-four (24) of the 47 surface sediment sample locations had light to moderate sheening visible in the sample material. Only sample location SD-01 had significant sheening. A picture of the significant sheening at SD-01 is included in Appendix B.

Table 6 presents the analytical results for sediment samples using data as provided by the analytical laboratories. Figure 4 shows analytical results for samples collected in

Iliuliuk Harbor, and Figure 5 shows analytical results for samples collected in Dutch Harbor.

All 47 surface sediment samples had at least two PAH compounds detected. Thirty-six (36) locations had at least one PAH compound that exceeded a TEL benchmark for sediment quality, and ten of the samples had at least one compound that exceeded a PEL benchmark. Two of the sediment samples exceeded the PEL benchmark for total PAHs: SD-60 at the Former Submarine Base/Ship Repair Facility and SD-73 near the Coastal Transportation dock. Twenty-five (25) other sediment samples also exceed the TEL benchmark for total PAHs.

Lastly, samples were collected for analysis of RCRA metals and TBT at sample locations SD-01 and SD-60 at the Former Submarine Base/Ship Repair Facility. Analytical results show that arsenic, cadmium, lead, and mercury exceeded TEL benchmarks at SD-01, and arsenic, lead, and mercury exceeded TEL benchmarks at SD-60. TBT was detected at both sample locations, which indicates that the anti-fouling agent probably was used at the former facility.

3.2.2. Core Sediment Results

Table 7 presents the analytical results for sediment core samples, and Figure 6 shows analytical results by sample location. Only four of the 12 samples had at least one PAH compound detected above a TEL benchmark, and no compound in any of the samples exceeded a PEL benchmark. The core sample from sample location SD-03 at UniSea was the only sample that exceeded the TEL for total PAHs. Two core samples, SD-02 and SD-79, did not have a single PAH compound detected.

The ratio of total PAHs in the core sample to total PAHs in the surface sample offers a compelling comparison of how sediment depth affects concentrations of PAHs. Table 7 contains these ratios. The ratios ranged from 0.002 in SD-37 to 1.04 in SD-77 with two locations, SD-02 and SD-79 that are not quantifiable because no PAH compound was detected above laboratory reporting limits. The 1.04 ratio for SD-77 is somewhat misleading because the surface concentration (292 micrograms per kilogram [µg/kg]) and core concentration (304 µg/kg) are significantly less than the TEL benchmark for both samples, and therefore this sample location does not enter the discussion of areas impacted by petroleum pollution. So if SD-77 is excluded from the analysis of ratios of total PAHs, the new range of results is 0.002 in SD-37 to 0.70 in SD-03. As previously noted, the concentration of total PAHs in the core sample from SD-03 was the only core sample that exceeded the TEL benchmark. Based on this result, it appears that hydrocarbons extend vertically into the sediment horizon at this location near UniSea. So if SD-03 also is excluded from the analysis of ratios of total PAHs, the new range of results is 0.002 in SD-37 to 0.18 in SD-50 with a median result of 0.09. This analysis shows that at a depth of one foot concentrations of PAHs are likely to be one-tenth of surface concentrations.

3.2.3. TOC-Normalized Analytical Results

Concentrations of PAHs in sediments often show significant variability because naturally present organic carbon acts as an attractor or accumulator of hydrophobic compounds such as petroleum hydrocarbons (Luthy 2004). As a result, concentrations of PAHs in sediments may vary between areas if one area has greater organic carbon content even though the mass of hydrocarbons released to each area may be the same. A method to address this natural variability caused by organic carbon is to normalize concentrations of PAHs by dividing analytical results by the concentration of TOC in each sample.

Table 8 shows the TOC-normalized data for PAHs. The important issue is whether the distribution of concentrations for TOC-normalized data are significantly different than the non-normalized data. In other words, do the locations of the most impacted and least impacted samples vary when the data is TOC-normalized? To analyze this issue, the correlation of paired data (normalized and non-normalized data at each sample location) is tested using the non-parametric Spearman's Rank Correlation Test with the following hypothesis:

H_0: There is no correlation between the concentrations of total PAHs for TOC-normalized data and non-normalized data (i.e., the ranks of concentrations by sample location are statistically different).

H_1: There is correlation between the concentrations of total PAHs for TOC-normalized data and non-normalized data (i.e., the ranks of concentrations by sample location are not statistically different).

This test is performed with a level of significance (α) equal to 0.05. The details of Spearman's Rank Correlation Test are available on the Internet and are not reproduced here. The resulting test statistic, $\rho = 0.783$, exceeds the test's critical value of 0.591; therefore, the null hypothesis is rejected in favor of the conclusion that correlation does exist between the two data sets. This conclusion means that the ranks of total PAH concentrations between TOC-normalized data and non-normalized data are not statistically different. In summary, normalization of PAH concentrations using TOC concentrations does not change where the highest concentrations of PAHs are located in the study area. The result is that there is no difference whether the non-normalized data or normalized data is used to discuss the impact of PAHs to sediments in the study area. This finding also is consistent with the analysis of TOC-normalized data from April 2007 and September 2007.

3.2.4. Bulk Sediment Samples

Table 9 presents analytical results of the bioassay tests. The complete laboratory report from ToxScan Inc., is provided in Appendix F.

For the acute bioassay test involving the mussel *M. galloprovincialis*, which used an elutriate rinse comprised of site water from each bulk sediment sample location, survival and development metrics did not statistically differ from laboratory control metrics. In addition, calculated point estimates for toxicity, median lethal concentration (LC_{50}) and half maximal effective concentration (EC_{50}), were all greater than 100 percent, which means that the actual toxic point estimates are greater than the unmeasured concentrations provided in the samples from SD-01, SD-45, and SD-88.

The other acute bioassay test was a benthic survival analysis using the amphipod *A. abdita*. The survival rates (91% and 78%) at sample locations SD-01 and SD-45, respectively, were statistically compared to the survival rate (80%) at the site control sample SD-88. The result was that there was no statistical difference at a significance level of 0.05. In addition, the laboratory control sample, also known as the home sample, had a survival rate of 87%, which is comparable to the test results for SD-01 and SD-45.

The final bioassay test was a chronic response test for survival and growth involving the polychaete *N. arenaceodentata*. The survival rates were 100% at the three bulk sediment sample locations. Average growth was comparable between all sites at 0.617 milligrams per day (mg/d), 0.547 mg/d, and 0.657 mg/d for locations SD-01, SD-45, and SD-88, respectively. In addition, average growth rate for the laboratory control sample was 0.652 mg/d, which further supports the normalcy of the observed growth rates.

3.3. Comparison of Cumulative Results

Table 10 shows cumulative surface sediment data from April 2007, September 2007, and September 2008, for locations that were sampled during at least two of the three sampling events. Figure 7 shows the cumulative results for sediment grab samples for all three sample events with average concentrations for sample locations sampled more than once.

Fifteen (15) sediment sample locations were sampled in September 2008 that were previously sampled. The results generally are consistently elevated, although actual concentrations of PAHs show significant variability between sampling events. However, there were two sample locations, SD-21 and SD-56, which had significant decreases in concentrations of total PAHs. These two locations appear to be near the fringes of priority areas of impairment, which could be a possible explanation for the variation.

4. QUALITY ASSURANCE REVIEW

The analytical results for all field, quality control (QC), and laboratory quality assurance samples were evaluated. The data were reviewed to determine the integrity of the reported analytical results and ensure analytical results met data quality objectives as presented in the Quality Assurance Project Plan (OASIS 2007b) and its addendum (OASIS 2008c). Appendix G presents a quality assurance review of the analytical data using ADEC's Laboratory Data Review Checklist.

The following list provides a brief review of data quality objectives. More details are presented in Appendix G.

- All work was performed by OASIS or subcontractor personnel who are qualified individuals as per 18 AAC 75.990(100).
- Completeness – 100% of samples submitted were analyzed, thereby meeting the data quality objective of 90%.
- Accuracy – All primary, matrix spike/matrix spike duplicate, laboratory control, and method blank samples met method criteria for surrogate recoveries, except for samples 08-DH-0923-50-SD and 08-DH-0924-62-SD. The results for these samples have been flagged as estimated.
- Precision – Overall there were good correlation and low relative percent differences (RPD) between primary and duplicate samples. The water sample results were either non-detect or estimated concentrations less than the laboratory reporting limit, so no valid comparison could be made except that the concentrations are low in both primary and duplicate samples. RPDs for sediment samples were less than 60% for total PAHs, although some individual PAH compounds exceeded 60% for pairs 08-DH-0925-68-SD/08-DH-0925-115-SD and 08-DH-0924-75-SD/08-DH-0924-114SD. The individual compounds have been qualified as estimates, but given that total PAHs were within limits and this data point is the primary metric for evaluating results, the qualifications have no impact on data quality. In addition, the concentration of lead in the pair 08-DH-0925-01-SD/08-DH-0925-117-SD also exceeded 60%; however, both results exceed the TEL, so interpretation of the result is the same, even though the results have been qualified as estimates. Lastly, RPDs for matrix spike/matrix spike duplicate and laboratory control samples also met criteria.
- Comparability – Samples were collected and analyzed in a manner that allowed analytical results to be compared to each other.
- Representativeness – Water samples were collected in a manner that minimally disturbed the water column and retrieved the sample matrix from the desired depth. Sediment sampling procedures included the use of dedicated sampling tools and procedures that produces samples of similar volume. Analysis of trip blank samples indicated that no cross-contamination occurred during the project.

Lastly, ToxScan provided an internal review in the data report, which indicates that laboratory analysis and results met acceptable control performance for all bioassay tests. A cursory review by OASIS confirms this conclusion.

5. EVALUATION OF FINDINGS

OASIS conducted an assessment of Dutch Harbor and Iliuliuk Harbor on behalf of ADEC in September 2008 to refine areas of impairment and assess deleterious effects to aquatic life. The assessment included collection of four surface water samples, three storm water samples, 47 surface sediment samples, 11 sediment core samples, and three bulk sediment samples. The purpose of the assessment was to refine the understanding of PAH contamination in sediment for the priority areas of impairment; evaluate water and sediment quality in Margaret Bay; evaluate the contribution of storm water to sediment contamination in the priority areas of impairment; and determine whether documented sediment contamination is having a deleterious effect on aquatic life. The following is a summary of findings from the assessment:

- Benzene was detected at estimated concentrations less than laboratory reporting limits in all four surface water samples in Margaret Bay. The resulting TAH values are less than the water quality standard of 10 µg/L.
- Field personnel documented the location of 25 storm water outfalls in Iliuliuk Harbor and Dutch Harbor. Composite samples were collected from three of the outfalls, and PAH compounds were detected in all three samples; however, concentrations from outfalls near the Former Submarine Base/Ship Repair Facility and UniSea were estimated less than the laboratory limits. Concentrations of PAHs in an outfall at the top of Dutch Harbor were detectable, but the resulting TAqH value was less than the water quality standard of 15 µg/L.
- Sheening was observed in sample material for over half of the surface sediment sample locations.
- All 47 surface sediment samples had multiple PAH compounds detected. Thirty-six (36) sample locations had at least one PAH compound that exceeded a TEL benchmark, and ten of the samples had at least one compound that exceeded a PEL benchmark. Two of the sediment samples exceeded the PEL benchmark for total PAHs: SD-60 at the Former Submarine Base/Ship Repair Facility and SD-73 near the Coastal Transportation dock. Twenty-five (25) other sediment samples also exceeded the TEL benchmark for total PAHs.
- Analysis of the ratios of total PAH concentrations between sediment core samples and corresponding surface sediment samples indicate that concentrations decrease with depth. The average reduction measured in the core sediment samples was approximately one-tenth of the concentration in the surface sediment samples.
- Statistical analysis of sediment sample analytical results for TOC-normalized PAH concentrations and non-normalized PAH concentrations demonstrates that the two data sets are statistically correlated. This means that ranking of the data sets from most impacted to least impacted for concentrations of total PAHs is statistically the same whether TOC-normalized or non-normalized data are used.

- The bioassay results showed that sediment impacted with PAHs from sample locations SD-01 and SD-45 showed no effect on survival, development, and growth of aquatic life when compared to the same endpoints for the control sample location (SD-88) and the laboratory control sample.
- Two surface sediment samples from the Former Submarine Base/Ship Repair Facility had concentrations of arsenic, cadmium, lead, and mercury that exceeded TEL benchmarks. In addition, TBT was detected in both samples.

5.1. Conclusions

Based on the findings summarized above and data from the two previous assessments, the conclusions for this assessment are:

- Surface water and subtidal sediment in Margaret Bay do not appear to be impacted with petroleum hydrocarbons.
- Storm water data from the outfalls at the Former Submarine Base/Ship Repair Facility and UniSea indicate that effluent is not a significant contributing factor to sediment contamination in these priority areas. However, storm water effluent from the top of Dutch Harbor may be influencing sediment contamination in this priority area. The source of the PAHs in the storm water from outfall ST-22 is unknown at this time.
- The surface sediment samples collected during this assessment refined the locations of impact from PAHs in the priority areas of impairment by increasing sample density. The findings may be visually observed in Figures 4 and 5, which highlight in red the sample locations that exceeded the TEL for total PAHs.
- The surface sediment data does not appear to provide evidence if or how upland sources of contamination might be affecting sediment concentrations.
- The results of the sediment core samples show that impact from PAHs generally appears to be limited to the sediment surface. Concentrations of PAHs showed a marked decrease at a depth of one foot into the sediment horizon. The notable exception is sample location SD-03 at UniSea, where the concentration of total PAHs only declined by 30 percent, and the resulting concentration of total PAHs exceeded the TEL.
- The current assessment provided more evidence that the carbon content of the sediment has negligible effect on concentrations of PAHs. This finding is consistent with the two previous assessments.
- Arsenic, cadmium, lead, and mercury exceeded TELs at the Former Submarine Base/Ship Repair Facility, and TBT was detected in both samples collected at this priority area. These findings provide evidence that additional assessment may be necessary for this potential contaminated site.
- All three bioassay tests showed no reduction in survival, development, or growth for the three forms of aquatic life tested: mussel, amphipod, and polychaete. The tests

compared results for sample locations SD-01 and SD-45 to both the site control sample at SD-88 and laboratory control samples.

- The cumulative set of surface sediment data for all three assessments, as seen in Figure 7, demonstrates that sediment contamination is limited to the priority areas of impairment under investigation for this assessment: Former Submarine Base/Ship Repair Facility, Small Boat Harbor, UniSea, Alyeska Seafoods (including the Coastal Transportation dock), Delta Western dock, and the top of Dutch Harbor. In addition, the cumulative data further support the finding from September 2007 that the impacted sediments generally are located near the docks within the priority areas of impairment.
- The data gathered over the three assessments provide an adequate baseline of impact from petroleum hydrocarbons in Dutch Harbor and Iliuliuk Harbor. Based on the water quality criteria in Table 1, only two clauses remain in question for attainment of the impaired water bodies: 1) may not cause a film, sheen, or discoloration on the floor of the water body, and 2) there may be no concentrations of petroleum hydrocarbons, animal fats, or vegetable oils in shoreline or bottom sediments that cause deleterious effects to aquatic life. The former standard is not met because approximately one-half of the sediment samples collected in the priority areas of impairment have visible sheening. On the other hand, the latter standard was met during this current assessment based on the results of bioassay tests performed on three samples; however, given the numerous locations in the study area where subtidal sediments exceed TEL or PEL benchmarks for total PAHs, it does not seem prudent to move forward with a finding of attainment for this standard based on only three data points.

5.2. Recommendations

The following recommendations are provided as possible actions to take for the goal of water quality attainment. The recommendations serve as options for ADEC to consider in future project planning. ADEC is not obligated to enact or implement any or all of the recommendations.

- Initiate the process of water quality attainment for Dutch Harbor and Iliuliuk Harbor. This should include the development of a TMDL for petroleum hydrocarbons, additional future bioassay tests to verify current findings, coordination with involved parties to determine and enact uniform best management practices for docks and harbors, and a long-term plan to monitor concentrations of PAHs in subtidal sediments for the priority areas of impairment.
- The production of a TMDL will allow ADEC to satisfy its regulatory requirement for impairment of Dutch Harbor and Iliuliuk Harbor. While this recommendation is contrary to recommendations from previous assessments, it now seems like the most efficient and effective approach at this time. The TMDL should call for a zero-discharge of petroleum hydrocarbons to Dutch Harbor and Iliuliuk Harbor as there

are no point-source facilities that knowingly discharge hydrocarbons, and therefore, no manner to allocate contaminant masses.

- Additional bioassay tests should be performed to verify and supplement the results from this assessment. The current results for the bioassay test should be viewed as cursory. An extensive bioassay sample program would be needed to understand the real toxicity of impacted sediments, and to provide data that would be of sufficient quality for management decisions. It also would be useful to review plans for additional bioassay tests to ensure that appropriate sampling techniques, species, and analytical methods are used for decision-making purposes.
- Convene a group of stakeholders to develop uniform best management practices for docks and harbors given that the most elevated concentrations of PAHs in sediments occur at docks. The group should include local, state, and federal government agencies that have a presence in Dutch Harbor, private enterprises that would be directly affected, and any interested non-government organizations.
- Plan to re-sample subtidal sediments in the priority areas of impairment at some distant time (e.g., five years from now) to determine if concentrations appear to be trending downward.
- Consider additional evaluation of storm water at the top of Dutch Harbor. The concentration detected in the sample from outfall ST-22 may contribute to sediment contamination at the top of Dutch Harbor, and there are other outfalls that are located nearby which also may be contributing. The source of the impacted runoff also is not known at this time.
- Consider sampling other storm water outfalls that were not sampled because of access issues and lack of precipitation.
- Determine whether the concentrations of metals and TBT in subtidal sediments near the Former Submarine Base/Ship Repair Facility warrant additional investigation of this area as a contaminated site.

6. REFERENCES

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TABLES

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FIGURES

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APPENDIX A

Field Notes

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APPENDIX B

Photographs

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APPENDIX C

Water Sample Data Sheets

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APPENDIX D

GPS Coordinates

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APPENDIX E

Sediment Sample Data Sheets

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APPENDIX F

Laboratory Analytical Reports

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APPENDIX G

Quality Assurance Review