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Expert Report on Economic Feasibility Shipyard Sediment Site

San Diego, California

March 2011

ARCADIS

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Table of Contents

Summary of Opinions **1**

1. Introduction **2**

1.1 Background 2

1.2 Remedial Options 3

1.3 Economic Feasibility Analysis 3

1.4 Outline of the Report 5

2. Remedial Options **5**

2.1 Description of the Options 5

2.1.1 DTR-Recommended Option 6

2.1.2 Background Remedial Option 8

2.1.3 Alternative Remedial Option 10

2.1.3.1 Triad Results 11

2.1.3.2 Implications of Uncertainties for Protectiveness of Beneficial Uses 17

2.1.3.3 Summary of Alternative Remedial Option 18

2.1.3.4 Compliance with California State Water Board Resolution No. 92-49 19

3. Costs of Remedial Options **20**

3.1 Overview of Cost Assessment 20

3.2 Discussion of Costs by Option 21

3.2.1 DTR-Recommended Option 22

3.2.2 Background Remedial Option 22

3.2.3 Alternative Remedial Option 22

3.3 Present Value Analysis of Costs 23

3.4 Discussion of Other Social Costs 23

3.4.1 Community Impacts 24

3.4.2 Habitat Impacts 26

3.4.3 Business Impacts 27

4. Effectiveness Metric **28**

4.1 Data and Methods 28

4.1.1 Post-Remediation SWAC Calculation Method – DTR 28

4.1.2 Alternative Post-Remediation SWAC Calculation Method 29

4.2 Results and Comparisons of Alternative Remedial Footprints 30

5. Cost-Effectiveness Analysis Results **32**

6. References **33**

Tables

Table 1 Summary of DTR-Recommended Option

Table 2 Summary of Remedial Components

Table 3 Cost Estimate for Remedial Footprint – DTR-Recommended Option

Table 4 Summary of Background Remedial Option

Table 5 Background Remedial Option Cost Estimate

Table 6 Summary Results by Station for Alternative Remedial Option

Table 7 Summary of Alternative Remedial Option

Table 8 Alternative Remedial Option Cost Estimate

Table 9 Cash Flow Analysis

Table 10 Present Value Cost of Options

Table 11 Transportation of Sediment Offsite

Table 12 Potential Risks of Transportation of Sediment Offsite

Table 13 SWACs for Primary COCs under Alternative Scenarios

Table 14 SWAC Reduction as a Function of Background

Table 15 Exposure Reduction by Options (Percent)

Figures

Figure 1 Site Map

Figure 2 DTR-Recommended Remedial Option

Figure 3 Background Remedial Option

Figure 4 Alternative Remedial Option

Figure 5 Incremental Cost-Effectiveness Results: 3 Percent Discount Rate

Figure 6 Incremental Cost-Effectiveness Results: 7 Percent Discount Rate

Appendices

A Resumes of Experts

B Rates Used for this Work

C Bivalve Normality Results (Exponent 2003)

Acronyms and Abbreviations

AnchorQEA	AnchorQEA, L.L.P.
BAE	DLA Piper for BAE Systems
BRI	benthic response index
CEA	cost-effectiveness approach
COCs	contaminants of concern
COPCs	chemicals of potential concern
cy	cubic yards
cy/day	cubic yards per day
°C	degrees Centigrade
DTR	*Draft Technical Report for Tentative Cleanup and Abatement for the Shipyard Sediment Site in San Diego Bay*
HPAHs	total high molecular weight polycyclic aromatic hydrocarbons
LAETs	Lowest Apparent Effects Thresholds
LPL	lower predictive limit
mg/L	milligrams per liter
MM	million
NASSCO	National Steel and Shipbuilding Company (General Dynamics subsidiary)
OMB	Office of Management and Budget
PCBs	total polychlorinated biphenyls
ppt	parts per trillion
SDRWQCB	San Diego Regional Water Quality Control Board
SMUs	sediment management units
sq-ft	square feet
SS-MEQ	site-specific mean effects quotient
SWAC	surface area-weighted average concentration
TBT	tributyl tin
TMDL	Total Maximum Daily Load

TOC	total organic carbon
Triad	combination of sediment chemistry, sediment toxicity, and benthic community data
UPL	upper prediction limit
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
WOE	weight-of-evidence
303(d)	California Clean Water Act Section 303(d) List of Water Quality Limited Segments

Summary of Opinions

- **Opinion 1:** Based on the available data, it is possible to identify Triad results and associated polygon areas which could be considered for remedial action to address uncertainty and to thereby create a "margin of safety" associated with protection of beneficial uses. The resulting alternative footprint, while smaller than the currently proposed footprint in the *Draft Technical Report for Tentative Cleanup and Abatement Order No. R9-2010-0002* (DTR), provides protection of designated uses, and thus equally addresses impairments for nearshore sediments driven by sediment toxicity and/or benthic community impacts (i.e., California Clean Water Act Section 303(d) List of Water Quality Limited Segments).

- **Opinion 2:** Resultant surface-weighted average concentrations (SWACs) for COCs, based on two proposed remedial footprints, were compared to current and background SWACs. The results of that comparison indicate that increasing the number of locations of remediation from 12 (Alternative Remedial Option) to 23 (DTR-Recommended Option) and the area of remediation from approximately 7.5 to 17.4 acres does not result in a commensurately proportional decrease in SWACs for the COCs at the Shipyard Sediment Site.

- **Opinion 3:** Remediation costs of approximately $29,700,000 for the Alternative Remedial Option have been estimated using the cost estimate developed by AnchorQEA, L.L.P. (AnchorQEA) for the DTR-Recommended Option.

- **Opinion 4:** We anticipate significantly greater social costs including community impacts, habitat impacts, and business impacts will be incurred with implementation of the Background Remedial Option than the other two options. The lowest social costs would be associated with the Alternative Remedial Option.

- **Opinion 5:** We conducted an incremental cost-effectiveness evaluation, which is consistent with the economic feasibility assessment as described in California State Water Board Resolution No. 92-49. From a cost-effectiveness evaluation, the Background Remedial Option appears to be substantially worse than the other two options. It has greater incremental cost per exposure reduction than the other two options. When combined with the other adverse effects including community impacts, business impacts, and habitat impacts, social costs that are not quantified, this incremental cost difference will be even greater. Similar to the conclusions reached in the DTR, the Background Remedial Option is not economically feasible; the incremental cost of further reductions outweighs the incremental benefits, and no further reduction in impairment is achieved.

1. Introduction

This report has been prepared by several individuals employed at ARCADIS U.S., Inc. having specific expertise in the areas of contaminated sediment assessment and management as well as economics. These individuals are listed here along with their areas of expertise and responsibilities for this document:

- Philip Spadaro, Principal Scientist, responsible for overall report and technical integration
- Poh Boon Ung, Principal Economist, responsible for economic feasibility analysis
- Matthew Butcher, Principal Scientist, responsible for statistical analysis of remedial options
- Paul Doody, Technical Expert, responsible for analysis of remedial option costs
- Derek Edge, Technical Expert, responsible for development of alternative remedial option.

Resumes for these individuals are provided in Appendix A.

The scope of this work consisted of reviewing and evaluating available documentation regarding the proposed sediment remediation at the Shipyard Sediment Site, and conducting an economic feasibility evaluation in accordance with State Water Board Regulation No. 92-49 and other applicable guidance. The economic feasibility evaluation includes evaluation of three remedial options. One of the options consists of remediation utilizing alternative cleanup levels outlined in Tentative Cleanup and Abatement Order No. R9-2010-0002 and the DTR (hereinafter referred to as the “DTR-Recommended Option”). The other two options include remediation to background and an option that was developed as part of this work.

1.1 Background

The DTR defines the Shipyard Sediment Site as follows:

> *The Shipyard Sediment Site is located on the eastern shore of central San Diego Bay, approximately one half mile south of the Coronado Bridge and half the total distance into the Bay. The NASSCO and BAE Systems leaseholds, portions of which lie in the Shipyard Sediment Site, are adjacent to each other, have a similar range of water depths, and lie within the same hydrologic and biogeographic area. The total combined San Diego Bay water acres included in the NASSCO and BAE Systems leaseholds is approximately 56 acres. The Shipyard Sediment Site encompasses the entire 56 water acres of the NASCCO and BAE Systems leaseholds. Also included in the Shipyard Sediments Site investigation were areas just*

outside the northwestern boundary of the BAE Systems leasehold and areas west of the leasehold near the eastern edge of the shipping channel. (SDRWQCB 2010).

A map of the Shipyard Sediment Site is provided on Figure 1.

Sediment quality at the Site has been studied extensively. The results of such studies are presented in numerous documents including the following:

- Tentative Cleanup and Abatement Order No. R9-2010-0002
- *Draft Technical Report for Tentative Cleanup and Abatement Order No. R9-2010-0002 (*San Diego Regional Water Quality Control Board [SDRWQCB] 2010*)*
- *NASSCO and Southwest Marine Detailed Sediment Investigation* (Exponent 2003).

These documents and others referenced in this report have been used in forming the opinions expressed herein.

1.2 Remedial Options

This report addresses the following different remedial options:

- The recommended remedial option presented in the DTR ("DTR-Recommended Option")
- A more extensive cleanup option identified in the DTR ("Background Remedial Option")
- An alternative remedial area identified here for the purpose of providing another point of comparison for the cost effectiveness analysis ("Alternative Remedial Option").

These options are described in more detail in Section 2.

1.3 Economic Feasibility Analysis

This report evaluates the economic feasibility of three potential remedial options at the Site. As noted in the DTR (SDRWQCB 2010), the "San Diego Water Board must apply Resolution No. 92-49[1] when setting

[1] Policies and Procedures for Investigation and Cleanup and Abatement of Discharges Under Water Code Section 13304.

cleanup levels for contaminated sediment if such sediment threatens beneficial uses of the waters of the state and the contamination or pollution is the result of a discharge of waste. Contaminated sediment must be cleaned up to background sediment quality unless it would be technologically or economically infeasible to do so" (DTR Section 29-2). In particular, State Water Board Resolution No. 92-49 defines the term economic feasibility as follows:

> *Economic feasibility is an objective balancing of the incremental benefit of attaining further reductions in the concentrations of constituents of concern as compared with the incremental cost of achieving those reductions. The evaluation of economic feasibility will include consideration of current, planned, or future land use, social, and economic impacts to the surrounding community including property owners other than the discharger. Economic feasibility, in this Policy, does not refer to the discharger's ability to finance cleanup. Availability of financial resources should be considered in the establishment of reasonable compliance schedules.* (Cited from 92-49-Section III-H-1-b.)

As further discussed in the DTR, economic feasibility involves "estimating the costs to remediate constituents of concern at a site to background and the costs of implementing other alternative remedial levels. An economically feasible alternative cleanup level is one where the incremental cost of further reductions in primary COCs outweighs the incremental benefits" (SDRWQCB [2010], 31-1). Based on the results of the SDRWQCB's analysis, cleanup to background sediment quality levels is not economically feasible (SDRWQCB [2010] 31-3, 32-40). The DTR concludes that this alternative remedial footprint (hereafter referred to as the "DTR-Recommended Option") is protective of beneficial uses.

This report includes an independent economic feasibility assessment using a cost-effectiveness approach (CEA). Although Resolution No. 92-49 does not provide specific guidance on how to conduct the economic feasibility evaluation, the definition provided above is consistent with the use of an incremental CEA. Cost-effectiveness analysis is a well-accepted approach, with both the Office of Management and Budget (OMB) and U.S. Environmental Protection Agency (USEPA) providing regulatory guidance for its use.

- OMB states that CEA should be used for rulemakings for which the primary benefits are improved public health and safety.
- USEPA states that CEA provides useful information to policy makers and conforms to the general principle of minimizing the cost of achieving particular policy goals.

Cost-effectiveness analysis is an economic methodology that is widely used to identify and select options that achieve the most effective use of limited resources (see for example OMB 2003, USEPA 2000). In particular, the approach measures the added—incremental—costs to society compared to the reductions in concentration levels for successively more stringent options. By measuring the incremental costs and incremental reduction in concentration levels, the approach provides a means for comparing different options and selecting the most cost-effective option.

1.4 Outline of the Report

The remainder of this report is organized as follows.

- Section 2 describes the three remedial options considered in this analysis.
- The estimated costs associated with each remedial option are presented in Section 3.
- Section 4 provides estimates of the changes in average sediment concentrations with different remediation options.
- The results of the cost-effectiveness analysis are presented in Section 5.
- References are included in Section 6.
- ARCADIS staff resumes are presented in Appendix A.
- A current rate schedule can be found in Appendix B.
- Bivalve normality results compiled by Exponent (2003) are presented in Appendix C.

2. Remedial Options

This section discusses the remedial options considered in this assessment.

2.1 Description of the Options

The OMB cost-effectiveness guidance recommends evaluating at least three options—the preferred remedial option, a more stringent option, and a less stringent option—while recognizing that looking at a continuum of options is not feasible. Therefore, the three remedial options listed in Section 1.2 were evaluated. These three options are discussed in greater detail below.

2.1.1 DTR-Recommended Option

The basis for this option is described in the DTR; however, a description of the DTR-Recommended Option is provided below to set the stage for discussions about implementation cost estimates and other associated social costs. The following is summarized from the DTR (SDRWQCB 2010).

The DTR-Recommended Option footprint is approximately 17.4 acres and was developed for the protection of aquatic-dependent wildlife and human health. Due to the spatial heterogeneity associated with concentrations in Shipyard Sediment Site sediment and mobility of aquatic-dependent wildlife and angler-targeted game species, SWACs were utilized to assess potential impacts to human health and aquatic-dependent wildlife. The pre-remedy surface sediment concentrations of the primary COCs are provided in Table 1.

The DTR-Recommended Option cleanup levels were developed to address human health and wildlife beneficial use impairments. These cleanup levels (post-remedial SWACs) were developed to mitigate unreasonable health risk to human health or aquatic dependent wildlife, and were the lowest concentrations that were technologically and economically feasible to achieve (SDRWQCB 2010). According to the DTR, SWACs were not developed for secondary COCs as they are highly correlated with the primary COCs, and remediation of the primary COCs to post-remedial SWACs will address the secondary COCs. In addition, the remedial footprint will be remediated to background levels to ensure the SWACs are attained on a site-wide basis, and to ensure protection of aquatic life beneficial uses (SDRWQCB 2010).

To calculate the SWACs, a geospatial technique (Thiessen polygons) was used to represent the area of the Site represented by each sediment sample. By defining the area most closely associated with each sampling point, a value for that point (e.g., chemical concentration) can be spatially weighted based on the area it represents. Sixty-five polygons were delineated based on the 65 sampling station locations at the Site, as shown in Figure 2. The polygons were then ranked based on a number of factors including the composite SWAC for the five primary COCs, site-specific mean effects quotient (SS-MEQ), and highest concentration of individual primary COCs. Additional details on the calculation of SWACs and ranking of polygons are provided in the DTR (SDRWQCB 2010). The DTR-Recommended Option remedial footprint is defined in the DTR as an area including 23 polygons and approximately 17.4 acres, as detailed in Table 2 and depicted on Figure 2. The polygon containing station NA22 was excluded from the Site, and is being evaluated under the Chollas Creek Mouth Total Maximum Daily Load (TMDL). Additional information is provided in Volume 3 of the DTR (SDRWQCB 2010).

The primary components of the DTR-Recommended Option are debris removal and management, dredging, capping, resuspension controls, and monitoring. The remediation approach was described in the DTR and is summarized below for reference.

- Resuspension controls (silt curtains/oil booms) would be installed to mitigate migration of resuspended sediment prior to intrusive activities. Debris removal and management would proceed following installation of resuspension controls. Debris quantities were assumed to represent 5% of the total dredge volume.

- Dredging would be conducted over approximately 15 acres and target the removal of an estimated 143,400 cubic yards (cy) of sediment. Dredging areas have been divided into the northern dredge unit located adjacent to the BAE Systems Site, which consists of 18 polygons[2], and the southern dredge unit located adjacent to the National Steel and Shipbuilding Company (NASSCO) site, which consists of five polygons (Figure 2). Table 1 shows the estimated dredge volume targeted for removal, dredge depth, and area for each polygon.

- Dredging production was estimated at 1,000 cubic yards per day (cy/day) for approximately 6 months per year (September 15 through March 31). This limited dredging "window" was established to protect the endangered California Least Tern (SDRWQCB 2010; Templeton and Whelan 2010 Pers. Comm.).

- Dredging would be performed via mechanical techniques from the shoreline or barge, depending on the location and depth of material scheduled for removal. Due to shipyard logistics and the presence of marine structures, both unconstrained open-water dredging and constrained dredging from the inner shipyard will be required. The total removal volume (143,400 cy) has been divided between the two categories on a percentage basis: 12.5% for unconstrained and 87.5% for constrained dredging (see Table 3 for removal quantities associated with each dredging type). The percentages were calculated based on the dredge footprint located inside and outside the leasehold boundary (Templeton and Whelan 2010 Pers. Comm.) as depicted on Figure 2.

- Following dredging, confirmation samples would be collected to verify that cleanup levels have been achieved. If necessary, contingency measures such as second pass dredging and/or residual capping would be implemented.
  - Second pass dredging has been assumed over half of the remedial area to a depth of 2 feet, resulting in an additional removal volume of 28,100 cy.
  - Capping would consist of 3 feet of clean sand assumed over half of the dredge footprint.
  - Under pier capping would consist of a 3-foot thick layer of clean sand over the existing sediment (SDRWQCB 2010) in areas which are inaccessible to dredge equipment (under and adjacent to piers, wharves, and bulkheads). The under pier capping footprint encompasses approximately 2.5 acres (see Table 2 and Figure 2).

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[2] The term "polygons" is used throughout the text to denote the Thiessen polygons used in the characterization of the Site.

- Eel grass habitat may be disturbed or destroyed by dredging and capping activities. Eel grass habitat mitigation construction and maintenance was assumed at 5% of the total remedial acreage (0.87 acres).

- Dredged sediment would be offloaded, dewatered, and characterized prior to off-site transportation and disposal.

  – Processing is assumed to include transport of removed material to a staging area in the immediate area of the shipyard operations for stockpiling and addition of lime or cement admixture (as necessary) to facilitate dewatering.

  – Processed sediment would be loaded into 20-ton dump trucks and transported to an off-site disposal facility. An alternative to landfill disposal may be confined aquatic disposal or a near-shore confined disposal facility (SDRWQCB 2010).

- The estimated schedule for implementation of the DTR-Recommended Option is three construction seasons to account for the annual California Least Tern restriction window. The construction duration was provided in the DTR and estimated by AnchorQEA assuming a specific number of disposal trips per day and the quantity of sediment scheduled for removal and disposal (Table 2).

- Water quality monitoring, sediment monitoring (confirmation sampling), and disposal monitoring would be performed during remediation activities. Water quality monitoring (turbidity and dissolved oxygen) would be conducted at a compliance point outside the construction area during active remediation to demonstrate that implementation of the remedy does not result in violations of water quality standards.

- Post-remediation monitoring would be initiated 2 years following the completion of the dredging and capping and continue for a period of up to 10 years (4 events per year).

  – For human health and aquatic-dependent wildlife beneficial uses, post-remediation monitoring would include sediment chemistry (including a subset of samples to be subjected to bioaccumulation testing using the 28-day macoma test).

  – For aquatic wildlife beneficial uses, post-remediation monitoring would include sediment chemistry, toxicity, and benthic community condition assessments (Table 3).

2.1.2 Background Remedial Option

Section 17 of the DTR discusses how the background reference pool was selected (SDRWQCB 2010). In summary, the SDRWQCB selected a group of background stations from three independent sediment quality investigations to compare environmental conditions at the Shipyard Sediment Site with conditions found in other, relatively cleaner areas of San Diego Bay. The criteria for selecting acceptable background stations included: 1) low levels of anthropogenic contaminant concentrations; 2) locations remote from contamination sources; 3) similar biological habitat to the Shipyard Sediment Site; 4) sediment total organic carbon (TOC) and grain size profiles similar to the Shipyard Sediment Site; and 5) adequate sample size for statistical analysis and sediment quality data comparability. The 18 locations selected to represent background conditions were evaluated for sediment chemistry, amphipod survival, and benthic response index (BRI) scores in table 17-2 of the DTR.

Section 29 of the DTR describes the process used to establish background sediment concentrations for the Shipyard Sediment Site (table 29-1) using the 18 selected reference locations (SDRWQCB 2010). Considering the background concentration estimates listed in table 29-1 of the DTR and existing data in all defined polygons within the Site boundary, all polygons would need to be addressed to achieve the objective of reducing concentrations of all COCs to background concentrations within the Site boundary. The estimated extent of remediation under the Background Remedial Option is shown on Figure 3.

The remedial approach for the Background Remedial Option is similar to the approach described above for the DTR-Recommended Option except for the increased remedial footprint. The expanded footprint includes 66 polygons (including NA22)[3] for remediation, as compared to the 23 polygons identified for remediation under the DTR-Recommended Option. The increase in the number of polygons directly impacts several parameters which affect the remedial approach, construction schedule, and cost estimates (further discussed below). These parameters, as detailed in Table 2, include, among other things: approximate total remedial area (150 acres), approximate remedial area targeted for dredging (142 acres), approximate dredge volume (1,150,000 cy), and under pier area targeted for capping (7.2 acres).

Resuspension control installation and debris removal would be conducted prior to dredging activities. Consistent with the DTR-Recommended Option, debris quantities have been estimated at 5% of the total dredge volume. The northern and southern dredge units located within the remedial footprint consist of 35 and 31 polygons, respectively. The estimated extent of dredging is shown on Figure 3. Dredge production and the construction window have been assumed to be the same as the DTR-Recommended Option. The specific dredge volume targeted for removal, dredge depth, and area for each polygon are provided in Table 4. Unconstrained dredging would be conducted at about 60% of the dredge area, whereas constrained dredging would be conducted over about 40% of the area. The results of confirmation sampling conducted following dredging will determine contingency measures, if necessary. Second pass dredging is assumed at the same percentage as the DTR-Recommended Option, resulting in an estimated removal of 240,000 cy, while residual capping assumes 360,000 cy of sand placement.

The under pier capping component of the remedy would be conducted in areas which are inaccessible to dredge equipment, and include areas under and adjacent to piers, wharves, and bulkheads. The under pier

[3] The Background Remedial Option includes polygon NA22, making the total number of polygons 66. NA22 was excluded from the DTR-Recommended Option as described in SDRWQCB (2010) because a TMDL is being developed for the mouth of Chollas Creek, which encompasses NA22. This TMDL will reportedly apply to sediments in the mouth of Chollas Creek.

capping footprint encompasses approximately 7.2 acres, as detailed in Table 2 and depicted on Figure 3. The under pier capping component of the remedy would consist of the placement of a 3-foot thick clean sand layer. Eel grass habitat mitigation has been estimated at 5% of the remedial acreage.

Sediment processing and management would be conducted similar to that of the DTR-Recommended Option. Processed sediment would be transported offsite and disposed at a landfill regulated to accept such waste (SDRWQCB 2010). Implementation of the Background Remedial Option has been estimated at 14 construction seasons, which accounts for the annual California Least Tern restriction window (SDRWQCB 2010; Templeton and Whelan 2010 Pers. Comm.).

Monitoring activities for the Background Remedial Option are the same as those specified for the DTR-Recommended Option (see Section 2.1.1) and include water quality monitoring, sediment monitoring (confirmation sampling), and disposal monitoring. The variation between options is the duration and number of samples/locations which have increased due the size of the remedial footprint. See Tables 3 and 5 for additional details.

2.1.3 Alternative Remedial Option

The DTR assessed potential risks to aquatic life associated with exposure to site sediments (SDRWQCB 2010). Recognizing that there is no promulgated and/or commonly used single method or metric to assess risk, effects, or impacts to aquatic life exposed to contaminated sediments, a weight-of-evidence (WOE) approach using multiple lines of evidence and best professional judgment was used to evaluate the potential for impacts to aquatic life exposed to Shipyard sediments. The output of this assessment was then used to inform the development of remedial options and selection of a recommended alternative (to the DTR-Recommended Option). The Shipyard Sediment Site risk evaluations were conducted on a station-by-station basis in the DTR, and were based on a combination of sediment chemistry, sediment toxicity, and benthic community data (commonly referred to as the Triad). Thirty sediment stations had Triad results, while the remaining 36 stations used other metrics to estimate the health of the benthic community. ARCADIS has independently evaluated the sediment Triad results, and considered the highest relative concentrations of individual chemicals of potential concern (COPCs) in the Thiessen polygons evaluated in the DTR to determine if there is a technically defensible basis to support the development of an Alternative Remedial Option. The goal of this analysis is to establish an alternative which is protective of designated beneficial uses, and therefore addresses the current 303(d) impairment designations (which are based on benthic community impacts and sediment toxicity). ARCADIS' evaluation did not re-evaluate data in all polygons, but instead focused on the 23 sediment sample locations identified in the DTR and their respective polygons proposed for removal in the DTR-Recommended Option.

The following sections describe the different lines of evidence and how ARCADIS utilized them to develop an Alternative Remedial Option that is consistent with the 303(d) listing of the area for elevated levels of copper, mercury, zinc, PAHs, and PCBs in marine sediment impairing the aquatic life, aquatic-dependent wildlife, and human health beneficial uses designated for San Diego Bay. A description of the Alternative Remedial Option is provided in Section 2.1.3.3.

2.1.3.1 Triad Results

Sediment toxicity was evaluated in the DTR using three endpoints: amphipod survival, urchin fertilization, and bivalve development. The interpretation of the results presented in the DTR for both amphipod survival and urchin fertilization appear reasonable, but the bivalve development results require further evaluation to establish their usability for developing an Alternative Remedial Option.

As specified in the standardized bivalve development test (USEPA 1995), normal development in control units should be at least 90% to satisfy test acceptability criteria. However, review of the percent normal shell development of surviving control bivalves in table G-6 (Exponent 2003) shows this criterion was not met for the second batch of test organisms (88%). Failure to meet the minimum percent normal shell development criterion in control exposures indicates that the exposed organisms were potentially more sensitive to stressors than normal and, by USEPA's standardized methodology, renders the collective test(s) unacceptable (which corresponds to all stations analyzed in the second batch[4]).

As described in Appendix H of the Exponent report titled *NASSCO and Southwest Marine Detailed Sediment Investigation* (Exponent 2003), suspect results such as elevated ammonia concentrations in interstitial water and dissolved oxygen values below the recommended minimum value were also reported during the bivalve testing. The interstitial ammonia concentration during the test ranged from 0.24 to 30.2 milligrams per liter (mg/L). Assuming average values for temperature (15 degrees Centigrade [°C]), pH (7.8), salinity (30 parts per trillion [ppt]), and total ammonia (15.2 mg/L), this would result in an unionized ammonia concentration (the toxic portion) of 0.2 mg/L, which is greater than the 0.120 mg/L EC_{50} (Phillips et al. 2005) and suggests that ammonia may be a contributor to the observed toxicity. In addition, dissolved oxygen in several of the overlying water test replicates was lower than the recommended minimum value of 5 mg/L at test termination. Given the uncertainty of exactly when the dissolved oxygen dropped below 5 mg/L (could be between 0 and 24 hours after the previous readings),oxygen deficiency may be a contributor to any toxicity observed in these tests.

Unusually high variability in organism response was also observed in the bivalve development results for several samples.[5] After ARCADIS' review of the data, variability is not clearly attributable to any aspect of

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[4] Second batch samples include test stations NA01, NA03, NA04, NA05, NA09, NA12, NA15, NA16, NA17, NA19, NA22, SW11, SW17, SW18, SW22, SW23, SW25, and SW27.

[5] Unusually high variabiliy observed in test stations NA11, NA12, NA16, SW13, SW17, SW18, SW21, SW23, SW25, and SW27.

laboratory performance or to specific conditions within the unusual replicates. The variability in the test may reflect varying sensitivity within the group of test organisms, handling of the samples or test organisms, the quantity and quality of food provided, and temperature control. In addition, modification of the standard bivalve test methods (USEPA and USACE 1998) to isolate the larvae from the sediment (Anderson et al. 1996, 2001) may have introduced physical variations within the test chamber that affected larval development. The lack of consistency among some bivalve test replicates may indicate problems with the bivalve test method or test conditions, and the data from these tests should be considered suspect.

Taking the above issues and uncertainties into account, ARCADIS re-evaluated the results for both batches of bivalve development results (due to the large sample size the laboratory split the test into two batches [Exponent 2003]). In general, batch 1 had relatively consistent responses across replicates, with corresponding low coefficients of variation. In contrast, batch 2 exposures had poor replication with much higher coefficients of variation (attachment 1, table G-3, Exponent 2003). This sharp increase in variability between batches could potentially be a result of several laboratory issues (as described above) but it appears that a systematic test inconsistency may account for such poor replication. For example, the SW23 test location had one replicate at 52% normal development and all other four replicates were below 15%. Sample location SW17 had a single replicate with 69% normal development and all other replicates were 0%. In addition, a single SW27 test location replicate had 72% normal development and all remaining replicates were below 12%. In each of these three samples, development within an individual replicate far exceeded the 95% reference lower predictive limit (LPL) of 37%, which is used as the criteria for determining toxicity, but poor replication resulted in high variability with mean values below this threshold. The high variability across these sample replicates generates considerable uncertainty when inferring a toxic designation, especially considering that individual replicate values in each sample were above the LPL. These specific bivalve results are therefore considered unreliable and should not be considered when making remedial decisions.

Removal of these suspect bivalve samples (SW17, SW23, and SW27) changes interpretation of the toxicity line of evidence because neither amphipod survival nor urchin fertilization results indicated toxicity for any of these three samples. Thus, the toxicity line of evidence would change from “moderate” to “low” in each of these samples by removing these inconclusive bivalve results. The collective WOE category subsequently changes from “possible” to “unlikely” for the SW27 and SW17 samples. For SW23, the WOE category changes from “likely” to “possible” because the sediment chemistry category is “high.” However, a high sediment chemistry category with corresponding low toxicity for a sample demonstrates lack of dose-response, thus indicating the likelihood for no impact.

In addition to sediment toxicity, sediment chemistry and benthic community metrics were considered as part of the Triad analysis. Although these are considered as independent lines of evidence in the Triad evaluation, they should not all be considered as having the same weight or associated level of certainty. For example, sediment chemistry results for COCs with no established relationship to sediment toxicity or benthic community impacts (especially if a link cannot be established because no effects are present) have a high degree of uncertainty and should be considered to carry a very low weight in determining potential impacts. More specifically, a "moderate" or "high" sediment chemistry ranking for a station with corresponding "low" toxicity and/or "low" benthic community response indicated should not be used as a basis to conclude that remedial actions are necessary to protect designated uses. The chemistry result is somewhat meaningless in the absence of any biological or toxicological response. Several stations including NA06, NA15, and NA17 are currently recommended (in the DTR) for inclusion in the DTR-Recommended Option based solely on the chemistry finding and in the absence of significant toxicity or benthic community effects, or an established exposure-response relationship. These locations are proposed to be dropped from the Alternative Remedial Option based on re-evaluation of the Triad data. The only station with moderate benthic community response is SW04, and this station is retained in the footprint based on our re-evaluation of the Triad data. The proposed modifications to the Triad interpretation provided in the DTR are presented in Table 6 (with summarized rationale), and the influence of our analysis on the development of the Alternative Remedial Option is discussed on a station-by-station basis below.

As describe in the DTR, only limited data were available for the 36 non-Triad locations to assess potential impacts to aquatic life (SDRWQCB 2010). The available data at non-Triad stations generally included surface sediment constituent concentrations and proximate Sediment Profile Image (SPI) analysis of the benthic community successional stage. The classification of benthic community impact (likely, possible, or unlikely) in the DTR for these locations relied upon these available data and site-specific chemical thresholds that were developed from the Triad stations in the Shipyard Report (Exponent 2003). These chemical thresholds include site-specific Lowest Apparent Effects Thresholds (LAETs) for individual COPCs and SS-MEQ results to address the combined effects of multiple COPCs.

ARCADIS reviewed the LAET, SS-MEQ, and successional stage assessments presented in the DTR as lines of evidence for evaluation of the sediment locations without Triad results. The above three results were used in combination with individual constituent concentrations to determine if the removal of the given location would have potential impact on the 303(d) listing in the absence of Triad results. Based on these results, the following BAE Systems Southwest Marine samples were removed from the Alternative Remedial Option: SW05, SW10, SW14, SW16, and SW20. The proposed modifications to the Triad interpretation provided in the DTR are presented in Table 6 (with summarized rationale), and the influence of our analysis on the development of the Alternative Remedial Option is discussed on a station-by-station basis below.

The DTR identified the sediment locations with the ten highest concentrations for each of the nine COPCs (total high molecular weight polycyclic aromatic hydrocarbons [HPAHs], polychlorinated biphenyls [PCBs], tributyl tin [TBT], copper, mercury, lead, arsenic, zinc and cadmium) at the Shipyard Sediment Site (tables 33-3, 33-4, and 33-5 in the DTR; SDRWQCB 2010). ARCADIS used these rankings and locations to evaluate the sediment chemistry of the 23 polygons contained in the Alternative Remedial Option. The sediment chemistry line of evidence was evaluated by comparing how the SWAC for the Site will be affected by the inclusion or removal of a given polygon during the proposed dredging. These sediment concentrations and resulting SWACs were evaluated along with the benthic community and Triad results to determine if the removal of a location would have potential impact on the 303(d) listing for the Site.

The proposed modifications to the Triad interpretation provided in the DTR are presented in Table 6 (with summarized rationale), and the influence of the current analysis on the development of the Alternative Remedial Option are discussed on a station-by-station basis below. Using the available sediment chemistry, benthic community, and sediment toxicity results, ARCADIS proposes the removal of the following 11 Thiessen polygons that are currently included in the DTR-Recommended Option (Table 6):

- **NA06:** WOE for the Triad approach indicates the health of the benthic community is unlikely to be adversely impacted from these sediments. NA06 had low toxicity and low benthic community impacts. Although NA06 has the ninth highest copper, second highest mercury, and sixth highest lead concentrations of all the polygons/samples, the lack of dose response indicates that mercury is not a risk driver. There will be very little effect to the SWACs for copper and lead if NA06 is not remediated.

- **NA15:** WOE for the Triad approach indicates the health of the benthic community is unlikely to be adversely impacted from these sediments. NA15 had low toxicity and low benthic community impacts. NA15 has the seventh highest TBT concentration at the Site, but the lack of a dose response indicates that TBT is a not risk driver. There will be very little effect to the TBT SWAC if NA15 is not remediated.

- **NA17:** Although the WOE indicates a possible adverse impact from these sediments based on some elevated chemistry results, there is no evidence of a dose response relationship that would confirm this possibility. Given the lack of a dose response, as shown by the low toxicity and low benthic community results, it does not appear that elevated concentrations of constituents at NA17 have the potential to cause adverse effects to the benthic community.

- **SW05:** No toxicity or benthic community data are available to complete the Triad evaluation at SW05. There were no COPC exceedances of the LAET and only relatively low exposures are indicated from the COPCs, which do not indicate an adverse impact from these sediments at SW05. There would appear to be very little effect to SWACs for the few COPCs listed at SW05; therefore it is proposed that SW05 not be remediated.

- **SW10:** No toxicity or benthic community data are available to complete the Triad evaluation at this location. Only relatively low exposures are indicated from the COPCs, which do not indicate an adverse impact from these sediments. There will be minimal change in the SWACs for the COPCs at SW10; therefore it is recommended that SW10 not be remediated.

- **SW14:** No toxicity or benthic community data are available to complete the Triad evaluation at this location. There were no exceedances of either the LAET or the SS-MEQ, and the only COPC listed is the ninth highest concentration of TBT. Therefore, based on no indication of benthic toxicity and a single low TBT concentration that will not change the SWAC for TBT, SW14 should not be remediated.

- **SW16:** No toxicity or benthic community data are available to complete the Triad evaluation at SW-16. No COPC concentrations exceeded the LAET at SW16. SW16 is located between three large polygons with low chemistry, and therefore no appreciable increase in protectiveness would be achieved with the removal of SW16.

- **SW17:** The initial designation of "moderate" toxicity in the Triad analysis is based on a low average bivalve development response; however, significant replicate variability in the bivalve response is inconclusive, especially considering the low exposures indicated from the COPCs and the lack of toxicity observed in the amphipod and urchin tests; thus, when the toxicity endpoint is modified to "low" the WOE changes from "possible" to "unlikely." Therefore, the WOE for the Triad approach indicates the health of the benthic community is unlikely to be adversely impacted from these sediments, and with no COPC concentrations in the top ten, it is recommended that SW17 be removed from the Alternative Remedial Option.

- **SW20:** No toxicity or benthic community data are available to complete the Triad. There were no COPC concentrations that exceeded the LAET, and only two constituents had concentrations in the top ten at SW20. Since there will be minimal change in the SWACs for the COPCs at SW20, it is recommended that SW20 not be included in the Alternative Remedial Option.

- **SW23:** The initial designation of "moderate" toxicity in the Triad analysis is based on a low average bivalve development response; however, significant replicate variability in the bivalve response is inconclusive, especially considering the low exposures indicated from the COPCs and the lack of toxicity observed in the amphipod and urchin tests; thus, when the toxicity endpoint is modified to "low" the WOE changes from "possible" to "unlikely." Therefore, the WOE for the Triad approach indicates the health of the benthic community is unlikely to be adversely impacted from these sediments, and with only two COPC concentrations in the top ten, it is recommended that SW23 be removed from the Alternative Remedial Option.

- **SW27:** The initial designation of "moderate" toxicity in the Triad analysis is based on a low average bivalve development response; however, significant replicate variability in the bivalve response is inconclusive, especially considering the low exposures indicated from the COPCs and the lack of toxicity observed in the amphipod and urchin tests; thus, when the toxicity endpoint is modified to "low" the WOE changes from "possible" to "unlikely." Therefore, the WOE for the Triad approach indicates the health of the benthic community is unlikely to be adversely impacted from these sediments, and with no COPC concentrations in the top ten, SW27 should be removed from the Alternative Remedial Option.

Based on the analysis provided above and summarized in Table 6, the removal of 11 polygons from the DTR-Recommended Option is supported. Although this analysis does not support the conclusion that there are significant and/or widespread impacts to the benthic community and/or sediment toxicity, uncertainties exist regarding the potential for risk or impacts in a subset of the 23 polygons that are currently included in the DTR-Recommended Option. Based on the evaluation described above, 12 of the 23 polygons included in the DTR-Recommended Option have been retained to address potential uncertainty, provide a margin of safety for the benthic community, and to address SWAC targets. These polygons, and a description of the source and nature of the residual uncertainty, are addressed below, and their inclusion in the Alternative Remedial Option is summarized in Table 6.

- **NA09:** The Triad results indicated moderate sediment chemistry and moderate benthic toxicity, leading to an overall Triad WOE conclusion of "possible." NA09 is included in the Alternative Remedial Option to address any uncertainty regarding the moderate benthic toxicity classification.

- **NA19:** The Triad results indicated high sediment chemistry and moderate benthic toxicity, leading to an overall Triad WOE conclusion of "likely." NA19 is included in the Alternative Remedial Option to address any uncertainty regarding the "likely impacted" Triad classification driven by the "moderate" benthic toxicity classification.

- **SW01:** SW01 was included in the Alternative Remedial Option due to the lack of Triad results, multiple elevated COPC concentrations, and the proximity to SW02.

- **SW02:** SW02 contains highest concentrations of PCBs, mercury, and cadmium at the Shipyard Sediment Site. Even though the Triad results showed no dose response, this location is included in the Alternative Remedial Option to address any uncertainty regarding the importance of sediment chemistry in achieving SWAC targets.

- **SW04:** The Triad results indicated "high" sediment chemistry and "moderate" benthic community results, leading to an overall Triad WOE conclusion of "likely." SW04 contains the highest concentrations of TBT, copper, lead, arsenic, and zinc. SW04 is included in the Alternative Remedial Option to address any uncertainty regarding the moderate benthic toxicity result, and a goal of achieving SWAC targets.

- **SW08:** The Triad results showed no effects or associated exposure-response relationship at SW08, but this location contains the second highest concentrations of HPAH, TBT, copper, and lead. SW08 is included in the Alternative Remedial Option to address potential uncertainty associated with achieving SWAC targets for these COPCs.

- **SW09:** The Triad results showed no effects or exposure-response at SW09, but this location contains the second highest concentrations of arsenic and zinc. SW09 is included in the Alternative Remedial Option to address potential uncertainty associated with achieving SWAC targets for these COPCs.

- **SW13:** The Triad results indicated elevated sediment chemistry and "moderate" benthic toxicity, leading to an overall Triad WOE conclusion of "likely." SW13 is contained in the Alternative Remedial Option to address potential uncertainty regarding the "likely impacted" Triad classification driven by the "moderate" benthic toxicity classification.

- **SW21:** The Triad results indicated no effects or exposure-response at SW21, but this location contains the third highest concentrations of PCBs. SW21 is included in the Alternative Remedial Option to address potential uncertainty associated with achieving the SWAC target for PCBs.

- **SW22:** The Triad results indicated "high" sediment chemistry and "moderate" benthic toxicity, leading to an overall Triad WOE conclusion of "likely." SW22 is included in the Alternative Remedial Option to address any uncertainty regarding the "likely impacted" Triad classification driven by the "moderate" benthic toxicity classification.

- **SW24:** SW24 contained the highest concentration of HPAH. Without Triad results to determine the presence of effects or an associated exposure-response relationship, SW24 is included in the Alternative Remedial Option to account for potential uncertainty associated with achieving the SWAC targets for HPAHs.

- **SW28:** SW28 contained relatively high concentrations of HPAH and PCBs. Without Triad results to determine the presence of effects or an associated exposure-response relationship, SW28 is included in the Alternative Remedial Option to account for potential uncertainty associated with achieving SWAC targets for HPAHs and PCBs.

2.1.3.2 Implications of Uncertainties for Protectiveness of Beneficial Uses

Removal of the 11 identified polygons for the development of the Alternative Remedial Option is technically defensible, given the lack of toxicity or benthic community evidence indicating impacts at these stations, and the relatively lower weight given to sediment chemistry results driven by a lack of any apparent exposure response relationship. The polygons retained in the Alternative Remedial Option are included, recognizing that some uncertainty exists regarding the potential influence of chemical concentrations in these areas on attainment of beneficial uses, and a desire to incorporate a margin of safety into the areas selected for remediation. It is important to discuss, however, the real potential implications of the uncertainties which drive inclusion of these areas in the Alternative Remedial Option, as these uncertainties do not likely translate to overall impacts to the designated beneficial uses of sediments within the boundary of the Site.

For example, the primary source of sediment toxicity-associated uncertainty is a small number of bivalve development results. Three of the eleven sites proposed for removal from the DTR-Recommended Option indicated possible impairment according to the bivalve development assay. It is important to note that in each of these cases (where some level of bivalve larval development response was observed), no amphipod survival or urchin fertilization toxicity was observed. Disregarding the issues associated with the bivalve bioassay (described above), the results from these three stations are not considered to indicate use impairment. They represent a relatively small proportion of the overall Site, and an even smaller proportion of benthic habitat in south San Diego Bay. Even if there are small proportional effects to bivalve larval development in a relatively small and isolated area of this heavily used industrialized Shipyard area, these potential effects are not expected to impact the overall bivalve community at the Site or in the larger bay. Additionally, this specific aspect of use (the use of substrate for larval development) represents only a small piece of ecological use. The lack of toxicity in two other sensitive species and endpoints, and a general lack of benthic community effects, indicate that uses are generally protected. Therefore, although uncertainty exists regarding the potential for limited and isolated effects to bivalve larval development, this uncertainty does not translate to potential impacts to sediment uses in general.

2.1.3.3 Summary of Alternative Remedial Option

The Alternative Remedial Option derived in this section will be referred to as the “Alternative Remedial Option” in the remainder of this report. The approach for implementing the Alternative Remedial Option is similar to the approach provided for the other two options, with the exception of exhibiting a reduced remedial footprint. Under the Alternative Remedial Option, 12 polygons will be targeted for remediation as compared to 23 polygons for the DTR-Recommended Option and 66 for the Background Remedial Option. The reduced number of polygons directly impacts several key parameters in the remedial approach including total remedial area (7.5 acres), approximate remedial area targeted for dredging (6.5 acres), approximate dredge volume (65,250 cy), and approximate under pier capping area (1.0 acres). See Table 2 for a summary of key parameters for the three remedial options. The approach to remedy implementation remains consistent over the three remedial options and includes resuspension controls, debris removal and management, dredging, second pass dredging and/or residual capping (as necessary), under pier capping, sediment dewatering, and off-site transportation and disposal at a commercial landfill.

As with the DTR-Recommended Option, debris removal and management is assumed at 5% of the dredge volume. Dredging would be conducted over an area of approximately 6.5 acres and target the removal of approximately 65,250 cy of sediment. The northern and southern dredge units located within the remedial footprint consist of 10 and 2 polygons, respectively. Dredging and/or capping would be conducted in each polygon as identified on Figure 4. Dredging production and construction window is assumed to be the same as the DTR-Recommended Option. The specific dredge volume targeted for removal, dredge depth, and area for each polygon is provided in Table 7. The percentages delineating unconstrained and constrained dredging have been calculated at 20% and 80%. Second pass dredging is assumed at the same percentage as the DTR-Recommended Option, resulting in an estimated removal volume of 12,100 cy, while residual capping is estimated at a volume of approximately 18,100 cy.

The under pier capping footprint encompasses approximately 1.0 acres, as detailed in Table 2 and depicted on Figure 4. Eel grass habitat mitigation construction and maintenance is estimated at 0.37 acres, using the same percentage as the DTR-Recommended Option. Sediment processing and management would be conducted similar to that for the other two remedial options. Processed sediment would be transported and disposed at a landfill regulated to accept such waste (SDRWQCB 2010). Implementation of the Alternative Remedial Option has been estimated at two construction seasons, which accounts for the annual California Least Tern restriction window.

Monitoring activities for the Alternative Remedial Option are the same as those specified for the other options (see Sections 2.1.1 and 2.1.2) and include water quality monitoring, sediment monitoring (confirmation sampling), and disposal monitoring. The variation between options is the duration and number of samples/locations, which have decreased due the reduced size of the remedial footprint. See Tables 2 and 8 for additional details.

2.1.3.4 Compliance with California State Water Board Resolution No. 92-49

In part, California State Water Board Resolution No. 92-49 addresses how—barring the feasibility of cleanup to background—a proposed cleanup approach will meet the following requirements:

> *[D]ischargers are required to clean up and abate the effects of discharges in a manner that promotes attainment of either background water quality, or the best water quality which is reasonable if background levels of water quality cannot be restored, considering all demands being made and to be made on those waters and the total values involved, beneficial and detrimental, economic and social, tangible and intangible*
>
> *Any such alternative cleanup level shall:*
>
> – *Be consistent with maximum benefit to the people of the state*
> – *Not unreasonably affect present and anticipated beneficial use of such water; and*
> – *Not result in water quality less than that prescribed in the Water Quality Control Plans and Policies adopted by the State and Regional Water Boards."*

Since the available data do not indicate impairment of the beneficial uses, the performance of the three options—the DTR-Recommended Option, the less stringent Alternative Remedial Option, and the Background Remedial Option—may only be compared against these requirements in a relative way.

Calculations presented in Section 4, Effectiveness Metric, show that increasing the area of remediation from the amount identified for the Alternative Remedial Option to that of the DTR-Recommended Option results in relatively small decreases in exposure concentrations, relative to background concentrations or the human health criteria. Additionally, Section 2.1.3.2 points out that substantial uncertainty exists about the relationship between remediation and any reduction in impact, as measured by the Triad results.

The Background Remedial Option removes additional sediments when compared to the DTR-Recommended Option, and that additional remediation would, of course, result in the removal of additional mass of the COPCs. For one COPC (PCBs) the background concentration fails to meet the human health criteria. The ecological benefits of this additional remediation are also uncertain.

Under the consideration of the “maximum benefit” of the alternatives, the DTR concluded that the DTR-Recommended Option would have fewer impacts to the community than the Background Remedial Option (SDRWQCB 2010). The differences in biological or ecological benefits between the three alternatives are uncertain and possibly indistinguishable, and therefore any differences between them in beneficial uses or water quality resulting from the remediation are also likely indistinguishable.

3. Costs of Remedial Options

This section presents the estimated costs for the three remedial options. It also provides an overview of the different cost components considered in the evaluation.

3.1 Overview of Cost Assessment

This section evaluates potential social costs—that is, the costs to society as a whole—as it relates to the three options. This approach is consistent with sound cost assessment as noted by the USEPA and OMB (USEPA 2000, OMB 2003) that requires a complete consideration of social costs.

> *The total social cost is the sum of the opportunity costs incurred by society because of a new regulatory policy; the opportunity costs are the value of the goods and services lost by society resulting from the use of resources to comply with and implement the regulation, and from reductions in output.* (USEPA 2000, p. 113)

The USEPA guidelines further describe five basic components of total social costs (USEPA 2000, pp. 113-114):

- *Real-resource compliance costs*, which consist of the actual costs of the additional social resources (e.g., materials for control equipment, labor for the operation of control equipment, and resources related to changes in production processes and product markets), including unpriced social resources, that affected entities would use as a result of the policy in question;

- *Government regulatory costs*, which are the costs to the government of monitoring, administering, and enforcing compliance with the proposed policy;

- *Social welfare losses*, which are losses in producer and consumer surplus attributable to the proposed policy's effects on prices and the production of goods and services;

- *Transitional costs*, which include the value of any displaced resources and the costs of reallocating these resources (e.g., the cost to society of the dislocation caused by unemployment); and

- *Indirect costs*, which include any adverse effects on product quality, productivity, innovation, and indirect market effects that would result from the policy in question.

As noted by the USEPA, of these five components of total social costs, the most significant component is generally the value of the real-resource compliance costs. As such, this report focuses on the potential real-resource costs of the options, referred to as remediation costs, and excludes other components of social costs from the quantitative evaluation. To the extent that these other social costs are relevant to the options, total social costs of the options would be understated. Section 3.4 provides a qualitative discussion of other social costs that are not quantified.

3.2 Discussion of Costs by Option

The following sections discuss the estimated potential remediation costs for the three options. The cost estimates rely on the inputs and discussions obtained from prior cost estimates developed by AnchorQEA. This includes the costs presented in the DTR for the DTR-Recommended Option as well as costs for the Background Remedial Option. The cost details provided by AnchorQEA for the DTR-Recommended Option provided the basis for estimating remediation costs associated with the Background Remedial Option and the Alternative Remedial Option. For purposes of comparison, the estimated costs for the other two remedial options were developed using the same line items, unit costs, and best efforts to proportion other costs based on the size, cost or estimated duration of the remedial option. The remediation costs for each option include direct construction costs and long-term monitoring costs. All costs are presented in 2010 dollars.

3.2.1 DTR-Recommended Option

The total cost for the implementation of the DTR-Recommended Option, as developed by Anchor QEA and provided in the appendix for Section 32 of the DTR, is $58.1 million (MM) (SDRWQCB 2010). The estimate is reproduced as Table 3 herein. Total direct construction costs were calculated at approximately $38.9 MM. Bid management and support, construction management, contingency costs, monitoring costs, and other non-construction costs were calculated at approximately $19.2 MM. The cost estimate assumes that work is to be completed in three construction seasons, resulting in three mobilizations and demobilizations.

3.2.2 Background Remedial Option

The total estimated cost for implementing the Background Remedial Option is $379.5 MM (Table 5). The cost estimates utilized the same unit costs as those provided for the DTR-Recommended Option, with the exception of Additional Pre-Design Site Characterization, Survey and Engineering Design, and Permitting. These line items used a percent multiplier based on the DTR-Recommended Option unit cost per line item and sum of the direct construction costs, excluding Additional Pre-design Site Characterization, Survey and Engineering, and Permitting. For example, the unit cost for permitting for the DTR-Recommended Option was estimated at $400,000, which is 1 percent of the sum of the direct construction costs: $36,568,785, excluding Additional Pre-design Site Characterization, Survey and Engineering, and Permitting. The Permitting line item for the Background Remedial Option was then estimated by taking 1 percent of the sum of direct construction costs for the Background Remedial Option, excluding Additional Pre-design Site Characterization, Survey and Engineering, and Permitting. Based on this approach, the total direct construction costs were calculated at approximately $264.2 MM. Bid management and support, construction management, contingency costs, monitoring costs, and other non-construction costs were calculated at approximately $115.3 MM.

The cost estimate assumes that work is to be completed in 14 construction seasons, resulting in 14 mobilizations and demobilizations.

3.2.3 Alternative Remedial Option

The total cost for the implementation of the Alternative Remedial Option is $29.7 MM (Table 8). The cost estimates utilized the same unit costs as those provided for the DTR-Recommended Option, with the exception of Additional Pre-Design Site Characterization, Survey, and Engineering Design and Permitting. These line items used a percent multiplier based on the DTR-Recommended Option unit cost per line item and sum of the direct construction costs, excluding Additional Pre-design Site Characterization, Survey and Engineering, and Permitting, similar to the approach described above for the Background Remedial Option. Based on this approach, the total direct construction costs were calculated at approximately $19.2 MM. Bid management and support, construction management, contingency costs, monitoring, and other non-construction costs were calculated at approximately $10.5 MM.

The cost estimate assumes that work is to be completed in two construction seasons, resulting in two mobilizations and demobilizations.

3.3 Present Value Analysis of Costs

The remediation costs for each option discussed above are presented in 2010 dollars and are expected to be incurred at different points in time (and have different durations). Because costs occur in different years, present value analysis, or discounting, is appropriate to account for the time value of money. Conducting present value analysis requires using an appropriate discount rate. Following OMB and USEPA guidance, the cost-effectiveness analysis applies both a 3% and a 7% annual real (inflation-adjusted) discount rate. In addition, it is assumed that costs occur in a steady stream (and not in a lump sum at year-end). We make the appropriate adjustment by applying a mid-year discount rate. The cash flow assumptions for the Alternative Remedial Option, DTR-Recommended Remedial Option, and Background Remedial Option are provided in Table 9. Table 10 shows the present value costs for each option using the different discount rates. Discounting has the largest impact on the Background Remedial Option, given the longer duration associated with this option.

3.4 Discussion of Other Social Costs

As discussed earlier, there are several components of social costs. The remedial costs presented above do not represent the true total cost of the options. Other social costs associated with these options that are likely to occur, and are potentially significant but are not quantified, include:

- Community impacts
- Habitat impacts (beyond eel grass mitigation costs, which were included)
- Business impacts.

The magnitude and duration of these impacts is directly related to the size and duration of the selected remedial option. By not quantifying these other social cost components, the cost estimates developed understate the expected total social costs of the remedial options.

The DTR concluded that the DTR-Recommended Option would have fewer impacts to the community than the Background Remedial Option (SDRWQCB 2010). The potential social costs of the DTR-Recommended

Option and the Background Remedial Option are discussed in more detail below, as well as potential social costs of the Alternative Remedial Option.

3.4.1 Community Impacts

Potential community impacts associated with remedial implementation include noise, increased traffic, air quality, and the potential for release of contaminants into the bay. The magnitude and duration of the community impacts vary for the three remedial options. The in-water work for all three options would be limited to September 15 to March 31, although some upland-located activities may occur year round. The Alternative Remedial Option is estimated to have a construction duration of approximately two construction seasons. The DTR-Recommended Option is estimated to last one additional construction season (SDRWQB 2010). The background remedial option would be a significantly longer project, with an estimated duration of approximately 14 construction seasons (SDRWQB 2010) (see Table 2).

During construction, noise will be generated by construction equipment used in-water and at the upland staging site as well as trucks transporting sediment to the landfill (assumed to be the Otay Landfill in Chula Vista, California). This noise may impact local residents and businesses 24 hours a day for the duration of construction unless operations are limited to daytime hours only.

Marine and road traffic will be increased in the vicinity of the upland staging site. Marine traffic will be increased by equipment such as dredges, barges, tugboats, and support boats and may also be impacted by the presence of resuspension control devices (silt curtains, booms). Road traffic impacts may include noise, increased congestion on local streets, increased diesel and greenhouse gas emissions, and increased risk of accidents. It is anticipated that trucks will be used to transport sediment offsite from the dewatering/processing site to an off-site landfill, and that this would be the greatest traffic impact of construction to the community. Depending on the location of the upland staging site, this traffic is expected to impact city streets used by local residents and workers (both vehicles and pedestrians). The number of trucks and duration of truck transport is directly related to the quantity of sediment dredged. The volume of truck traffic was estimated assuming approximately 20 tons of sediment would be transported offsite per truck, and that each truckload will be transported approximately 25 miles. The potential risk of accidents and resulting injuries and fatalities were estimated using published large truck accident statistics (U.S. Department of Transportation [USDOT] 2010a, 2010b) and the estimated total miles traveled for each option. Tables 11 and 12 summarize the truck traffic and accident statistics for each of the options.

The Alternative Remedial Option would have a little less than half of the trucks and mileage required for the DTR-Recommended Option and approximately 6% of the trucks and mileage required for the Background Remedial Option. The DTR-Recommended Option would require approximately 12% of the trucks and mileage required for the Background Remedial Option. The Background Remedial Option would have a significantly larger impact on traffic than the other two options, both in terms of overall duration and volume of traffic. The risk of accidents is proportional to the total miles traveled; therefore the options with the greatest total mileage have the greatest potential risk for accident. The Background Remedial Option would have significantly greater risks of accidents and accident-related injuries or fatalities than the DTR-Recommended Option and the Alternative Remedial Option. In 2008, approximately 11% of all motor vehicle accident fatalities involved a large truck[6] (USDOT 2010a).

Dredging will resuspend contaminated sediment, which would act to elevate the suspended solids and the concentration of contaminants in the water column. It is anticipated that the remedial design would include measures to reduce the potential for resuspension; however, resuspension cannot be eliminated completely. The potential for resuspension is a function of removal method and removal quantity and would therefore be the greatest for the Background Remedial Option, followed by the DTR-Recommended Option, with the Alternative Remedial Option having the lowest impact from resuspension.

Air quality is another important quality of life parameter that may be impacted by the remediation. The Alternative Remedial Option would have the lowest overall potential for air emissions and the shortest duration of air emissions due to the reduced dredging and disposal volume and associated reduction in truck traffic. The DTR-Recommended Option would have greater potential for air emissions in comparison with the Alternative Remedial Option, but would have significantly lower potential for air emissions and a significantly lower duration of air emissions in comparison with the Background Remedial Option. Air quality impacts of the remedial implementation potentially include the following:

- Vehicle, off-road, and diesel- and gasoline-operated marine equipment may adversely affect ambient air quality and increase emissions of criteria pollutants, in addition to greenhouse gases.

- Dredging and handling of contaminated sediment have the potential to result in air emissions by each of following mechanisms:

  - Volatilization from the water column (bay) during dredging due to increased levels of chemical contaminants dissolved into the water column. Under these conditions, chemicals are released via chemical transport processes through the water column and then volatilized through the air-water interface from the water surface.
  - Volatilization from exposed sediment on a barge or at the upland staging site.
  - Airborne particulate matter, or fugitive dust, from the exposed sediment.

- Odors caused by the volatilization of contaminants in the sediment or naturally occurring, sulfur-containing compounds or decaying vegetation/biota in the sediment.

[6] USDOT defines a large truck as a truck with over 10,000 pounds gross vehicle weight rating.

The Alternative Remedial Option is anticipated to have the smallest amount of community impacts, followed by the DTR-Recommended Option, and then by the Background Remedial Option. Both the Alternative Remedial Option and the DTR-Recommended Option will have significantly less noise, less truck traffic, lower potential for traffic accidents, less potential air emissions, and less overall disruption to the local community in comparison with the Background Remedial Option. Finally, the Alternative Remedial Option and DTR-Recommended Option reduce the volume of landfill capacity required to dispose of the removed sediment in comparison with the Background Remedial Option.

3.4.2 Habitat Impacts

Dredging and other in-water construction activities may have the potential for both short-and long-term impacts on the habitat. Short-term effects of dredging would include destruction of benthic macroinvertebrate communities and eelgrass habitat, as well as resuspension. Eelgrass has been observed in the shallowest water near the west and east ends of the shipyards, but was not observed in the center of either of the shipyards where most ship construction and ship repair occurs (Exponent 2003). Eelgrass is presently located in water depths of less than 10 feet. Epibenthic organisms (e.g., fish and lobsters) that feed on benthic macroinvertebrates or that use the eelgrass beds as nurseries would also be affected due to reduced resources at the Site (Exponent 2003). In the long-term, benthic macroinvertebrate communities are likely to be reestablished (Exponent 2003). However, changes in habitat such as increased water depths may result in permanent changes in habitat. In particular, eelgrass would be affected by deeper water. Restoration of eelgrass beds would be required and some mitigation costs have been included in the remedial cost estimates, but there is the potential that restoration may not be successful in reestablishing all of the disturbed eelgrass beds and the mitigation costs may not accurately capture the total costs for habitat impacts.

The distribution of eelgrass at BAE and NASSCO from a previous investigation (figures 2-8 and 2-9; Exponent 2003) was compared with the remedial areas for each alternative. The DTR-Recommended Option would likely disturb all of the eelgrass beds at BAE, and up to half of the eelgrass beds along the western portion of the NASSCO site. The Alternative Remedial Option would likely disturb most of the eelgrass beds at BAE and one to three eel grass beds along the western-most portion of NASSCO. Thus, the Alternative Remedial Option would have less impact on the eelgrass habitat, possibly up to 50% less than the DTR-Recommended Option. The Background Remedial Option would likely disturb all of the eelgrass beds previously observed at both BAE and NASSCO. The Background Remedial Option may impact as much as 25 to 30% more eelgrass beds than the DTR-Recommended Option[7].

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[7] The cost estimates utilize the DTR assumption that 5% of the remedial area will require mitigation.

3.4.3 Business Impacts

The remedial implementation will directly impact the shipyards and may indirectly impact shipyard customers (e.g., the Navy), shipyard employees, shipyard subcontractors and suppliers, and the local economy. The magnitude of the business impacts associated with each remedial options business impact is dependent on the construction duration and amount of construction adjacent to or within the shipyard work areas. The design and remedial action plan for the remedies would include measures to reduce the impacts to the shipyard, such as careful coordination and re-scheduling of work adjacent to or within the shipyard work area. However, the location and extent of in-water construction make conflicts with shipyard operations unavoidable for all three of the remedial options. The extent of these impacts would be related to both the size of the areas to be remediated, as it overlaps with the shipyard operations, as well as overall construction duration.

The shipyards perform strategically important ship maintenance, repair, and modernization work and are currently performing important multiyear contracts for both military and commercial customers, including the building of double-hulled petroleum tanks. Delays or interruptions in the delivery of these ships would potentially have significant impacts on these important customers.

The shipyard's work is scheduled several years in advance, and shipyard berths and dry docks are generally fully utilized. NASSCO and BAE are the only two shipyards in California that are capable of providing both dry docking and pier-side berthing for these contracts. Interruptions and delay in ship construction activities not only would cause a breach of the schedule terms of those contracts, but would substantially drive up the costs of performing those contracts as scheduled work was disrupted and performed in later periods. The shipyards could be exposed to millions of dollars of potential damages to both their customers and subcontractors. Interruptions in repair activities would have significant adverse consequences to shipyard employees, subcontractors, and Navy contractors. Although some work could be redirected to other shipyards, if larger contracts cannot be completed because of disruptions due to the remediation, this work would have to be performed at facilities outside of California. The local tax base would also be affected, as taxable revenue from the shipyards and other local businesses would be reduced.

The three remedial options all have the potential to negatively impact the economy as described above. The Alternative Remedial Option would have the least impact due to the shorter duration and decreased amount of work in the vicinity of the shipyards. In comparison with the Alternative Remedial Option, the DTR-Recommended Option would have a greater impact due to the additional construction season and greater amount of dredging and capping in the shipyard's work area. The Background Remedial Option would have a significantly longer-term impact due to the length of construction, which is 11 more seasons than the DTR-Recommended Option. The Background Remedial Option includes the entire shipyard leasehold and would affect all of the shipyard berths and docks at some point during the 14 years of construction. The Background Remedial Option would likely impact the shipyard's productivity over a long period of time, which may adversely affect the shipyards and the local economy. The DTR-Recommended Option and Alternative Remedial Option would negatively affect the shipyards and San Diego economy for a shorter time period and to a lesser extent than the Background Remedial Option.

Conversely, the remedial implementation is likely to have some short-term positive economic impacts, such as creation of construction jobs and additional tax revenue from dredging activities. However, this positive impact is likely to be limited (in terms of offsetting the negative impacts) as the marine contractors are likely to bring in skilled workers from outside the area and some of the materials and expenses are likely to be purchased or spent outside the local area (e.g., clean fill material, landfill fees, etc.).

4. Effectiveness Metric

Using the Alternative Remedial Option discussed above, an alternative footprint was derived for the Site. One means to evaluate the effectiveness of this option, in comparison to others, is by comparison of its SWACs to the SWACs representing the current conditions at the Site. While the SWAC is not a direct expression of the benefit to the biological community that may be provided by a given remedial option, it was utilized in the DTR. For comparability, it is used herein. In this section, changes in SWACs under the different potential remedial options are considered.

4.1 Data and Methods

Surface sediment chemistry data and Thiessen polygon surface areas were obtained from the DTR (September 2010). This data was used to calculate pre- and post-remediation SWACs for five analytes of concern: copper, mercury, HPAHs, total PCB congeners, and TBT. Total HPAHs and PCBs, as presented in the DTR, were calculated using one-half the detection limit for nondetects. SWACs were calculated as the sum of polygon areas times analyte concentration divided by the total areas. The pre-remediation and post-remediation SWACs, as presented in the DTR, were recalculated as a quality control check of the dataset and calculation methods used herein.

4.1.1 Post-Remediation SWAC Calculation Method – DTR

The DTR identifies 23 polygons for remediation. However, the DTR acknowledges that dredging these oddly shaped polygons poses feasibility issues. The DTR's proposed remediation is, therefore, based on sediment management units (SMUs). SWAC calculations presented in the DTR are based on SMU areas, where dredging or other under pier remediation is proposed. For each station, the DTR identifies the area within the remediation footprint and/or the area outside the remediation footprint (see tables A32-3 and A33-8 of the DTR). For SWAC calculations, analyte concentrations within the remediation footprint are replaced with the upper prediction limit (UPL) calculated from the background reference population. Where only a portion of a Thiessen polygon is identified for removal, SWACs are calculated as follows:

$$SWAC = ([\text{Polygon Area}_{\text{outside footprint}} \times \text{Station Conc}] + [\text{Polygon Area}_{\text{within footprint}} \times \text{UPL}]) / \text{Total Polygon Area}$$

In its post-remediation SWAC calculations, the DTR appears to distinguish between dredge remedial areas and under pier remedial areas. Based on ARCADIS' review of their calculations (and the areas presented in tables A33-2 and A33-8), the DTR SWAC calculations only use background concentrations in association with the areas to be dredged; whereas, the remedial areas under piers are associated with the pre-remediation analyte concentration for that polygon. For instance, SW04 (22681.7 square feet [sq-ft]) appears entirely within the remedial boundary on figure 33-4; however, a section of the polygon is identified for under pier remediation. The DTR identifies only 15943.17 sq-ft as an area to be remediated and the remaining 6738.53 sq-ft as being outside the remediation footprint. There are other inconsistencies between figures 33-4 and 33-5 and the polygon areas inside and outside the remediation footprint. For instance:

- SW03 appears to be entirely outside the remediation footprint. However, the DTR identifies approximately 200 sq-ft (of the total 48811 sq-ft) as being outside the remediation footprint.

- Similarly, NA15 and NA17 appear to be entirely within the remediation footprint, whereas a fraction of the area is identified as being outside the remediation footprint.

These differences in assignment of areal extent to remediated—or un-remediated—portions of the footprint are relatively small in comparison to the total areas of the site and proposed remediation. Table 15 provides the estimated exposure reduction calculations for the options applied in the cost-effectiveness analysis in Section 5.

4.1.2 Alternative Post-Remediation SWAC Calculation Method

For the consideration of the Alternative Remedial Option, SWACs were calculated on the basis on total area represented by the Thiessen polygons associated with sampling locations, independent of SMU areas. To facilitate a direct comparison of post-remediation SWACs between alternative remediation options (as well as to current and background SWACs), ARCADIS re-calculated the SWACs using the 23 Thiessen polygons associated with those samples identified by the DTR for remediation. As will be seen below, the differences between SWACs based on SMUs and Thiessen polygons for the DTR-Recommended Option are relatively small for all chemicals.

ARCADIS calculated SWACs using an alternate remediation footprint, in which 12 polygons are identified for remediation (i.e., the Alternative Remedial Option). Samples were identified as “North Bay” and “South Bay.” SWACs calculations herein were based on the combined dataset, which matches the approach of the DTR.

The DTR uses a calculation of decrease in SWAC for a remedial alternative, scaled by the difference between current SWAC and background SWAC; the differences in SWACs results between remedial alternatives are also evaluated using this metric.

4.2 Results and Comparisons of Alternative Remedial Footprints

SWACs were calculated for four scenarios:

- Pre-remediation – current conditions
- DTR-Recommended Option – remediation footprint identified in the DTR
- Background Remedial Option – based on the background concentrations provided in the DTR
- Alternative Remedial Option – alternative remediation footprint.

For the DTR-Recommended Option, concentrations based on the SMUs were slightly higher than those based on the Thiessen polygons (for the five chemicals considered in this analysis, the exception was mercury, for which the results were essentially equal) (Table 13). SWACs based on Thiessen polygons are, therefore, slightly lower, which serves to make the DTR-Recommended Option using this approach slightly more favorable in comparison to SWACs for the Alternative Remedial Option.

The SWACs are lower for the DTR-Recommended Option than for the Alternative Remedial Option (Table 13). This is not surprising, given that more areas are identified for removal, and the constituent concentrations for samples representing those areas are greater than the background. The differences between the DTR-Recommended Option and the Alternative Remedial Option are not larger than the differences between the current conditions and the Alternative Remedial Option. This suggests that:

- No samples selected for the DTR-Recommended Option but not selected for the Alternative Remedial Option have substantial influence on the resultant SWACs.
- The additional areas of remediation identified in the DTR-Recommended Option do not result in SWACs which are conspicuously closer to the background concentrations predicted in the DTR for those chemicals.

The increased remediation effort associated with the DTR-Recommended Option does not result in conspicuously greater reductions in SWACs.

The decreases in SWACs between the remedial options may also be evaluated using the formula provided in the DTR:

$$\text{Proportional Decrease} = (\text{SWAC}_{\text{Current}} - \text{SWAC}_{\text{Remediation Option}}) / (\text{SWAC}_{\text{Current}} - \text{SWAC}_{\text{Background}})$$

As the post-remediation SWAC approaches the background concentration, the result approaches 100%.

The proportional decreases for the Alternative Remedial Option range from 26 to 43% across the chemicals of concern, averaging 31%; for the DTR-Recommended Option, the range and average are 44 to 59% and 49%, respectively. The differences in proportional decrease are almost constant across the chemicals of concern, ranging from 16 to 20%, with an average decrease of 18% (Table 14).

In summary, the results indicate that increasing the number of areas of remediation from 12 to 23 and increasing the area of remediation from approximately 7.5 to 17.4 acres does not result in a commensurately proportional decrease in SWAC. The results for each chemical of concern may be summarized as follows:

- For copper and mercury, current SWACs are less than twice background concentrations, allowing for a relatively small potential decrease in exposure concentrations for any remedial option.

- Current HPAHs and TBT SWACs are roughly five and seven times greater, respectively, than background concentrations. Increasing the area of remediation from the Alternative Remedial Option to the DTR-Recommended Option, however, results in only 18 and 20% greater reduction in SWACs, respectively. Neither remedial option approaches a substantial reduction in the 5X and 7X differences between current and background SWACs, with the DTR-Recommended Option reducing SWACs for both chemicals by only 44%.

- For PCBs, the DTR-Recommended Option results in only a 16% greater reduction in SWAC when compared to the Alternative Remedial Option, resulting in a decrease of approximately 60% from the current average concentration. Neither remedial option, however, meets the human health criterion; indeed, the background concentration exceeds the criterion. The absolute or incremental decreases in SWAC for PCBs are not, therefore, substantially different between the remedial options.

In an alternative analysis, Integral concluded that:

> *The results of the evaluation of possible biological effects-based metrics indicate that the WOE categories in the DTR do not correspond to either simple or complex measurements of actual biological effects. The result is consistent with the relatively minor level of adverse effects that have been observed at the shipyard site (Exponent 2003, SDRWQCB 2010, Nielsen 2011, Integral 2011).*

5. Cost-Effectiveness Analysis Results

This section presents the cost-effectiveness of the three options. Cost effectiveness—measured as the added costs to society compared to the reductions in exposure levels—is a useful metric that allows comparisons of the options. The results presented in Figures 5 and 6 show the incremental costs and incremental reduction in exposure relative to background levels, measured in percent for the five primary COCs, for the increasingly larger remedial footprint levels.[8] For example, in analyzing the cost-effectiveness of the DTR-Recommended Option, we estimate the added cost per additional exposure reduction relative to the (less stringent) Alternative Remedial Option. This information is important to understand the true cost-effectiveness of the selected option and for deciding whether it is economically feasible to adopt a more costly remedial option.

Figures 5 and 6 show that the incremental cost-effectiveness of adopting the Background Remedial option is substantially more expensive than the other two options. The cost per exposure reduction (measured relative to background levels) increases from about $900,000 under the Alternative Remedial Option to about $2,300,000 under the DTR-Recommended Option. However, the incremental cost per exposure reduction under the Background Remedial Option is $3,400,000 (using a 7% discount rate) to almost $4,400,000 (using a 3% discount rate), much greater than the other two options. This differential will increase significantly when we consider the impacts of the un-quantified costs which are substantially worse under the Background Remedial Option.

[8] The evaluation applies the same metric as in the DTR in measuring the effectiveness of the options. In particular, the DTR applies an exposure reduction calculation using estimated post-remedial surface-area weighted average concentrations (SWAC) for the primary COCs. “Exposure reduction was defined for this purpose as the reduction in sediment SWAC for the shipyard site, relative to background, where the pre-remedial SWAC is considered zero reduction and background is considered 100 percent reduction” (SDRWQCB 2010).

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ARCADIS

Tables

Table 1. Summary of DTR-Recommended Option

Expert Report on Economic Feasibility

Shipyard Sediment Site

Polygon ID	Total Remedial Area (sf)	Dredging Area (sf)	Under Pier Area (sf)	Rock Protection (tons)	Dredge Depth[2] (ft)	Dredge Volume Per Polygon (cy)	Pre-Remedy Surface Sediment Chemistry				
							Copper (mg/kg)	Mercury (mg/kg)	Total HPAH (half DL) (µg/kg)	Total PCB (µg/kg)	TBT (µg/kg)
SW04	22,921	16,282	6,639	1,453	6	3,618	1,500	1.75	14,000	4,000	3,250
SW08	15,421	9,066	6,355	1,547	7	2,350	920	2.25	25,500	2,100	1,850
SW02	37,018	37,018			6	8,226	580	4.45	14,500	5,450	167
SW24	25,940	20,006	5,934	659	4	2,964	300	1.9	52,000	950	165
SW09	24,389	19,598	4,791	515	4	2,903	660	0.96	17,000	710	910
SW13	37,141	19,937	17,204	1,130	6	4,430	800	0.86	12,000	490	790
NA17	29,690	29,690		1,313	6	6,598	510	0.85	2,950	550	1,350
SW01	33,247	33,247		454	5	6,157	560	1.45	7,325	1,600	450
SW16	18,273	18,223	51	19	6	4,049	430	1	5,700	430	1,100
SW21	13,641	13,641		490	4	2,021	260	1.4	9,700	2,400	170
SW28	50,535	44,431	6,104	1,754	7	11,519	265	0.88	17,000	2,100	150
NA06	64,379	41,427	22,952	1,944	6	9,206	395	2.35	3,800	640	225
SW20	27,601	7,966	19,635	671	4	1,180	290	0.99	11,000	1,600	130
SW05	25,402	18,892	6,510	593	6	4,198	230	0.96	13,000	1,200	170
SW23	26,842	16,950	9,892	369	4	2,511	280	1	11,000	1,000	210
SW22	4,440	4,440			4	658	260	1.1	12,000	900	190
SW17	56,117	46,963	9,155	1,322	8	13,915	270	0.98	10,000	540	440
NA19	32,701	32,701		791	8	9,689	270	0.78	3,000	990	570
SW14	16,747	16,208	539	233	4	2,401	280	1	8,400	400	450
NA15	51,282	51,282		1,727	8	15,195	250	0.98	3,300	340	670
SW10	21,626	18,389	3,237	233	4	2,724	160	0.58	16,000	610	250
SW27	77,527	77,488	39		6	17,220	210	0.68	12,000	200	250
NA09	28,922	28,922		1,132	10	10,712	260	1.2	2,800	290	120
Total	741,802	622,765	119,037	18,351	--	144,445	--	--	--	--	--
Average	32,252	27,077	7,936	918	6	6,280	--	--	--	--	--

Notes:

(1) Information provided herein was obtained from the California Water Board's *Draft Technical Report for Tentative Cleanup and Abatement* dated September 15, 2010 for surface sediment chemistry and file received from Anchor QEA titled "2010-07-27-Economic Feasibility 07-27-10.xlsx" for areas and quantities (total remedial area, dredging area, etc.).

(2) Dredge depth includes a 1-foot overdredge.

(3) information provided by Anchor QEA for areas provided herein is inconsistent with information provided in the DTR (SDRWQCB 2010).

cy = cubic yards

DL = detection limit

ft = feet

HPAH = High Molecular Weight Polynuclear Aromatic Hydrocarbons

µg/kg = microgram per killogram

mg/kg = milligrams per kilogram

PCB = polychlorinated biphenyl

sf = square feet

TBT - tributyl tin

Table 2. Summary of Remedial Components
Expert Report on Economic Feasibility
Shipyard Sediment Site

Remedial Components	Units	Remedial Options		
		DTR-Recommended Option[1]	Background Remedial Option[2]	Alternative Remedial Option[2]
Dredging/Capping Activities				
Total Remedial Area	SQUARE FEET	759,790	6,481,158	326,316
Total Remedial Area	ACRES	17.4	148.8	7.5
Dredge Volume	CUBIC YARDS	143,400	1,147,770	65,248
Dredge Area	SQUARE FEET	656,100	6,167,316	279,289
Dredge Area	ACRES	15.1	141.6	6.4
Additional Dredging (Second Pass)	CUBIC YARDS	28,100	240,000	12,100
Dredge Window	--	September 15 - March 31	September 15 - March 31	September 15 - March 31
Dredge Polygons	NUMBER	23	66	12
Average Dredge Depth	FEET	5.8	5.1	5.9
Residual Capping	CUBIC YARDS	42,211	360,064	18,129
Under Pier Capping	SQUARE FEET	103,705	313,842	47,027
Under Pier Capping	ACRES	2.4	7.2	1.1
Duration of Construction	YEARS	3	14	2
Disposal				
Distance Traveled[3]	MIILES	25.0	25.0	25.0
Rehandling and Dewatering (cubic yards)	CUBIC YARDS	171,500	1,387,770	77,348
Dredge Material for Disposal (tons)	TONS	257,250	2,081,655	116,023
Disposal Trips (Rounded)	NUMBER	12,900	104,100	5,900
Total Truck Miles	MILES	322,500	2,602,500	147,500
Monitoring				
Water Quality Monitoring	WEEKS	24	0	0
Post -Dredging Confirmation Sampling	SAMPLES	45	387	19
Post-Remediation Monitoring	LOCATIONS	30	86	16
Miscellaneous Impacts				
Impact to Eel Grass: Eel Grass Habitat Mitigation	ACRES	0.87	7.44	0.37
Cost				
Total Direct Construction Costs	--	$38,891,785	$264,224,164	$19,251,784
Bid Management and Support	--	$25,000	$25,000	$25,000
Construction Management	--	$1,350,000	$6,300,000	$900,000
Contingency	--	$12,080,036	$81,164,749	$6,053,035
Monitoring	--	$3,184,239	$10,854,205	$1,975,254
Other Non-Construction	--	$2,527,000	$16,952,626	$1,486,574
Total	--	**$58,100,000**	**$379,500,000**	**$29,700,000**

Notes:
(1) DTR-Recommended Remedial Option quantities and information obtained from the California Water Board's *Draft Technical Report for Tentative Cleanup and Abatement* dated September 15, 2010.
(2) The Background Remedial Option and Alternative Remedial Option were developed using the same unit costs as the DTR Recommended Option (SDRWQCB 2010) with exception to additional pre-design characterization, surveys and engineering design and permitting which utilized a multiplier derived from the DTR Recommended Option.
(3) Total truck miles is based on an assumption that the landfill is located in Chula Vista, California.
(4) The volume of material to be dewatered includes the estimated volume of dredged material from second pass dredging.

Table 3. Cost Estimate for Remedial Footprint - DTR-Recommended Option
Expert Report on Economic Feasibility
Shipyard Sediment Site

Item	Probable Quantity	Unit	Unit Cost	Probable Cost	Assumptions
DESIGN AND PERMITTING					
Additional Pre-Design Site Characterization	1	LUMP SUM	$348,000	$348,000	
Surveys and Engineering Design	1	LUMP SUM	$675,000	$675,000	
Permitting	1	LUMP SUM	$400,000	$400,000	See Note 1.
CEQA EIR - if required	1	LUMP SUM	$900,000	$900,000	As discussed in Note 1, we do not believe an EIR will be required; however in the event that a EIR is required, we have added in estimated costs for the preparation and submittal of an EIR.
CONSTRUCTION PREPARATION					
Mobilization(s) and Demobilization(s)	3.0	CONSTRUCTION SEASONS	$300,000	$900,000	Estimate assumes work is completed in 3 construction seasons.
Demolition	1	LUMP SUM	$500,000	$500,000	Includes demolition of dormant BAE pier.
DREDGING					
Unconstrained open-water dredging (outside of leasehold area)(12.5% of dredge area)	17,925	CUBIC YARDS	$10	$179,250	Unit costs are typical for unconstrained dredging outside of shipyard area.
Constrained dredging from inner shipyard (within leasehold area)(87.5% of dredge area)	125,475	CUBIC YARDS	$18	$2,258,550	Higher cost for dredging within leasehold line, near piers, in areas of ship traffic, etc.
Dredging Surface/Subsurface Debris	7,170	CUBIC YARDS	$120	$860,400	Unknown quantity. Estimates assume 5% of total dredge volume. Pricing includes landfill disposal.
Engineering Controls (silt curtain, oil boom)	3.0	CONSTRUCTION SEASONS	$32,000	$96,000	Estimate assumes work is completed in 3 construction seasons.
Additional Dredging (as needed for 2nd pass)	28,100	CUBIC YARDS	$18	$505,800	Two feet of dredging over one-half the remedial area. Same unit costs as for constrained dredging from inner shipyard.
MARINE STRUCTURES					
Placement of Quarry Run Rock for Protection of Marine Structures	21,887	TON	$45	$984,915	No structural retrofit of structures is assumed to be necessary. Estimated costs assume setback of dredging from marine structures and revetments, and placement of quarry run blankets or berms to reinstate lateral resistance.
SEDIMENT OFFLOADING AND DISPOSAL					
Acquisition/Lease of Sediment Offloading Area	3.0	CONSTRUCTION SEASONS	$300,000	$900,000	An off-site sediment staging area will be needed in the vicinity of the project area. Location is unknown at this time. Costs assume a three-year construction period.
Preparation of Sediment Offloading Area	1	LUMP SUM	$300,000	$300,000	Preparation of sediment handling and dewatering area.
Rehandling and Dewatering	171,500	CUBIC YARDS	$25	$4,287,500	Assumes stockpiling of sediments prior to transport to landfill and addition of lime or cement admixture to facilitate dewatering.
Transportation and Disposal at Landfill	257,250	TON	$75	$19,293,750	Assumes disposal at regional hazardous waste landfill outside of San Diego County (Copper Mountain in Nevada).
UNDERPIER REMEDIATION					
Purchase and place 3 feet of clean sand/gravel beneath piers and overwater structures	103,705	SQUARE FEET	$30	$3,111,150	Assumes 3 foot thick layer of sand placed only under pier areas in the dredging footprint, quarry run rock assumed to be placed on the setback areas.
PLACEMENT OF CLEAN SAND COVER	42,211	CUBIC YARDS	$40	$1,688,422	Assumes one half of dredged area receives 1-3 feet of sand.
SW04 cleanout, BMP Installation, Investigation	1	LUMP SUM	$703,048	$703,048	
TOTAL DIRECT CONSTRUCTION COSTS				**$38,891,785**	
BID MANAGEMENT AND SUPPORT	1	LUMP SUM	$25,000	$25,000	
CONSTRUCTION MANAGEMENT	3.0	CONSTRUCTION SEASONS	$450,000	$1,350,000	Estimate assumes work is completed in 3 construction seasons.
CONTINGENCY	30%	PERCENT		$12,080,036	Unquantifiable or identifiable unknowns

Table 3. Cost Estimate for Remedial Footprint - DTR-Recommended Option

Expert Report on Economic Feasibility

Shipyard Sediment Site

Item	Probable Quantity	Unit	Unit Cost	Probable Cost	Assumptions
MONITORING COSTS					
Water Quality Monitoring during construction	24	WEEK	$18,000	$432,000	Consistent with project approach per mediation discussions.
Post-Dredging Confirmational Sampling	45	SAMPLES	$8,000	$362,801	Consistent with project approach per mediation discussions.
Long-Term Monitoring of Remediated Areas	30	LOCATIONS	$60,000	$1,794,000	Consistent with project approach per mediation discussions.
SW04 long term monitoring	1	LUMP SUM	$595,437	$595,437	PV for 100 years $20K/year, 5% discount rate.
OTHER (NON-CONSTRUCTION) COSTS					
Eel Grass Habitat Mitigation (if needed) Construction and maintenance)	0.87	ACRES	$600,000	$522,000	Assumes 5% of dredged acreage will require mitigation.
Eel Grass land lease costs in perpetuity (lump sum)	0.87	ACRES	$1,500,000	$1,305,000	
Internal Shipyard Costs	1	LUMP SUM	$250,000	$250,000	
RWQCB Oversight Costs	10	YEARS	$45,000	$450,000	Duration covers periods of design, construction, and long-term monitoring oversight.
GRAND TOTAL				**$58,100,000**	

Notes:

(1) This is inclusive of all required permits. Required permits will be identified with legal assistance. Implementation of the cleanup program requires resource agency permits and environmental review under state [California Environmental Quality Act (CEQA)] and possibly federal [National Environmental Policy Act (NEPA)] guidelines.

(2) Cost estimate as reproduced herein was developed by Anchor QEA and provided in the appendix for Section 32 of the DTR (SDRWQCB 2010).

EIR = Environmental Impact Report

RWQCB = Regional Water Quality Control Board, San Diego Region

Table 4. Summary of Background Remedial Option

Expert Report on Economic Feasibility

Shipyard Sediment Site

Polygon ID	Total Remedial Area (sf)	Dredging Area (sf)	Under Pier Area (sf)	Rock Protection (ton)	Dredge Depth[2] (ft)	Dredge Volume Per Polygon (cy)	Pre-Remedy Surface Sediment Chemistry				
							Copper (mg/kg)	Mercury (mg/kg)	Total HPAH (half DL) (µg/kg)	Total PCB (µg/kg)	TBT (µg/kg)
SW04	22,921	16,282	6,639	1,453	6	3,618	1500	1.75	14000	4000	3250
SW08	15,421	9,066	6,355	1,547	7	2,350	920	2.25	25500	2100	1850
SW02	37,018	37,018			6	8,226	580	4.45	14500	5450	167
SW24	25,940	20,006	5,934	659	4	2,964	300	1.9	52000	950	165
SW09	24,389	19,598	4,791	515	4	2,903	660	0.96	17000	710	910
SW13	37,141	19,937	17,204	1,130	6	4,430	800	0.86	12000	490	790
NA17	29,690	29,690		1,313	6	6,598	510	0.85	2950	550	1350
SW01	33,247	33,247		454	5	6,157	560	1.45	7325	1600	450
SW16	18,273	18,223	51	19	6	4,049	430	1	5700	430	1100
SW21	13,641	13,641		490	4	2,021	260	1.4	9700	2400	170
SW28	50,535	44,431	6,104	1,754	7	11,519	265	0.88	17000	2100	150
NA06	64,379	41,427	22,952	1,944	6	9,206	395	2.35	3800	640	225
SW20	27,601	7,966	19,635	671	4	1,180	290	0.99	11000	1600	130
SW05	25,402	18,892	6,510	593	6	4,198	230	0.96	13000	1200	170
SW23	26,842	16,950	9,892	369	4	2,511	280	1	11000	1000	210
SW22	4,440	4,440			4	658	260	1.1	12000	900	190
SW17	56,117	46,963	9,155	1,322	8	13,915	270	0.98	10000	540	440
NA19	32,701	32,701		791	8	9,689	270	0.78	3000	990	570
NA07	32,593	32,593		531	4	4,829	225	1.45	15850	495	111
SW14	16,747	16,208	539	233	4	2,401	280	1	8400	400	450
NA15	51,282	51,282		1,727	8	15,195	250	0.98	3300	340	670
SW10	21,626	18,389	3,237	233	4	2,724	160	0.58	16000	610	250
NA23	67,024	54,124	12,900	1,896	5	10,023	350	1.1	3400	510	120
SW29	66,095	66,095		408	4	9,792	220	0.93	4600	820	190
NA04	81,308	74,178	7,130	1,400	10	27,473	260	1.1	3500	250	300
NA01	100,720	99,946	774		7	25,912	252.5	1.06	6575	375	157
NA27	57,956	57,956		146	4	8,586	390	1.2	2800	210	100
NA16	36,736	36,736			8	10,885	252.5	1.09	3200	590	175
SW30	76,779	76,779			7	19,906	240	1.1	4900	380	200
SW27	77,527	77,488	39		6	17,220	210	0.68	12000	200	250
NA03	120,986	120,725	261	597	4	17,885	220	1.1	6100	370	180
SW25	70,172	46,636	23,536	1,488	6	10,364	230	0.78	8150	350	231
SW15	57,423	57,423			4	8,507	230	0.9	7700	380	170
SW03	47,090	47,090			4	6,976	190	1.2	6800	410	53
SW06	26,105	20,429	5,676	360	4	3,026	170	0.75	12000	380	100
SW18	61,364	50,318	11,046	389	4	7,454	220	0.75	8100	440	130
NA09	28,922	28,922		1,132	10	10,712	260	1.2	2800	290	120
SW19	210,320	210,320		0	4	31,158	110	2.1	1100	94	37
NA18	45,370	45,370		476	4	6,722	230	0.79	2400	350	210
NA08	19,632	19,632		245	4	2,908	270	0.82	3500	310	110
NA28	56,241	56,241			4	8,332	290	0.89	3400	180	90
SW11	37,417	34,286	3,131	253	4	5,079	170	0.75	8000	200	140
NA21	514,183	491,946	22,236	2,659	7	127,542	150	0.51	2100	177	410
SW36	101,104	101,104			6	22,468	240	0.75	4000	200	49
NA24	60,391	55,524	4,867	1,725	4	8,226	200	0.9	2100	290	59

Table 4. Summary of Background Remedial Option

Expert Report on Economic Feasibility

Shipyard Sediment Site

							Pre-Remedy Surface Sediment Chemistry				
Polygon ID	Total Remedial Area (sf)	Dredging Area (sf)	Under Pier Area (sf)	Rock Protection (ton)	Dredge Depth[2] (ft)	Dredge Volume Per Polygon (cy)	Copper (mg/kg)	Mercury (mg/kg)	Total HPAH (half DL) (µg/kg)	Total PCB (µg/kg)	TBT (µg/kg)
SW34	302,142	302,142			4	44,762	320	0.75	1400	130	38
NA11	38,392	38,392			4	5,688	180	0.85	2800	190	38
NA02	160,570	160,570			5	29,735	170	0.7	2800	208	82
NA05	113,895	107,040	6,855	681	4	15,858	170	0.61	2800	180	110
NA13	255,537	255,537		1,225	4	37,857	185	0.65	1800	173	68
NA22	235,799	206,207	29,592	1,780	4	30,549	150	0.38	3600	180	120
NA10	29,008	29,008			4	4,297	160	0.58	1800	160	91
NA12	90,903	90,903		218	4	13,467	150	0.62	2000	150	80
SW07	37,022	32,235	4,787	369	4	4,776	150	0.52	3800	170	44
NA20	322,869	265,095	57,773	9,892	10	98,184	96	0.24	2900	120	280
NA30	239,380	239,380			4	35,464	140	0.71	1000	100	22
SW12	106,435	106,371	64	58	4	15,759	119.5	0.53	3000	155	36
NA29	203,451	203,451			4	30,141	110	0.55	1900	190	58
SW26	87,094	86,734	360	126	4	12,849	120	0.43	1600	293	49
NA14	211,512	211,512			4	31,335	130	0.55	1100	128	45
SW32	70,925	70,925			7	18,388	92	0.51	820	160	30
SW33	150,157	150,157			4	22,246	100	0.53	1000	100	19
NA26	299,493	299,493			4	44,369	80	0.48	850	180	37
NA25	513,303	513,303			4	76,045	85	0.42	1100	83	25
NA31	239,878	239,878			4	35,537	71	0.35	530	68	20
SW31	84,584	80,767	3,817	544	4	11,966	54	0.23	1200	66	36
Total	6,481,158	6,167,316	313,842	45,817	--	1,147,770	--	--	--	--	--
Average	98,199	93,444	9,808	1,041	5	17,390	--	--	--	--	--

Notes:

(1) Information provided herein was obtained from the California Water Board's *Draft Technical Report for Tentative Cleanup and Abatement* dated September 15, 2010 and file received from AnchorQEA titled "2010-07-27-Economic Feasibility 07-27-10.xlsx."

(2) Dredge depth includes a 1-foot overdredge.

cy = cubic yards

DL = detection limit

ft = feet

HPAH = high molecular weight polyclyclic aromatic hydrocarbons

µg/kg = micrograms per kilogram

mg/kg = milligrams per kilogram

PCB = polychlorinated biphenyls

sf = square feet

TBT - Tributyltin

Table 5. Background Remedial Option Cost Estimate

Expert Report on Economic Feasibility

Shipyard Sediment Site

Item	Probable Quantity OLD	Probable Quantity	Unit	Unit Cost	Probable Cost	Assumptions
DESIGN AND PERMITTING						
Additional Pre-Design Site Characterization	**1**	1	LUMP SUM	$2,412,016	$2,412,016	
Surveys and Engineering Design	**1**	1	LUMP SUM	$4,678,480	$4,678,480	
Permitting	**1**	1	LUMP SUM	$2,772,433	$2,772,433	See Note 1.
CEQA EIR - if required	**1**	1	LUMP SUM	$900,000	$900,000	As discussed in Note 1, we do not believe an EIR will be required; however in the event that a EIR is required, we have added in estimated costs for the preparation and submittal of an EIR.
CONSTRUCTION PREPARATION						
Mobilization(s) and Demobilization(s)	**26.9**	14	CONSTRUCTION SEASONS	$300,000	$4,200,000	Estimate assumes work is completed in 14 construction seasons.
Demolition	**1**	1	LUMP SUM	$500,000	$500,000	Includes demolition of dormant BAE pier.
DREDGING						
Unconstrained Open-water Dredging (outside of leasehold area)(59.4% of dredge area)	**681,775**	681,775	CUBIC YARDS	$10	$6,817,752	Unit costs are typical for unconstrained dredging outside of shipyard area.
Constrained Dredging from Inner Shipyard (within leasehold area)(40.6% of dredge area)	**465,994**	465,994	CUBIC YARDS	$18	$8,387,901	Higher cost for dredging within leasehold line, near piers, in areas of ship traffic, etc.
Dredging Surface/Subsurface Debris	**57,388**	57,388	CUBIC YARDS	$120	$6,886,618	Unknown quantity. Estimates assume 5% of total dredge volume. Pricing includes landfill disposal.
Engineering Controls (silt curtain, oil boom)	**26.9**	14	CONSTRUCTION SEASONS	$32,000	$448,000	Estimate assumes work is completed in 14 construction seasons.
Additional Dredging (as needed for 2nd pass)	**240,000**	240,000	CUBIC YARDS	$18	$4,320,000	Two feet of dredging over one-half the remedial area. Same unit costs as for constrained dredging from inner shipyard.
MARINE STRUCTURES						
Placement of Quarry Run Rock for Protection of Marine Structures	**45,817**	45,817	TON	$45	$2,061,744	No structural retrofit of structures is assumed to be necessary. Estimated costs assume setback of dredging from marine structures and revetments, and placement of quarry run blankets or berms to reinstate lateral resistance.
SEDIMENT OFFLOADING AND DISPOSAL						
Acquisition/Lease of Sediment Offloading Area	26.9	14	CONSTRUCTION SEASONS	$300,000	$4,200,000	An off-site sediment staging area will be needed in the vicinity of the project area. Location is unknown at this time. Costs assume a fourteen-year construction period.
Preparation of Sediment Offloading Area	1	1	LUMP SUM	$300,000	$300,000	Preparation of sediment handling and dewatering area.
Rehandling and Dewatering		1,387,770	CUBIC YARDS	$25	$34,694,242	Assumes stockpiling of sediments prior to transport to landfill and addition of lime or cement admixture to facilitate
Transportation and Disposal at Landfill	2,081,655	2,081,655	TON	$75	$156,124,090	Utilizes same unit costs as presented in the DTR.
UNDER PIER REMEDIATION						
Purchase and place 3 feet of clean sand/gravel beneath piers and overwater structures	**313,842**	313,842	SQUARE FEET	$30	$9,415,267	Assumes 3 foot thick layer of sand placed only under pier areas in the dredging footprint, quarry run rock assumed to be placed on the setback areas.
PLACEMENT OF CLEAN SAND COVER	**360,064**	360,064	CUBIC YARDS	$40	$14,402,573	Assumes one half of remedial area receives 3 feet of sand.
SW04 cleanout, BMP Installation, Investigation	**1**	1	LUMP SUM	$703,048	$703,048	
TOTAL DIRECT CONSTRUCTION COSTS					**$264,224,164**	
BID MANAGEMENT AND SUPPORT	**1**	1	LUMP SUM	$25,000	$25,000	
CONSTRUCTION MANAGEMENT	**26.9**	14	CONSTRUCTION SEASONS	$450,000	$6,300,000	Estimate assumes work is completed in 14 construction seasons.
CONTINGENCY	**30%**	30%	PERCENT		$81,164,749	Unquantifiable or identifiable unknowns

Table 5. Background Remedial Option Cost Estimate

Expert Report on Economic Feasibility

Shipyard Sediment Site

Item	Probable Quantity OLD	Probable Quantity	Unit	Unit Cost	Probable Cost	Assumptions
MONITORING COSTS						
Water Quality Monitoring during Construction	**24**	112	WEEK	$18,000	$2,016,000	Consistent with project approach per mediation discussions.
Post-Dredging Confirmational Sampling	**45**	387	SAMPLES	$8,000	$3,094,768	Consistent with project approach per mediation discussions.
Long-Term Monitoring of Remediated Areas	**30**	86	LOCATIONS	$60,000	$5,148,000	Consistent with project approach per mediation discussions.
SW04 long term monitoring	**1**	1	LUMP SUM	$595,437	$595,437	PV for 10 years $20K/year, 5% discount rate
OTHER (NON-CONSTRUCTION) COSTS						
Eel Grass Habitat Mitigation (if needed) Construction and Maintenance)	**7.44**	7.4	ACRES	$600,000	$4,463,607	Assumes 5% of remedial acreage will require mitigation
Eel Grass Land Lease Costs in Perpetuity (lump sum)	**7.44**	7.4	ACRES	$1,500,000	$11,159,018	
Internal Shipyard Costs	**1**	1	LUMP SUM	$250,000	$250,000	
RWQCB Oversight Costs	**10**	24	YEARS	$45,000	$1,080,000	Duration covers periods of design, construction, and long-term monitoring oversight.
GRAND TOTAL					**$379,500,000**	

Notes:

(1) This is inclusive of all required permits. Required permits will be identified with legal assistance. Implementation of the cleanup program requires resource agency permits and environmental review under state [California Environmental Quality Act (CEQA)] and possibly federal [National Environmental Policy Act (NEPA) guidelines

(2) Several unit costs (Additional Pre-Design Characterization, Surveys and Engineering Design, Permitting) were calculated based on a percentage of the total direct construction costs from the DTR-Recommended Remedial Option. The percentages were then applied to the specified line item and calculated utilizing the total direct construction cost for the Background Remedial Option. All other unit costs remained consistent with the DTR Recommended Option (SDRWQCB 2010).

(3) Duration of Water Quality Monitoring during Construction has been calculated based on multiplier developed from the total duration of construction from the DTR-Recommended Remedial Option and the Background Remedial Option.

CEQA = California Environmental Quality Act

EIR = Environmental Impact Report

RWQCB = Regional Water Quality Control Board, San Diego Region

Table 6. Summary Results by Station for Alternative Remedial Option
Expert Report on Economic Feasibility
Shipyard Sediment Site

September 15, 2010 DTR Results (SDRWQCB 2010)																	ARCADIS Evaluation Results					
	Triad Results				Non-Triad Station Results		Stations with Highest Individual COCs										Revised Triad Results					
Polygon ID	Sediment Chemistry	Toxicity	Benthic Comm.	Weight of Evidence Category	Exceeds LAET	Exceeds SS-MEQ	Top 10 HPAH	Top 10 PCB	Top 10 TBT	Top 10 Cu	Top 10 Hg	Top 10 Pb	Top 10 As	Top 10 Zn	Top 10 Cd	Contained in Current DTR Footprint?	Sediment Chemistry	Toxicity	Benthic Comm.	Weight of Evidence Category	Included in Proposed Alternative Footprint?	Evaluation Notes and Summary Rationale for Removal from Footprint
NA06	Moderate	Low	Low	Unlikely	No	Yes	--	--	--	9	2	6	--	--	--	Yes	Moderate	Low	Low	Unlikely	NO	WOE for Triad was "Unlikely" and Hg is not a likely driver at the Site.
NA09	Moderate	Moderate	Low	Possible	--	--	--	--	--	--	10	--	--	--	--	Yes	Moderate	Moderate	Low	Possible	Yes	Remain in footprint to address uncertainty associated with "moderate" toxicity finding.
NA15	Moderate	Low	Low	Unlikely	--	--	--	--	7	--	--	--	--	--	--	Yes	Moderate	Low	Low	Unlikely	NO	WOE for Triad was "Unlikely" and only the seventh highest concentration of TBT.
NA17	High	Low	Low	Possible	--	--	--	--	3	7	--	10	8	4	--	Yes	High	Low	Low	Possible	NO	Benthic and toxicity lines of evidence indicate no impacts. Although some evelvated chemncistry, no evidence of dose response.
NA19	High	Moderate	Low	Likely	--	--	--	10	8	--	--	--	--	9	--	Yes	High	Moderate	Low	Likely	Yes	Remain in footprint to address uncertainty associated with "moderate" toxicity finding.
SW01	--	--	--	--	No	Yes	--	7	10	6	7	5	--	7	--	Yes	--	--	--	--	Yes	Remain as adjacent to SW02, and uncertainty associated with no Triad results.
SW02	High	Low	Low	Possible	--	--	7	1	--	5	1	4	--	5	1	Yes	High	Low	Low	Possible	Yes	Remain in footprint as polygon contains max conc for one or more COCs.
SW04	High	Low	Moderate	Likely	--	--	8	2	1	1	6	1	1	1	2	Yes	High	Low	Moderate	Likely	Yes	Remain in footprint as polygon contains max conc for one or more COCs, and moderate benthic commnunity finding.
SW05	--	--	--	--	No	Yes	9	8	--	--	--	8	--	--	9	Yes	--	--	--	--	NO	No Triad results and only a few COPC concentrations in the top 10 (8s and 9s), thus relatively low exposure indicated.
SW08	High	Low	Low	Possible	--	--	2	4	2	2	3	2	3	3	8	Yes	High	Low	Low	Possible	Yes	Remain in footprint as polygon contains 2nd highest conc for more than one COCs.
SW09	High	Low	Low	Possible	--	--	3	--	5	4	--	3	2	2	3	Yes	High	Low	Low	Possible	Yes	Remain in footprint as polygon contains 2nd highest conc for more than one COCs.
SW10	--	--	--	--	Yes	Yes	5	--	--	--	--	--	--	--	7	Yes	--	--	--	--	NO	No Triad results and one fifth and one seventh highest concentration, thus relatively low exposure indicated.
SW13	High	Moderate	Low	Likely	--	--	--	--	6	3	--	--	5	6	10	Yes	High	Moderate	Low	Likely	Yes	Remain in footprint to address uncertainty associated with "moderate" response for toxicity or benthic community endpoints.
SW14	--	--	--	--	No	No	--	--	9	--	--	--	--	--	--	Yes	--	--	--	--	NO	No Triad results and only one ninth highest concentration, thus relatively low exposure indicated.
SW16	--	--	--	--	No	Yes	--	--	4	8	--	--	--	--	4	Yes	--	--	--	--	NO	Between 3 large polygons with relatively lower chemistry, and no basis of inclusion given triad results.
SW17	Moderate	Moderate	Low	Possible	--	--	--	--	--	--	--	--	--	--	--	Yes	Moderate	Low	Low	Unlikely	NO	Bivalve replicate variability too high to be conclusive - changing toxicity to "Low" and WOE to "Unlikely". No COCs in the top 10.
SW20	--	--	--	--	No	Yes	--	6	--	--	--	--	10	--	--	Yes	--	--	--	--	NO	No Triad results and one sixth and one tenth highest sediment concentration, thus relatively low exposure indicated.
SW21	High	Low	Low	Possible	--	--	--	3	--	--	9	9	--	--	--	Yes	High	Low	Low	Possible	Yes	Remain in footprint as polygon contains 3rd highest PCB concentration.
SW22	High	Moderate	Low	Likely	--	--	10	--	--	--	--	--	--	--	--	Yes	High	Moderate	Low	Likely	Yes	Remain in footprint to address uncertainty associated with "moderate" response for toxicity or benthic community endpoints.
SW23	High	Moderate	Low	Likely	--	--	--	9	--	--	--	--	7	--	--	Yes	High	Low	Low	Unlikely	NO	Bivalve replicate variability too high to be conclusive - changing toxicity to "Low" and WOE to "Unlikely". Low concentrations of COCs.
SW24	--	--	--	--	Yes	Yes	1	--	--	--	5	--	--	--	--	Yes	--	--	--	--	Yes	No Triad results, maximum concentration of HPAH, and uncertainty associated with LAET and SS-MEQ exceedances.
SW27	Moderate	Moderate	Low	Possible	--	--	--	--	--	--	--	--	--	--	--	Yes	Moderate	Low	Low	Unlikely	NO	Bivalve replicate variability too high to be conclusive - changing toxicity to "Low" and WOE to "Unlikely". No COCs in the top 10.
SW28	--	--	--	--	Yes	Yes	4	5	--	--	--	--	9	--	--	Yes	--	--	--	--	Yes	No Triad, and uncertainty associated with LAET and SS-MEQ exceedances.

Notes:
AS = arsenic
CD = cadmium
COC = contaminantsof concern
Cu = copper
DTR = Draft Technical Report for Tentative Cleanup and Abatement for the Shipyard Sediment Site in San Diego Bay
Hg = mercury
HPAH = total high molecular weight polycyclic aromatic hydrocarbons
LAET = Lowest Apparent Effects Threshold
ND = not detected
Pb = lead
PCB = polychlorinated biphenyl
SS-MEQ = site-specific mean effects quotient
SDRWQCB = California Regional Water Quality Control Board, San Diego Region
TBT = tributyl tin
WOE = weight-of-evidence
Zn = zinc

Gray shaded samples have been removed from the proposed remedial footprint based on the ARCADIS evaluation.
Green shaded samples remain in the ARCADIS evaluation of the DTR proposed remedial footprint.

Table 7. Summary of Alternative Remedial Option

Expert Report on Economic Feasibility

Shipyard Sediment Site

Polygon ID	Total Remedial Area (sf)	Dredging Area (sf)	Under Pier Area (sf)	Rock Protection (tons)	Dredge Depth[2] (ft)	Dredge Volume Per Polygon (cy)	Pre-Remedy Surface Sediment Chemistry				
							Copper (mg/kg)	Mercury (mg/kg)	Total HPAH (half DL) (µg/kg)	Total PCB (µg/kg)	TBT (µg/kg)
SW04	22,921	16,282	6,639	1,453	6	3,618	1500	1.75	14000	4000	3250
SW08	15,421	9,066	6,355	1,547	7	2,350	920	2.25	25500	2100	1850
SW02	37,018	37,018			6	8,226	580	4.45	14500	5450	167
SW09	24,389	19,598	4,791	515	4	2,903	660	0.96	17000	710	910
SW13	37,141	19,937	17,204	1,130	6	4,430	800	0.86	12000	490	790
SW01	33,247	33,247		454	5	6,157	560	1.45	7325	1600	450
SW21	13,641	13,641		490	4	2,021	260	1.4	9700	2400	170
SW28	50,535	44,431	6,104	1,754	7	11,519	265	0.88	17000	2100	150
SW22	4,440	4,440			4	658	260	1.1	12000	900	190
SW24	25,940	20,006	5,934	659	4	2,964	300	1.9	52000	950	165
NA19	32,701	32,701		791	8	9,689	270	0.78	3000	990	570
NA09	28,922	28,922		1,132	10	10,712	260	1.2	2800	290	120
Total	326,316	279,289	47,027	9,925	--	65,248	--	--	--	--	--
Average	27,193	23,274	7,838	993	6	5,437	--	--	--	--	--

Notes:

(1) Information provided herein was obtained from the California Water Board's *Draft Technical Report for Tentative Cleanup and Abatement* dated September 15, 2010 and file received from AnchorQEA titled "2010-07-27-Economic Feasibility 07-27-10.xlsx."

(2) Dredge depth includes a 1-foot overdredge.

cy = cubic yards

DL = detection limit

ft = feet

HPAH = high molecular weight polynuclear aromatic hydrocarbons

µg/kg = micrograms per kilogram

mg/kg = milligrams per kilogram

PCB = polychlorinated biphenyls

sf = square feet

Table 8. Alternative Remedial Option Cost Estimate

Expert Report on Economic Feasibility

Shipyard Sediment Site

Item	Probable Quantity	Unit	Unit Cost	Probable Cost	Assumptions
DESIGN AND PERMITTING					
Additional Pre-Design Site Characterization	**1**	LUMP SUM	$168,100	$168,100	
Surveys and Engineering Design	**1**	LUMP SUM	$326,056	$326,056	
Permitting	**1**	LUMP SUM	$193,218	$193,218	See Note 1.
CEQA EIR - if required	**1**	LUMP SUM	$900,000	$900,000	As discussed in Note 1, we do not believe an EIR will be required; however in the event that a EIR is required, we have added in estimated costs for the preparation and submittal of an EIR.
CONSTRUCTION PREPARATION					
Mobilization(s) and Demobilization(s)	**2**	CONSTRUCTION SEASONS	$300,000	$600,000	Estimate assumes work is completed in 2 construction seasons.
Demolition	**1**	LUMP SUM	$500,000	$500,000	Includes demolition of dormant BAE pier.
DREDGING					
Unconstrained Open-water Dredging (outside of leasehold area)(20.0% of dredge area)	**13,050**	CUBIC YARDS	$10	$130,497	Unit costs are typical for unconstrained dredging outside of shipyard area.
Constrained Dredging from Inner Shipyard (within leasehold area)(80.0% of dredge area)	**52,199**	CUBIC YARDS	$18	$939,577	Higher cost for dredging within leasehold line, near piers, in areas of ship traffic, etc.
Dredging Surface/Subsurface Debris	**3,262**	CUBIC YARDS	$120	$391,491	Unknown quantity. Estimates assume 5% of total dredge volume. Pricing includes landfill disposal.
Engineering Controls (silt curtain, oil boom)	**2**	CONSTRUCTION SEASONS	$32,000	$64,000	Estimate assumes work is completed in 2 construction seasons.
Additional Dredging (as needed for 2nd pass)	**12,100**	CUBIC YARDS	$18	$217,800	Two feet of dredging over one-half the remedial area. Same unit costs as for constrained dredging from inner shipyard.
MARINE STRUCTURES					
Placement of Quarry Run Rock for Protection of Marine Structures	**9,925**	TON	$45	$446,644	No structural retrofit of structures is assumed to be necessary. Estimated costs assume setback of dredging from marine structures and revetments, and placement of quarry run blankets or berms to reinstate lateral resistance.
SEDIMENT OFFLOADING AND DISPOSAL					
Acquisition/Lease of Sediment Offloading Area	**2**	CONSTRUCTION SEASONS	$300,000	$600,000	An off-site sediment staging area will be needed in the vicinity of the project area. Location is unknown at this time. Costs assume a three-year construction period.
Preparation of Sediment Offloading Area	**1**	LUMP SUM	$300,000	$300,000	Preparation of sediment handling and dewatering area.
Rehandling and Dewatering	**77,348**	CUBIC YARDS	$25	$1,933,711	Assumes stockpiling of sediments prior to transport to landfill and addition of lime or cement admixture to facilitate dewatering.
Transportation and Disposal at Landfill	**116,023**	TON	$75	$8,701,698	Utilizes same unit costs as presented in the DTR.
UNDERPIER REMEDIATION					
Purchase and Place 3 feet of Clean Sand/gravel Beneath Piers and Overwater Structures	**47,027**	SQUARE FEET	$30	$1,410,798	Assumes 3 foot thick layer of sand placed only under pier areas in the dredging footprint, quarry run rock assumed to be placed on the setback areas.
PLACEMENT OF CLEAN SAND COVER	**18,129**	CUBIC YARDS	$40	$725,147	Assumes one half of remedial area receives 3 feet of sand.
SW04 cleanout, BMP Installation, Investigation	**1**	LUMP SUM	$703,048	$703,048	
TOTAL DIRECT CONSTRUCTION COSTS				**$19,251,784**	
BID MANAGEMENT AND SUPPORT	**1**	LUMP SUM	$25,000	$25,000	
CONSTRUCTION MANAGEMENT	**2**	CONSTRUCTION SEASONS	$450,000	$900,000	Estimate assumes work is completed in 3 construction seasons.
CONTINGENCY	**30%**	PERCENT		$6,053,035	Unquantifiable or identifiable unknowns

Table 8. Alternative Remedial Option Cost Estimate

Expert Report on Economic Feasibility

Shipyard Sediment Site

Item	Probable Quantity	Unit	Unit Cost	Probable Cost	Assumptions
MONITORING COSTS					
Water Quality Monitoring during Construction	**16**	WEEK	$18,000	$288,000	Consistent with project approach per mediation discussions.
Post-Dredging Confirmational Sampling	**19**	SAMPLES	$8,000	$155,817	Consistent with project approach per mediation discussions.
Long-Term Monitoring of Remediated Areas	**16**	LOCATIONS	$60,000	$936,000	Consistent with project approach per mediation discussions.
SW04 Long Term Monitoring	**1**	LUMP SUM	$595,437	$595,437	PV for 10 years $20K/year, 5% discount rate
OTHER (NON-CONSTRUCTION) COSTS					
Eel Grass Habitat Mitigation (if needed) Construction and Maintenance)	**0.37**	ACRES	$600,000	$224,736	Assumes 5% of remedial acreage will require mitigation
Eel Grass Land Lease Costs in Perpetuity (lump sum)	**0.37**	ACRES	$1,500,000	$561,839	
Internal Shipyard Costs	**1**	LUMP SUM	$250,000	$250,000	
RWQCB Oversight Costs	**10**	YEARS	$45,000	$450,000	Duration covers periods of design, construction, and long-term monitoring oversight.
GRAND TOTAL				**$29,700,000**	

Notes:

(1) This is inclusive of all required permits. Required permits will be identified with legal assistance. Implementation of the cleanup program requires resource agency permits and environmental review under state [California Environmental Quality Act (CEQA)] and possibly federal [National Environmental Policy Act

(2) Several unit costs (Additional Pre-Design Characterization, Surveys and Engineering Design, Permitting) were calculated based on a percentage of the total direct construction costs from the DTR-Recommended Remedial Option. The percentages were then applied to the specified line item and calculated utilizing the total direct construction cost for the Alternative Remedial Option. All other unit costs remained consistent with the DTR Recommended Option (SDRWQCB 2010).

(3) Duration of Water Quality Monitoring during Construction has been calculated based on multiplier developed from the total duration of construction from the DTR-Recommended Remedial Option and the Alternative Remedial Option.

CEQA = California Environmental Quality Act

EIR = Environmental Impact Report

Table 9. Cash Flow Analysis
Expert Report on Economic Feasibility
Shipyard Sediment Site

Year	Alternative Remedial Option		DTR-Recommended Remedial Option		Background Remedial Option	
	Cost	**Activities**	**Cost**	**Activities**	**Cost**	**Activities**
0	$1,587,000	Design and Permitting	$2,323,000	Design and Permitting	$10,763,000	Design and Permitting
1	$13,061,000	First Year of Construction	$17,632,000	First Year of Construction	$25,852,000	First Year of Construction
2	$13,061,000	Second Year of Construction	$17,632,000	Second Year of Construction	$25,852,000	Second Year of Construction
3	$198,000	Only Long-Term Monitoring	$17,632,000	Third Year of Construction	$25,852,000	Third Year of Construction
4	$198,000	Only Long-Term Monitoring	$284,000	Only Long-Term Monitoring	$25,852,000	Fourth Year of Construction
5	$198,000	Only Long-Term Monitoring	$284,000	Only Long-Term Monitoring	$25,852,000	Fifth Year of Construction
6	$198,000	Only Long-Term Monitoring	$284,000	Only Long-Term Monitoring	$25,852,000	Sixth Year of Construction
7	$198,000	Only Long-Term Monitoring	$284,000	Only Long-Term Monitoring	$25,852,000	Seventh Year of Construction
8	$198,000	Only Long-Term Monitoring	$284,000	Only Long-Term Monitoring	$25,852,000	Eighth Year of Construction
9	$198,000	Only Long-Term Monitoring	$284,000	Only Long-Term Monitoring	$25,852,000	Ninth Year of Construction
10	$198,000	Only Long-Term Monitoring	$284,000	Only Long-Term Monitoring	$25,852,000	Tenth Year of Construction
11	$198,000	Only Long-Term Monitoring	$284,000	Only Long-Term Monitoring	$25,852,000	Eleventh Year of Construction
12	$198,000	Only Long-Term Monitoring	$284,000	Only Long-Term Monitoring	$25,852,000	Twelfth Year of Construction
13	$0		$284,000	Only Long-Term Monitoring	$25,852,000	Thirteenth Year of Construction
14	$0		$0		$25,852,000	Fourteenth Year of Construction
15	$0		$0		$682,000	Only Long-Term Monitoring
16	$0		$0		$682,000	Only Long-Term Monitoring
17	$0		$0		$682,000	Only Long-Term Monitoring
18	$0		$0		$682,000	Only Long-Term Monitoring
19	$0		$0		$682,000	Only Long-Term Monitoring
20	$0		$0		$682,000	Only Long-Term Monitoring
21	$0		$0		$682,000	Only Long-Term Monitoring
22	$0		$0		$682,000	Only Long-Term Monitoring
23	$0		$0		$682,000	Only Long-Term Monitoring
24	$0		$0		$682,000	Only Long-Term Monitoring
Total	**$29,700,000**		**$58,100,000**		**$379,500,000**	

Notes:
(1) The cash flow assumes that the construction costs are equally distributed across each construction season/year.
(2) The RWCQB oversight costs are included with the long-term monitoring costs for this analysis.

Table 10. Present Value Cost of Options ($ millions)
Expert Report on Economic Feasibility
Shipyard Sediment Site

	Discount Rate		
Option	**3%**	**7%**	**Non-Discounted Cost**
DTR-Recommended Option	$55.19	$51.87	$58.10
Background Remedial Option	$311.05	$246.56	$379.50
Alternative Remedial Option	$28.57	$27.27	$29.70

Table 11. Transportation of Sediment Offsite
Expert Report on Economic Feasibility
Shipyard Sediment Site

Option	Transportation of Sediment Offsite	
	Truckloads	Total Miles
DTR-Recommended Option	12,900	322,500
Background Remedial Option	104,100	2,602,500
Alternative Remedial Option	5,900	147,500

Note:
1. The volume of truck traffic was estimated assuming 20 tons of sediment would be transported offsite per truck and that each truck will be transported approximately 25 miles.

Table 12. Potential Risks of Transportation of Sediment Offsite
Expert Report on Economic Feasibility
Shipyard Sediment Site

Option	Estimated Accident Risks		
	Accidents	Injuries	Fatalities
DTR-Recommended Option	0.5	13%	0.6%
Background Remedial Option	4.2	1.0	4.8%
Alternative Remedial Option	0.2	6%	0.3%

Note:
1. The accident-related risks are estimated based on published data on large truck accidents in 2008 as documented by the USDOT (2010a, 2010b) and the estimated total truck miles for each alternative shown in Table 11. The potential accidents, injuries, and fatalities were estimated using the total number of accidents, injuries, and fatalities in large truck-involved accidents in 2008 and the total miles traveled by large trucks in 2008.

Table 13. SWACs for Primary COCs under Alternative Scenarios
Expert Report on Economic Feasibility
Shipyard Sediment Site

Chemical		Background	Current	DTR, SMU-based**	DTR	ARO*
Copper	mg/kg	121	187	159	153	165
Mercury	mg/kg	0.57	0.75	0.68	0.67	0.70
Total HPAH (half DL)	µg/kg	663	3,509	2,451	2,256	2,780
Total PCB	µg/kg	84.0	308	194	176	211
TBT	µg/kg	22.0	162	110	101	129

Notes:
Surface-weighted average concentrations (SWACs) are based on Thiessen polygons, except as noted.
* Alternative Remedial Option
** SWAC based on DTR Sediment Management Units (SMUs)
COCs = contaminants of concern
DL = detection limit
DTR = *Draft Technical Report for Tentative Cleanup and Abatement for the Shipyard Sediment Site in San Diego Bay*
HPAH = high molecular weight polycyclic aromatic hydrocarbons
mg/kg = milligrams per kilogram
µg/kg = micrograms per kilogram
PCB = polychlorinated biphenyls
TBT = tributyl tin

Table 14. SWAC Reduction as a Function of Background
Expert Report on Economic Feasibility
Shipyard Sediment Site

Chemical	ARO*	DTR	(DTR) - (ARO)**
Copper	34%	52%	18%
Mercury	29%	48%	19%
Total HPAH (half DL)	26%	44%	18%
Total PCB	43%	59%	16%
TBT	24%	44%	20%
Average	**31%**	**49%**	**18%**

Notes:

Surface-weighted average concentrations (SWACs) are based on Thiessen polygons, except as noted.

* Alternative Remedial Option

** Difference in SWAC reduction based on DTR and ARO.

DTR = *Draft Technical Report for Tentative Cleanup and Abatement for the Shipyard Sediment Site in San Diego Bay*

HPAH = high molecular weight polycyclic aromatic hydrocarbons

PCB = polychlorinated biphenyls

TBT = tributyl tin

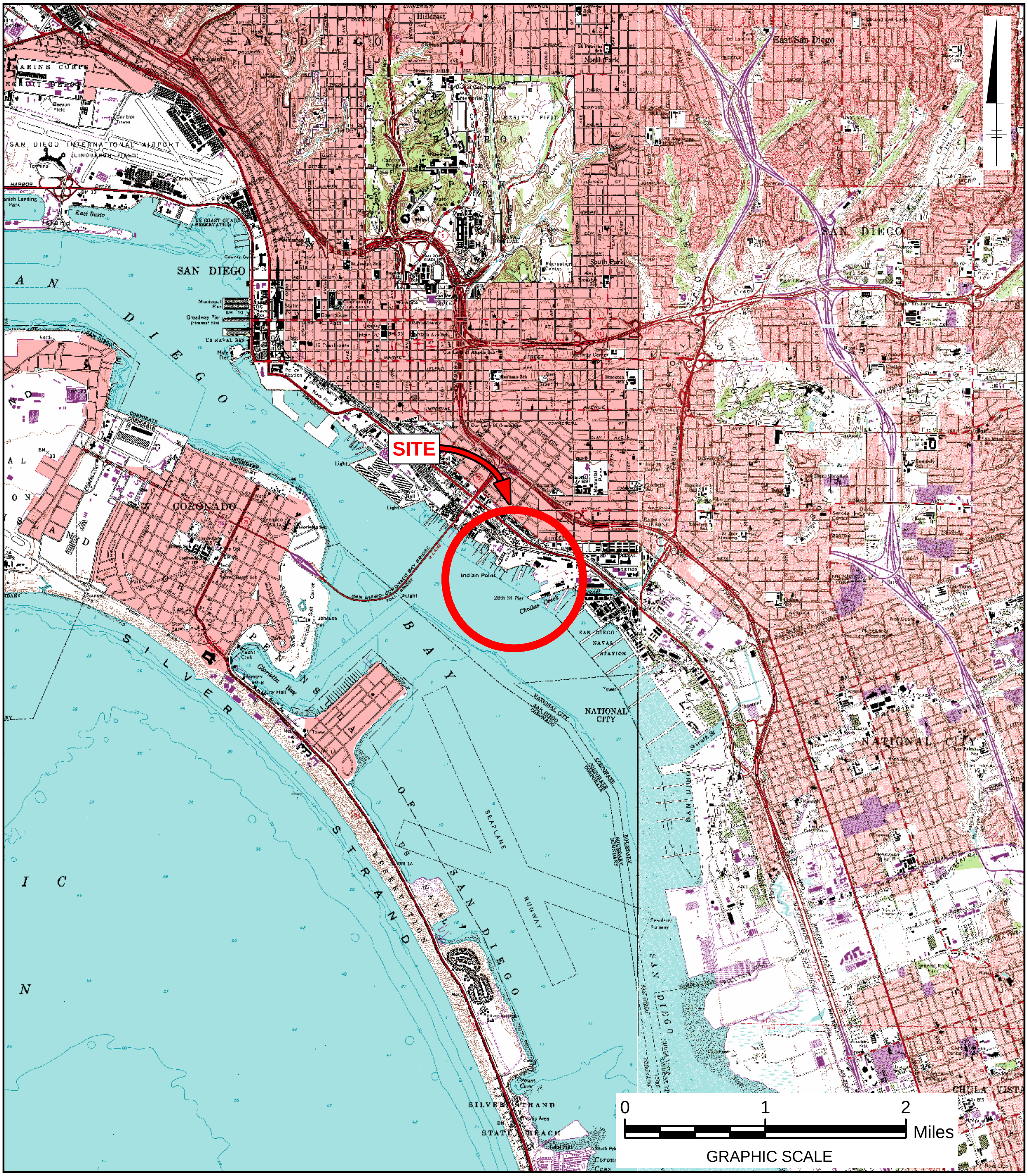
Table 15. Estimated Exposure Reduction by Options (Percent)
Expert Report on Economic Feasibility
Shipyard Sediment Site

	Alternative Remedial Option	**DTR-Recommended Remedial Option**	**Background Remedial Option**
Copper	34%	43%	100%
Mercury	29%	42%	100%
Total HPAH (half DL)	26%	37%	100%
Total PCB	43%	51%	100%
TBT	24%	37%	100%
Average	**31%**	**42%**	**100%**

Notes:
(1) DTR SWAC based on Sediment Management Unit.
DTR = *Draft Technical Report for Tentative Cleanup and Abatement for the Shipyard Sediment Site in San Diego Bay*
HPAH = total high molecular weight polycyclic aromatic hydrocarbons
PCB = total polychlorinated biphenyl
SWAC = surface-weighted average concentration
TBT = tributyl tin

ARCADIS

Figures



NOTE:

1. 7.5 MINUTE USGS QUADS OF POINT LOMA, CA AND NATIONAL CITY, CA.

DLA PIPER FOR BAE SYSTEMS
SAN DIEGO BAY SHIPYARD SEDIMENT SITE
EXPERT REPORT ON ECONOMIC FEASIBILITY SHIPYARD SEDIMENT SITE

SITE MAP

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FIGURE
1

SYR-90 MTK
BAE Systems 0
Q:\BAE\SanDiegoBay\RemedialAlternativeCostEvaluation\mxd\Site Map.mxd - 10/25/2010 @ 4:37:00 PM

LEGEND:

- SEDIMENT SAMPLE LOCATION
- LEASEHOLD BOUNDARY
- UNDER PIER CAPPING REMEDIAL AREA
- DREDGING REMEDIAL AREA

0 500 1,000 Feet

GRAPHIC SCALE

NOTES:

1. FIGURE DEVELOPED UTILIZING INFORMATION PROVIDED IN THE WATER CONTROL BOARD'S DRAFT TECHNICAL REPORT (SEPTEMBER 15, 2010).
2. AERIAL IMAGERY COLLECTED IN 2003 PROVIDED BY THE CALIFORNIA GEOSPATIAL CLEARINGHOUSE.
3. SW-## - BAE SYSTEMS NORTH REMEDIAL POLYGON IDENTIFICATION
   NA-## - NASSCO SOUTH REMEDIAL POLYGON IDENTIFICATION

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SAN DIEGO BAY SHIPYARD SEDIMENT SITE
EXPERT REPORT ON ECONOMIC FEASIBILITY SHIPYARD SEDIMENT SITE

DTR-RECOMMENDED REMEDIAL OPTION

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FIGURE
2

SYR-90 MTK
BAE Systems ()
Q:\BAE\SanDiegoBay\RemedialAlternativeCostEvaluation\mxd\Current Alternative.mxd - 10/25/2010 @ 4:43:12 PM

LEGEND:

- SEDIMENT SAMPLE LOCATION
- LEASEHOLD BOUNDARY
- UNDER PIER CAPPING REMEDIAL AREA
- DREDGING REMEDIAL AREA

0 500 1,000 Feet

GRAPHIC SCALE

NOTES:

1. FIGURE DEVELOPED UTILIZING INFORMATION PROVIDED IN THE WATER CONTROL BOARD'S DRAFT TECHNICAL REPORT (SEPTEMBER 15, 2010).
2. AERIAL IMAGERY COLLECTED IN 2003 PROVIDED BY THE CALIFORNIA GEOSPATIAL CLEARINGHOUSE.
3. SW-## - BAE SYSTEMS NORTH REMEDIAL POLYGON IDENTIFICATION
   NA-## - NASSCO SOUTH REMEDIAL POLYGON IDENTIFICATION

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EXPERT REPORT ON ECONOMIC FEASIBILITY SHIPYARD SEDIMENT SITE

BACKGROUND REMEDIAL OPTION

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FIGURE 3

SYR-90 MTK
BAE Systems ()
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LEGEND:

- SEDIMENT SAMPLE LOCATION
- LEASEHOLD BOUNDARY
- UNDER PIER CAPPING REMEDIAL AREA
- DREDGING REMEDIAL AREA

0 500 1,000 Feet

GRAPHIC SCALE

NOTES:

1. FIGURE DEVELOPED UTILIZING INFORMATION PROVIDED IN THE WATER CONTROL BOARD'S DRAFT TECHNICAL REPORT (SEPTEMBER 15, 2010).
2. AERIAL IMAGERY COLLECTED IN 2003 PROVIDED BY THE CALIFORNIA GEOSPATIAL CLEARINGHOUSE.
3. SW-## - BAE SYSTEMS NORTH REMEDIAL POLYGON IDENTIFICATION
   NA-## - NASSCO SOUTH REMEDIAL POLYGON IDENTIFICATION

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EXPERT REPORT ON ECONOMIC FEASIBILITY SHIPYARD SEDIMENT SITE

ALTERNATIVE REMEDIAL OPTION

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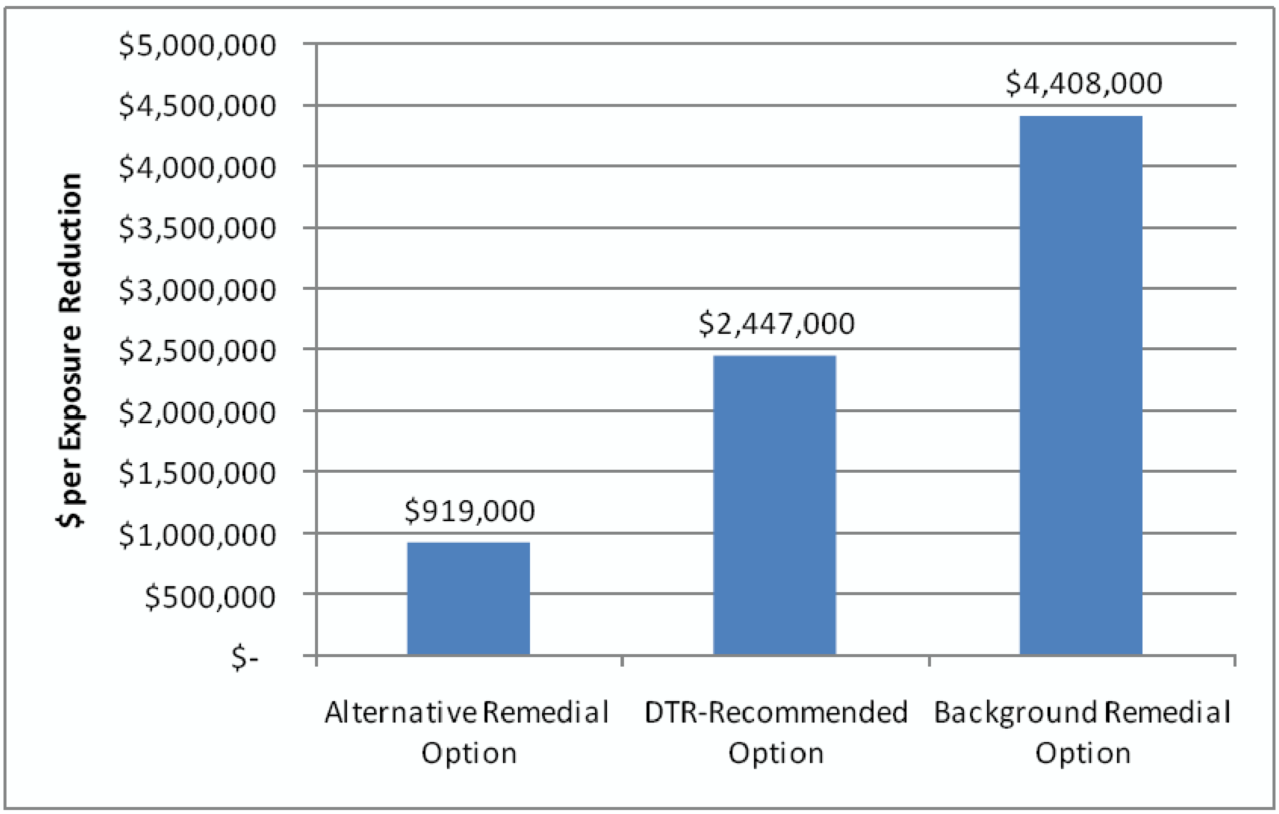
FIGURE 4

SYR-90 MTK
BAE Systems ()
Q:\BAE\SanDiegoBay\RemedialAlternativeCostEvaluation\mxd\Reduced Footprint Alternative.mxd - 10/25/2010 @ 4:46:14 PM



Note:

Exposure reduction calculations utilized estimated post-remedial surface-area weighted average concentrations (SWAC) for the primary COCs. DTR-Recommended Options based on SMU SWACs exposure reduction calculation using an estimated post-remedial surface-area weighted average concentrations (SWAC) for the primary COCs.

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SAN DIEGO BAY SHIPYARD SEDIMENT SITE
EXPERT REPORT ON ECONOMIC FEASIBILITY SHIPYARD SEDIMENT SIT

INCREMENTAL COST-EFFECTIVENESS RESULTS: 3 PERCENT DISCOUNT RATE

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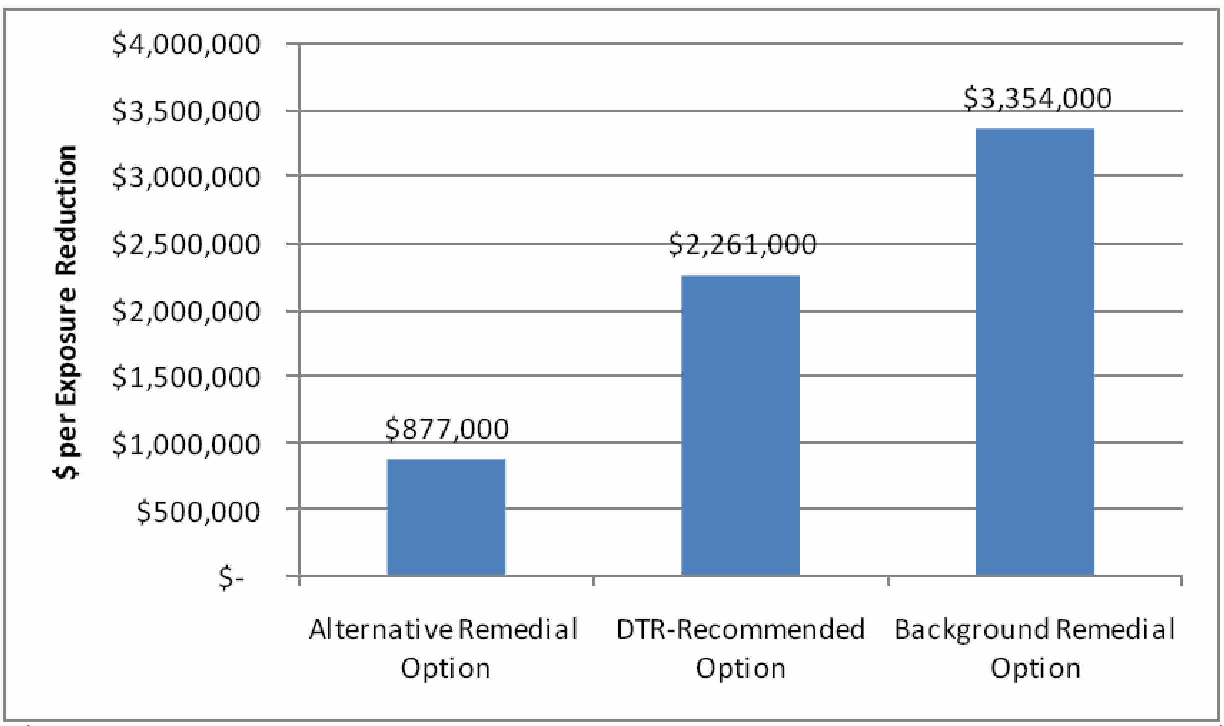
FIGURE
5

03/09/2011 SYRACUSE, NY-ENV/CAD-DJHOWES
B0080242/0000/00001/CDR/80242G02.CDR



Note:

Exposure reduction calculations utilized estimated post-remedial surface-area weighted average concentrations (SWAC) for the primary COCs. DTR-Recommended Options based on SMU SWACs exposure reduction calculation using an estimated post-remedial surface-area weighted average concentrations (SWAC) for the primary COCs.

DLA PIPER FOR BAE SYSTEMS
SAN DIEGO BAY SHIPYARD SEDIMENT SITE
EXPERT REPORT ON ECONOMIC FEASIBILITY SHIPYARD SEDIMENT SITE

INCREMENTAL COST-EFFECTIVENESS RESULTS: 7 PERCENT DISCOUNT RATE

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FIGURE
6

03/09/2011 SYRACUSE, NY-ENV/CAD-DJHOWES
B0080242/0000/00001/CDR/80242G03.CDR

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Appendix A

Resumes of Experts

ARCADIS

Education
MS, Geochemistry, University of Chicago, Chicago, IL, 1983
BS, Chemistry, Cook College at Rutgers University, New Brunswick, NJ, 1981

Years of Experience
Total - 26
With ARCADIS - 8

Professional Registrations
Licensed Geologist, WA
Licensed Geologist, OR

Professional Associations
American Chemical Society
Society for Environmental Toxicology and Chemistry
Western Dredging Association

Philip A. Spadaro, LG

Principal Scientist/Senior Vice President

Mr. Spadaro, a leading international expert in sediment cleanup and waterfront redevelopment, is a senior vice president of ARCADIS and senior scientist in the Waterfront and Sediment Division. Technically based in environmental chemistry with strong proficiency in hydrogeology, geology, regulatory affairs, and remediation, Mr. Spadaro has more than 26 years of experience applying his expertise and management skills to projects where sediment quality is a prominent issue. As a senior technical reviewer, Mr. Spadaro has extensive expertise in the siting, design, permitting, and construction of confined disposal facilities and in the fate and transport of contaminants in estuarine, riverine, and marine aquatic environments. He is an expert advisor to ARCADIS's sediment remediation team and discipline coordinator for international sediment management and remediation projects in Europe. In addition, Mr. Spadaro provides litigation support for construction claims and cost-recovery actions and other matters related to sediment remediation.

The successful execution of highly complex sediment remediation projects demands meticulous planning, strong scientifically sound technical approaches, and credibility with regulatory authorities. Mr. Spadaro's international reputation for designing and implementing inventive, appropriate, and cost effective waterfront solutions is anchored in these qualities and in his commitment to seek out and respect the unique needs of every project and client.

Project Experience

Litigation Support, Yosemite Creek Time-Critical Removal Action
Yosemite Creek PRP Group, San Francisco, California
2008 - Ongoing
USEPA has proposed time-critical removal action of over 20,000 cubic yards of contaminated sediment in this highly urbanized embayment within the San Francisco bay. Currently serving as senior technical advisor in negotiations with USEPA to improve removal action design and address community concerns regarding quality of life issues.

Litigation Support, Portland Harbor Superfund Site
Oregon Department of Transportation, Portland, Oregon
2009
Currently providing expert advice and testimony related to Portland Harbor Superfund Site. Key issues revolve around potential contributions from state-maintained roads and other facilities. Project includes extensive field studies as well as evaluation of available technical data from the RI/FS process.

Review of Corporate Contaminated Sediment Issues

Confidential Client, Arnhem, the Netherlands

2008

Provided training to high level corporate environmental staff in a two-day workshop dealing exclusively with contaminated sediment management. Reviewed contaminated sediment management policies and practices at numerous sites and provided suggestions for technical studies and negotiation strategies to improve outcomes.

Peer Review of Confined Disposal Facility Design and Management

US Army Corps of Engineers, New Orleans, Louisiana

2009

As part of restoration efforts following damage caused by Hurricane Katrina, ARCADIS was retained by the Corps to evaluate the disposal of contaminated dredge material from the Industrial Harbor Navigation Canal in a nearby confined disposal facility (CDF). Serving as overall technical advisor to the project team conducting peer review of CDF design, community safety, and long-term maintenance and monitoring. Assisting Corps in addressing community concerns about short- and long-term risks of CDF operation as well as the potential for catastrophic failure.

Litigation Support and Removal Action Design

Confidential Client, Passaic River, Newark, New Jersey

2000 - Ongoing

Long-term strategic technical advice on this complex and dynamic superfund site. Work has included evaluation of stormwater and CSO inputs, review of USEPA and consultant work products, and most recently preparation of design documents for Phase I and Phase II non-time-critical removal actions of 200,000 cubic yards of highly contaminated sediment. Serves as technical advisor for multi-disciplinary team performing studies of sediment quality, dredging, sediment processing, transport and disposal, water quality, hydrodynamics, community health and safety, and confined disposal facility siting and design.

EE/CA for Non-time-Critical Removal Action

Confidential Client, Portland, Oregon

2009

Serving as technical advisor to multi-disciplinary team performing engineering evaluation/cost analysis for DDT-contaminated sediments. Work includes negotiation with USEPA and conceptual design of dredging and confined disposal facility.

Sediment Removal Action Evaluation and Design

3M Corporation, East Cove, Cottage Grove, Minnesota

2007 - Ongoing

Provided strategic advice for negotiation of removal action with Minnesota Pollution Control Agency. Evaluated conceptual removal action design. Provided technical oversight for proposed design-build approach to remove sediments contaminated with fluorinated compounds in a cove adjacent to the Mississippi River.

Sediment Removal Action
3M Corporation, Sayerviille, New Jersey
2008
Assisted client with review of proposed removal action at Horseshoe Road Superfund Site on Raritan River. Evaluated capping, removal, and natural recovery.

Evaluation of Proposed Removal Action
Ford Motor Company, River Raisin, Michigan
2008
Evaluated the USEPA-proposed removal action for contaminated sediments in this highly industrialized river drainage. Advised client on removal action costs and benefits. Evaluated potential for additional PRP involvement. Performed limited sampling to refine agency proposed removal action design.

Contaminated Sediment Management and Remedial Design
Confidential Client, Rada di Augusta, Sicily, Italy
2005 - Ongoing
Working to define an overall strategy regarding 9,000,000 cubic yards of contaminated sediments in Rada di Augusta, a 25-square-kilometer bay. Initially asked to review the Italian government's investigation results and cleanup plan, which revealed extensive enrichment in mercury from a local chloralkali plant, as well as petroleum hydrocarbon contamination. The government's plan calls for large-scale dredging and construction of a confined disposal facility. Since performing the initial data review, ARCADIS has conducted focused sampling to evaluate conditions in the in the bay and is currently working with the Ministry of the Environment and its oceanographic research division to refine the proposed design and larger site strategy. An engineering evaluation is under way to assess remediation alternatives based on a multi-technology approach appropriate to this enormous and complex site.

Contaminated Sediment Management and Remedial Design
Confidential Client, Navassa, North Carolina
2006 - Ongoing
Prior investigation results indicated the presence of lead and other metals in the nearshore sediments adjacent to this former fertilizer plant on the Cape Fear River. Initially asked to review the existing engineering evaluation/cost analysis (EE/CA) as an expert on the remediation of contaminated sediments. Following the EE/CA review, the client tasked ARCADIS with additional

responsibilities. Now leading pre-design sampling of sediment and wetlands soils to support the design of a remedy.

Litigation Support for a Construction Claim

Confidential Client, Tacoma, Washington

2006 - 2007

Led a team that provided expert support regarding the validity of a contractor's claim that its own failure to perform on schedule resulted from a purportedly inadequate dredging design. Responsible for supervising engineers who reviewed the design, plans, and specifications and assisting the client's attorneys in developing their litigation strategy.

Design of Engineered Containment Facility for Contaminated Sediments

Hamilton Port Authority, Hamilton, Ontario

2004 - Ongoing

The Hamilton Port Authority, Environment Canada, and the Ontario Ministry of the Environment are planning to construct an engineered containment facility in the Randle Reef area of Hamilton Harbour, where sediments are contaminated as the result of a coal-tar spill in the 1980s. Serving as the environmental studies task manager and overall technical advisor for this multidisciplinary project. Critical factors for design include contaminant transport and fate, short-term and long-term water quality, and effluent treatment. The basis of design report and final design have been completed and accepted by the multi-agency consortium sponsoring the project. Construction is anticipated in 2010.

Litigation Support, Gashouse Cove Marina

Confidential Client, San Francisco, California

2004 - Ongoing

Gashouse Cove Marina is located at the site of a former manufactured gas plant (MGP) once operated by PG&E. Sediments in the vicinity are contaminated with polycyclic aromatic hydrocarbons from multiple sources, including the MGP. Working with PG&E's legal department to evaluate the City of San Francisco's proposed plan for redevelopment of the marina - the plan calls for dredging, which has the potential to expose contaminated sediments - and the City's claim against PG&E for partial cost of the redevelopment. In addition to litigation support, the team is conducting source evaluation and engineering analysis to help ensure that PG&E's level of responsibility is accurately assessed.

Control of NAPL Seeps, Pine Street Canal Superfund Site

Green Mountain Power, Burlington, Vermont

2006 - Ongoing

An existing sand cap that was designed by others to physically isolate chemical contaminants from the overlying water has failed, and nonaqueous-phase liquid (NAPL) is seeping through the cap and entering the water column. ARCADIS has been retained to evaluate NAPL controls that will eliminate seepage into the canal and can be readily and economically implemented as partial replacement for the existing sand cap. Serving as principal in charge for this evaluation and design effort, with responsibility for ensuring that activities are consistent with project goals and that technical work products meet quality assurance standards.

Due Diligence Investigation

Port of Tacoma, Tacoma, Washington

2006 - 2007

Serving as a consultant to the Port's environmental, real estate, and legal departments as they work to evaluate the Port's responsibilities and liabilities should it decide to purchase a large, contaminated property. The effort involves evaluating extensive environmental documentation reaching back to a 1970s-era cleanup, as well as the site's 100-year industrial history, its multi-agency regulatory history, and large-scale soil, groundwater, and sediment contamination with chlorinated solvents and caustics.

Litigation Support for Insurance Cost Recovery

Nadler Law Group and Confidential Puget Sound Port Authority, Washington

2005

Retained to serve as expert for a complex insurance cost recovery matter involving numerous waterfront properties. The key element of this case involved cost-recovery claims for construction of a confined disposal facility to contain contaminated sediments.

Upland Source Control Investigation and Remediation

Port of Portland, Portland, Oregon

2004 - 2005

Served as the principal in charge on this 5-year contract to evaluate and clean up multiple Port terminals and other properties along the Willamette River. The work involved review of historical and current site information and ongoing investigation consistent with agreements between the Port and Oregon Department of Environmental Quality.

EE/CA for Non-Time-Critical Removal Action

Port of Portland, Portland, Oregon

2003 - 2005

Served as project manager for a 3-year contract to provide technical assistance for the removal of contaminated sediments adjacent to Terminal 4. ARCADIS's responsibilities included managing characterization of contaminated Willamette River sediments, preparation of an engineering evaluation/cost analysis (EE/CA) in accordance with the Administrative Order by Consent between the Port and U.S. Environmental Protection Agency (USEPA) Region 10, and preparation of associated work plans and technical reports. Coordinated with the Port to integrate data and decision making for Terminal 4 with work at the larger Portland Harbor Superfund Site and to incorporate upland source control strategies now under development into removal alternatives for Terminal 4. The EE/CA was reviewed by the USEPA and accepted without comment.

Elliott Bay Water Quality Monitoring and Sediment Sampling

US Army Corps of Engineers, Seattle, Washington

2003 - 2004

The Pacific Sound Resources Superfund site, located on Elliott Bay, has long been a source of hazardous substances associated with former wood-treating operations. Cleanup actions included removing about 700 treated wood pilings, dredging 10,000 cubic yards of contaminated nearshore sediments, and placing a clean sediment cap over about 58 acres of contaminated sediments. ARCADIS supported the construction effort by monitoring water quality during dredging and cap placement and by conducting verification sampling to confirm the integrity and thickness of the engineered cap. Served as the officer in charge for ARCADIS's responsibilities, which included writing the sampling, monitoring, and quality assurance plans, mobilizing in the field to collect water quality and vibracore sediment samples, and coordinating laboratory analysis and data validation. Prior to cap placement, ARCADIS also coordinated physical and chemical testing of the import material to ensure it was suitable for use.

Sediment Sampling Program at Marine Transfer Stations

New York City Department of Sanitation, New York Harbor, New York

2003 - 2004

Working on behalf of the prime contractor, ARCADIS executed an initial sediment sampling program related to the conversion of eight former marine transfer stations operated in New York Harbor by the New York City Department of Sanitation. Conversion of the solid waste facilities involves demolishing several structures, removing old piles, repairing bulkheads, and dredging to increase navigational depths. Served as technical specialist for ARCADIS's sediment sampling program, which was designed to provide preliminary sediment and water quality data to aid in determining the engineering controls needed to limit contaminant releases to surface water during construction, as well as to identify handling, transportation, and disposal options for the dredged sediment.

Litigation Support for Insurance Cost Recovery

Short, Cressman, and Burgess and Confidential Puget Sound Port Authority, Washington

2002

Retained as an expert to review extensive documentation and current site conditions at multiple facilities owned by a mid-sized port authority. The sites included a shipyard, a boatyard, a landfill, and other types of active and unused facilities. Activities included extensive interaction with the port's attorneys, review of reports, site visits and interviews, preparation of expert opinions, and depositions. The port prevailed in its complaint and received a settlement in keeping with its expectations.

North Channel Confined Disposal Facility

Port Authority of Venice, Venice, Italy

2001 - 2002

The Port of Venice is contemplating construction of a large confined disposal facility to contain contaminated dredge materials. Retained by the Port as a special consultant to address contaminant mobility issues associated with facility construction. Short- and long-term issues are under consideration.

Sediment Treatment Technology Evaluation

State of Washington

2001

Served as project manager and senior scientist to evaluate several contaminated sediment treatment technologies for their effectiveness, implementability, and cost under three DNR-specified scenarios - two were particular to Bellingham Bay, where a multiagency group is working to establish a model process for selecting disposal sites; the third was more widely applicable to contaminated sediments from throughout Puget Sound. Together, the three scenarios form a natural progression for the development of sediment treatment technology in the region.

Removal Action at the Olympic View Resource Area

City of Tacoma, Tacoma, Washington

2001 - 2002

The USEPA approved a removal action at the Olympic View Resource Area (OVRA) to address approximately 2.2 acres of contaminated marine sediments within the 12.4-acre OVRA site. ARCADIS designed the removal action - including the development of design and construction documents, design methods, assumptions, and evaluations - and documented quality assurance methods in a construction quality assurance plan. In addition, ARCADIS was involved in the performance of an engineering evaluation/cost analysis for the removal action that summarized investigation results and evaluated remedial alternatives in accordance with the National Contingency Plan. Following public comment and USEPA review, a preferred remedial alternative was selected. The design team's analysis report presented design criteria and regulatory requirements for the preferred alternative, rationales for design decisions, and a detailed construction cost estimate. Served as senior technical review scientist for the project.

Metal Bank Superfund Site Remediation

PRP Group, Philadelphia, Pennsylvania

1998 - 2001

At this former metals recycling facility located on the banks of the Delaware River, river sediments and upland areas are contaminated with polychlorinated biphenyls from the recycling of 1970s-era transformers and transformer oils; the design team was responsible for remediation of the river sediments. Provided senior technical review during development of the preliminary design submittal to USEPA Region III.

Design of Hylebos Waterway, Phase I Dredging, Slip 1 Disposal

Port of Tacoma, Tacoma, Washington

1999 - 2002

Cleanup of the outer Hylebos Waterway will be the third major cleanup in the Commencement Bay Nearshore Tideflats since the bay was declared a Superfund site. Served as project manager for all three design projects. In this cleanup, contaminated sediments at the mouth of the waterway will be dredged and deposited in a confined disposal facility being constructed in Slip 1 at the Blair Waterway. While serving as project manager, responsibilities included senior technical review and oversight of all project elements, including design of both the dredging plan and the containment facility.

Hylebos Waterway, Area 5106 Dredging and Disposal Project

Port of Tacoma, Tacoma, Washington

1999 - 2002

Provided the Port with technical oversight as it developed plans for the dredging, treatment, and disposal of approximately 50,000 cubic yards of sediments heavily contaminated with volatile organic compounds. Plans called for hydraulic dredging followed by thermal treatment of the sediments at an upland treatment plant and disposal of the treated sediments in a confined disposal facility to be constructed in Slip 1 of the Blair Waterway. Responsible for reviewing all technical documents on behalf of the Port, including studies of fate and transport and the engineering evaluation/cost analysis.

Ross Island CAD Cells Assessment

Port of Portland, Portland, Oregon

1998 - 2000

From 1992 to 1998, sediments dredged by the Port of Portland were disposed of under permit at five capped aquatic disposal (CAD) cells in Ross Island Lagoon (Willamette River), where sand and gravel mining is ongoing. In 1999, the Port asked the design team to initiate a comprehensive site investigation to evaluate regulatory and environmental issues associated with use of the CAD cells, including such components as contaminant fate and transport, geotechnical stability, and ecological and human health risks. Served as program manager and provided senior technical review for the investigation, which incorporated extensive sampling of soil, sediments, and groundwater; a thorough review of the mining and disposal history, including a detailed permit review; biological surveys; risk assessments; and an analysis of lagoon bathymetry and groundwater flow and gradient. Evaluation of the investigation results will in part be used by the Oregon Department of Environmental Quality to determine whether this type of confined disposal will continue in Oregon. The investigation results demonstrated conclusively that capped aquatic disposal can be accomplished in an environmentally safe manner and that these CAD cells in particular are functioning as intended to isolate Port dredged material from the environment.

Thea Foss and Wheeler-Osgood Waterways Pre-Remedial Design

City of Tacoma, Tacoma, Washington

1994 - 2003

Served as project manager for the sediment remedial design component of this large-scale waterway redevelopment. The 8,000-foot-long waterway receives considerable storm drainage, as well as direct discharges from adjacent industries. Because of the variety of inputs, including impacts from operation of a former manufactured gas plant, there are several inorganic and organic constituents of interest in the sediments, such as oils, tars, polycyclic aromatic hydrocarbons, phthalates, and PCBs. Technical elements of the remedial design included an evaluation of source control measures, a natural recovery analysis, an evaluation of potential disposal sites, a hydrographic survey, and the development of habitat mitigation plans. The remedial design included natural recovery in the mouth of the waterway, enhanced natural recovery in its middle section, and more active remediation at the head of the waterway. Several alternatives were considered for the active remediation, including capping the contaminated sediments in place or removing them to a confined aquatic, nearshore, or upland disposal site. The pre-remedial design process concluded in 2000, and the remediation plan has received USEPA approval. The remedy will incorporate the dredging of approximately 700,000 cubic yards of sediments and the capping of 36 acres, including thin-layer and thick-layer caps, as well as an innovative hybrid sorbent cap that will combine the traditional function of isolation with a treatment component for oily seeps. In addition, managed the design of a confined disposal facility in the adjacent St. Paul Waterway, where the dredged sediments will be placed. Also assisted the city in a related effort to proportionately allocate cleanup costs among numerous non-City potentially responsible parties and to recover the City's costs from its insurers.

Contaminant Mobility Investigation and Dredging Feasibility Study

Confidential Client, Massachusetts

1998 - 2000

Served as technical specialist for issues of contaminant mobility and remedial alternatives in the evaluation of an historical manufactured gas plant. The site is regulated under the Massachusetts state cleanup program. Assisted the owners and prime consultants in their assessment of oil-releasing sediments; key to investigation was an evaluation of nonaqueous phase transport from upland areas to sediments, from sediments to the water column, and through the water column offsite to nearby estuaries. To accomplish this analysis, evaluated existing data, proposed additional data gathering to close gaps, and assisted in the development of a focused feasibility study for remedial action at site. Evaluated several technologies, including dredging to remove oil-containing sediments, capping, natural recovery, and control of nonaqueous phases, both to determine the best available technical approach and to control potential costs. Ultimately, provided the client, a potentially responsible party, with the information necessary to negotiate a financial settlement relieving it of future liability for the site. Cleanup is now under the authority of the State of Massachusetts.

Grand Calumet River/Indiana Harbor Ship Canal Remedial Options Assessment

PRP Group, East Chicago/Gary/Hammond, Indiana

1997 - 1999

On behalf of the potentially responsible parties (PRPs), assessed remedial options for sediments in this system under a Natural Resource Damage Assessment action brought by the Natural Resource Trustees, which included the USEPA, the U.S. Fish and Wildlife Service, and the Indiana Department of Natural Resources. Acted as technical specialist for the evaluation of remedial alternatives. Assisted the project team by identifying gaps in the existing data set; defining the need for further technical studies; interpreting existing chemical and physical testing data; establishing the history of dredging and sediment deposition in the waterways; and providing strategic guidance to the PRP group. On the basis of this evaluation, the PRPs have made a settlement offer to the regulatory agencies that is under consideration.

Island End River MGP Site Evaluation

Eastern Enterprises, Weston Massachusetts

1998 - 2001

Retained by the potentially responsible parties to evaluate the feasibility of reconfiguring a confined disposal facility (CDF) proposed to contain sediments contaminated with polycyclic aromatic hydrocarbons at this Boston Harbor site of a former manufactured gas plant. In addition, assessed methods for managing sheen-producing sediments that will remain outside the CDF's boundaries. Provided senior technical review for these evaluations, with particular emphasis on oil seepage and innovative approaches to the management of oily sediments.

Brooklyn Navy Yard Confined Disposal Area Feasibility Study

Brooklyn Navy Yard Development Corporation, Brooklyn, New York

1998 - 2000

Faced with the necessity of dredging to accommodate ongoing vessel maintenance, evaluated the feasibility of constructing a bermed, nearshore confined disposal facility (CDF) at the head of the Wallabout Channel to contain up to 450,000 cubic yards of dredged material. In addition, the feasibility study examined other disposal alternatives, such as constructing an upland CDF, using the dredged material as landfill cover, or removing the material for offsite disposal under a mine reclamation program. In support of the feasibility study and other efforts, provided senior technical review, with particular emphasis on the assessment of chemical fate and transport and contaminant mobility. Other elements of the project included development of a conceptual design for the CDF and an evaluation of the regulatory structure and key permitting requirements.

Fox River Dredging

Fort James Corporation, Green Bay, Wisconsin

1998 - 2000

As a result of historical discharges to the river system, bottom sediments in the lower Fox River are impacted by PCBs. As one potentially responsible party (PRP), Fort James Corporation had a keen interest in the selection of appropriate, technically sound, and cost-effective remediation and restoration actions. During early planning for a possible remedial action, assisted Fort James in assessing issues broadly associated with its liability. After a demonstration dredging project undertaken by the state and the Fox River Group, a PRP organization, failed to meet expectations and attain cleanup goals, Fort James elected to independently redesign and complete the project as a full-scale removal. For that more recent work, managed technical oversight of the dredging design. Careful engineering of the dredge prism was a key issue; because capacity at the disposal site was limited, cleanup goals had to be achieved while limiting the removal to 50,000 cubic yards. Following the removal action, verification sampling showed that the design team's engineering had successfully met both objectives, resolving Fort James' obligations at the site.

Claremont Channel Deepening

Hugo Neu Schnitzer East (HNSE), Jersey City, New Jersey

1997 - 2002

This project, a public-private partnership among the State of New Jersey, the City of Jersey City, HNSE (a major metal recycling firm), and Liberty National Development Corporation, incorporated several phases, all associated with improvements in the Claremont Channel. Key elements of the proposed effort included dredging 1.25 million cubic yards of contaminated sediments and beneficially using the dredged material to create 5 acres of intertidal habitat, as well as to cap two former upland industrial properties and grade a new golf course. Dredged material employed at the upland sites and in the golf course will be amended with PROPAT®, a product manufactured by HNSE from auto shredder residue, a recycled material. Served as a technical specialist regarding matters of dredging design, CDF design, bench-scale and pilot-scale mixing studies, permitting, and project funding, which will include state bond funds and funds designated for demonstrating the efficacy of new remediation technologies.

Nearshore Confined Disposal Facility

River Terminal Development Corporation, New Jersey

1996 - 1999

Served as a technical specialist for permitting and conceptual design of the first nearshore confined disposal facility in the New York-New Jersey area proposed for construction specifically to contain contaminated sediments. In the early project stages, responsibilities included negotiating with the Corps of Engineers and regional regulators (including the New Jersey Department of Environmental Protection) to secure the necessary permits. Also led discussions with local environmental groups to develop support for the remediation of severely contaminated sediments, which would lead to some habitat destruction, as well as to redevelop an important waterfront facility. Participation included assessments of contaminant mobility and habitat mitigation requirements.

Remedial Investigation/Feasibility Study (RI/FS) of Shipyard Sediment Operable Unit

Confidential Client, Seattle, Washington

1994 - 2000

Served as project manager for work undertaken on behalf of a potentially responsible party. Reviewed the USEPA's remedial investigation/feasibility study documents, developed supplemental remedial investigation strategies, and negotiated the statement of work and Administrative Order on Consent with the USEPA. Technical aspects of the preremedial design studies included surface and subsurface sediment sampling, biological evaluations, and natural recovery analysis. Involvement continued through design analysis and development of a preliminary remedy design that included limited dredging and capping. As a result of this work, the design team was successful in demonstrating to the USEPA that large-scale active remediation was unnecessary, thus reducing the projected costs of remedial action by more than a factor of 10.

Litigation Support for Blair, Sitcum, and Milwaukee Waterways Cost-Recovery Action

Attorneys for the Port of Tacoma, Tacoma, Washington

1995 - 1997

In support of litigation and cost-recovery actions, investigated the origins of sediment contamination in the waterways and adjacent upland properties and developed dredging and sediment contamination chronologies. To this end, implemented a methodology structured to capture all available literature and documentation, including such sources as Port contract records, Corps of Engineers files, previous investigations, aerial photographs, and personal interviews. Once gathered, the historical information was then correlated with sediment contamination profiles to provide technical grounds for legal action against insurers and other potentially responsible parties. The work culminated with testimony as an expert technical witness.

Sitcum Waterway Remediation

Port of Tacoma, Tacoma, Washington

1991 - 1995

Served as project manager for this complex, long-term remediation, the largest sediment remediation ever undertaken by USEPA mandate. One purpose of the project was to increase container terminal space by filling approximately 70 percent of the Milwaukee Waterway with 1.6 million cubic yards of fill sediments taken from the Blair Waterway (where redevelopment plans called for removing sediments to expand Port facilities) and the Sitcum Waterway (where sediment removal was a component of the CERCLA cleanup). The project began with a conceptual design in the early 1980s and progressed to encompass sediment quality testing, geotechnical engineering, hydrogeologic evaluations, and pre-remedial design and remedial design phases. Conceptualized specialty services executed by the design team that included elutriate, leaching, and settling tests; natural recovery modeling; and dredge and disposal water quality modeling. In addition, managed environmental permitting issues and ensured compliance with CERCLA and Clean Water Act mandates.

Mercury Contamination Source Evaluation Middle Waterway

Foss Maritime, Tacoma, Washington

1990 - 1993

Served as project manager for this investigation of the source of mercury contamination in sediments. Conceptualized and oversaw focused sampling of seeps, upland soils, and sediments to assess ongoing source control measures. This project required a comprehensive review of historical sources of mercury deposited in the waterway, which in turn led to subsequent development of an expanded PRP list. Components of the pre-remedial design included natural recovery modeling and an assessment of the feasibility of various alternatives for confined disposal.

Sediment Assessment of Blair Waterway, Slip 2 Nearshore Fill

Port of Tacoma, Tacoma, Washington

1987 - 1990

This logistically complex project called for expanding the land area of Terminal 3 and constructing Terminal 4 by dredging adjacent offshore sediments and using the dredged material to fill Slip 2. As project manager, oversaw the collection of sediment samples using hollow-stem augers, impact coring, and vibracoring through 40 to 60 feet of water and to 20 to 40 feet below the mud line. Able to significantly reduce the sampling and analysis requirements through negotiations with regulatory agencies. In addition, and of considerable benefit to the client, initial assessment of sediment chemistry was so thorough that when the Port altered its original plan, it was not necessary to negotiate the chemistry requirements.

Open-Water Disposal Permit for Sitcum Waterway Maintenance Dredging

Port of Tacoma, Washington

1987 - 2000

As project manager for Puget Sound Dredge Disposal Analysis (PSDDA) compliance, negotiated with regulatory agencies to develop technically sound and cost-effective sampling plans, oversaw and managed sampling and chemical analyses, and provided senior review of technical studies. Successfully obtained PSDDA-related permits.

Open-Water Disposal Permit for Everett Marina Project

Port of Everett, Washington

1989

As project manager for Puget Sound Dredge Disposal Analysis (PSDDA) compliance, negotiated with regulatory agencies to develop technically sound and cost-effective sampling plans, oversaw and managed sampling and chemical analyses, and provided senior review of technical studies. Successfully obtained PSDDA-related permits.

Open-Water Disposal Permit for Hylebos Facility Project

Lone Star NW, Washington

1990

As project manager for Puget Sound Dredge Disposal Analysis (PSDDA) compliance, negotiated with regulatory agencies to develop technically sound and cost-effective sampling plans, oversaw and managed sampling and chemical analyses, and provided senior review of technical studies. Successfully obtained PSDDA-related permits.

Open-Water Disposal Permit for West Blair Terminal Project

Port of Tacoma, Washington

1995

As project manager for Puget Sound Dredge Disposal Analysis (PSDDA) compliance, negotiated with regulatory agencies to develop technically sound and cost-effective sampling plans, oversaw and managed sampling and chemical analyses, and provided senior review of technical studies. Successfully obtained PSDDA-related permit.

Open-Water Disposal Permit for SeaLand Pier Extension Project

Port of Tacoma, Washington

1989

As project manager for Puget Sound Dredge Disposal Analysis (PSDDA) compliance, negotiated with regulatory agencies to develop technically sound and cost-effective sampling plans, oversaw and managed sampling and chemical analyses, and provided senior review of technical studies. Successfully obtained PSDDA-related permits.

Open-Water Disposal Permit for Pier 7D

Port of Tacoma, Washington

1988

As project manager for Puget Sound Dredge Disposal Analysis (PSDDA) compliance, negotiated with regulatory agencies to develop technically sound and cost-effective sampling plans, oversaw and managed sampling and chemical analyses, and provided senior review of technical studies. Successful obtained PSDDA-related permits.

Open-Water Disposal Permit for Terminal 3

Port of Tacoma, Washington

1987

As project manager for Puget Sound Dredge Disposal Analysis (PSDDA) compliance, negotiated with regulatory agencies to develop technically sound and cost-effective sampling plans, oversaw and managed sampling and chemical analyses, and provided senior review of technical studies. Successfully obtained PSDDA-related permits.

Selected Publications

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Templeton, D.W., P.A. Spadaro, and R. Gilmur. 1993. The role of natural recovery in sediment remediation projects. Proceedings, the International Conference on Contaminated Sediment Remediation, Milwaukee, Wisconsin.

Presentations

Spadaro, P.A. 2007. Sediment remediation technologies presented at the Environmental Law Education Conference, Washington Environmental Cleanup Conference, Seattle, Washington, June.

Spadaro, P.A. 2006. The construction phase of the project, presented at the Environmental Law Education Center Advanced Sediment Conference, Seattle, Washington, September.

Spadaro, P.A., and M.L. Henley. 2003. Thea Foss Waterway remedial design-Observations for future projects. Poster presentation, International Conference on Remediation of Contaminated Sediments, Venice, Italy, September.

Spadaro, P.A. 2003. Analysis of technical considerations for nearshore CDF design. Poster presentation, International Conference on Remediation of Contaminated Sediments, Venice, Italy, September.

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Spadaro, P.A., M.L. Henley, and J.R. Verduin. 1997. Interim status report: Thea Foss and Wheeler-Osgood Waterways cleanup. Presentation, Western Dredging Association, Eighteenth Annual Meeting.

Verduin, J.R., P.A. Spadaro, and T. Wang. 1996. A general framework for consideration of a nearshore CDF: Contaminated sediment confinement and upland creation. Presentation, Western Dredging Association, Seventeenth Annual Meeting.

Templeton, D.W., and P.A. Spadaro. 1996. The role of natural recovery in contaminated sediment. Presentation, Western Dredging Association, Seventeenth Annual Meeting.

Spadaro, P.A. 1995. Sediment remediation: Puget Sound case studies. Presentation, Law Seminars International's West Coast Conference on Contaminated Sediments.

ARCADIS

Poh Boon Ung

Principal Economist

Education

MA/Economics, University of Michigan, Ann Arbor, MI

BA/Economics and Mathematics, Brandeis University, Waltham, MA

Years of Experience

With ARCADIS for 10 Years

Professional Qualifications

Employee Award, ARCADIS, 2009

Employee Recognition Award, Blasland, Bouck and Lee, 2004

Employee Recognition Award, Triangle Economic Research, 2002

Joseph & Ida Butman Award for Scholarship and General Leadership, 1999

Sidney S. Cohen Award in Economics, 1999

Summa Cum Laude, Senior Honors Thesis, Brandeis University, 1999

Phi Beta Kappa, Brandeis University, 1999

Wien International Scholarship, 1995-1999

Maggie Cooks Prize for Minority/Community Service, 1998

Member, American Economic Association

Member, Institute for Operations Research and the Management Sciences (INFORMS)

Member, Society for Risk Analysis

Mr. Ung is a Principal Economist who specializes in environmental economics and environmental business consulting related issues. His experience spans a broad range of different areas and issues. Some of his recent work includes serving as a technical advisor to the US Army Corps of Engineers on the New Orleans Inner Harbor Navigation Canal hurricane protection project, evaluating the economic impacts of the Alaska Gasline Inducement Act (AGIA) for the State of Alaska, and estimating potential environmental liabilities for several confidential oil and gas companies and utility companies.

Mr. Ung manages projects related to water and air regulatory programs and has extensive experience in Section 316(b) assessments of the Clean Water Act. Mr. Ung has prepared Section 316(b) cost-benefit assessments for various power generating stations, including those on a major US waterway in the Northeast, the Delaware Estuary, and in the Midwest. These assessments involve various components of costs (engineering and potential power impacts) and benefits (commercial and recreational fishing). Mr. Ung has also developed models that incorporate uncertainty within a Monte Carlo framework when estimating the net benefits of various fish protection technologies being considered.

In addition, Mr. Ung manages projects involving different environmental regulations. These have included the costs and benefits of alternative emissions standards for various off-road engines, proposed emissions standards in California, and environmental/external costs of air emissions from power plants. These assessments often involve evaluation of potential health effects from proposed regulations and power generating stations. Prior to joining ARCADIS, Mr. Ung was a consultant at NERA Economic Consulting's Environmental Group where he managed similar assessments.

Mr. Ung is also skilled in the application of quantitative decision analysis (QDA), probabilistic and risk modeling techniques. He has applied these tools to develop QDA and multi-criteria decision analysis (MCDA) models to identify optimal strategic decisions under uncertainty for various industrial clients. Some of the models include assessment of dredging and remediation sites, environmental liability estimation, and cost-cap insurance feasibility. He applies a combination of Monte Carlo simulation techniques, decision tree analysis, and mathematical optimization techniques to develop these decision analysis models. The results of these models are often used to facilitate strategic planning for environmental projects. Mr. Ung also facilitates framing meetings to uncover and identify pertinent information. The information collected is then used to support the modeling and decision-making efforts.

Mr. Ung has experience in natural resource damage assessments (NRDAs) and has been involved in evaluating trustee's NRDA valuation estimates and developing independent valuation estimates. His NRDA experience includes developing random utility models (RUMs) to estimate angler satisfaction with respect to fish consumption advisories and gains from compensatory restoration projects. Mr. Ung has also developed habitat equivalency analysis (HEA) and resource equivalency analysis (REA) spreadsheet models to determine the appropriate scale of compensatory restoration actions for losses of natural resource and ecological services. He has also managed the collection and evaluation of existing information on the characteristics and use of recreation areas. Mr. Ung is familiar with the literature on groundwater and wetlands valuation studies.

Mr. Ung's survey design, development and administration experience includes developing and administering recreational surveys, environmental health and safety (EHS) surveys and client satisfaction surveys. He has also been involved in training and monitoring counters for recreation-related surveys.

Experience

Environmental Life-Cycle/Reserve Estimation
Confidential Client, United Kingdom
Ongoing
Evaluating potential environmental life-cycle costs/liabilities for a large portfolio of sites in the United Kingdom. Results of assessment is being used to evaluate risks of portfolio for divestiture considerations. Assessment incorporates combination of statistical methods and Monte Carlo simulation techniques to predict risks and quantify cost uncertainties.

Probabilistic Cost Models
Confidential Client, various locations in South Carolina
Ongoing
Developing probabilistic cost models to evaluate soil and sediment impacts at former chemical manufacturing plants. Cost model results will be used to better understand range of potential remedial costs and identify key cost drivers at sites.

Anti-degradation Review: Economic Assessment
Confidential Client
Ongoing
Conducting economic assessment to examine impacts of installing alternative treatment processes at chemical treatment plant. Economic assessment performed in support of

regulatory anti-degradation review process.

Probabilistic Cost Model

Confidential Client, North Carolina

Ongoing

Developing probabilistic cost model to evaluate potential remedial costs at a former chemical manufacturing plant.

Quantitative Decision Analysis: Remedial Strategy Assessment

Confidential Client, California

Ongoing

Assessing various remedial strategies at a contaminated manufacturing facility using decision analysis techniques. Assessment uses Monte Carlo simulation methods and decision tree framework to evaluate cost uncertainties, quantify potential risks associated with the various strategies and understanding impacts of different sequence of events or pathways.

Statistical Evaluation/Data Analysis

Confidential Client, Various Location

Ongoing, Project Cost: $350,000

Managing and assessing large portfolio of sites including service stations, terminals, and pipelines for a confidential oil and gas client. Assessment includes data evaluation, assessment of historical remediation costs, and estimating potential future costs and future liabilities.

Natural Resource Damage Assessment: Recreational Fishing Assessment

Confidential Client, Massena, New York

Ongoing, Project Cost: $680,000

Developing random utility models (RUMs) to estimate angler satisfaction with respect to fish consumption advisories and gains from potential compensatory restoration projects. Part of the analysis involved developing and managing a large dataset of fishing sites and characteristics for modeling fishing losses from fish consumption advisories on several water bodies. Also collected and evaluated existing information on the characteristics and use of recreation areas.

Environmental Life-Cycle/Reserve Estimation

Confidential Client, Various Locations

Ongoing, Project Cost: $50,000

Developing potential environmental life-cycle costs/reserve estimates for a large portfolio of sites. Results of assessment are being used for portfolio divestiture. Assessment applies statistical models using limited available information for a subset of sites. Analysis also incorporates Monte Carlo simulation techniques to capture and quantify uncertainties.

Portfolio Model of Potential Life-Cycle Costs

Confidential Client, Various Locations

Ongoing, Project Cost: $600,000

Developing portfolio model of potential life-cycle costs of more than 2,000 sites. Part of the assessment involved developing web-based tools to collect data and statistical models to analyze data to identify cost reducing strategies. Manages annual database system of lifecycle cost data. Goal is to help client measure business unit performance and to develop strategies for reducing costs.

Quantitative Decision Analysis: Remedial Strategy Assessment

Confidential Client, California

2010

Developed quantitative decision analysis model to quantify the cost impacts of implementing different remedial alternatives at a contaminated manufacturing facility. Decision analysis model used Monte Carlo simulation methods to evaluate cost uncertainties, quantify potential risks, and understand cost drivers and likelihood of success.

Quantitative Decision Analysis: Former Terminal Remediation

Confidential Client, Oregon

2010

Assessed various remedial options and potential costs to remediate soil and sediment impacts at a former terminal. Monte Carlo simulation methods used to quantify cost uncertainties, cost drivers and understand potential risks of different remedies.

Probabilistic Cost Model: River Sediment Remediation

Confidential Client, Southern U.S.

2010

Developed probabilistic cost model to evaluate river sediment remediation costs at a confidential site in Southern United States. Costs were evaluated within a Monte Carlo uncertainty analysis framework and key sensitivity parameters were identified.

Quantitative Decision Analysis: Terminal Remediation

Confidential Client, New Jersey

2010

Assessed various remedial options, potential costs and uncertainties at a former terminal.

Environmental Life-Cycle/Reserve Estimation

Confidential Client, Various Locations

2009. Project Cost: $100,000

Estimated potential environmental life-cycle costs/reserve estimates for a large portfolio of sites in Latin America. Results of assessment were used to evaluate risks of portfolio for divestiture considerations. Assessment incorporated statistical models using limited available information for a subset of sites. Analysis also incorporated Monte Carlo simulation techniques to address uncertainties.

Data (Cost) Analysis

Confidential Client, Various Location

2009

Managed and assessed historical costs of large portfolio of service stations. Results of assessment were used to better understand and identify cost differences/drivers within the portfolio.

Quantitative Decision Analysis: Site Clean-up Assessment

Confidential Client, Arizona

2009

Assessing various clean-up strategies at a contaminated site using decision analysis techniques. Assessment uses Monte Carlo simulation methods to evaluate cost uncertainties related to excavation methods, property management options and clean-up standards.

Source Selection Evaluation Board (SSEB) Advisor

US Army Corps of Engineers, New Orleans

2008

Member of technical advisory team supporting the SSEB. Primary responsibility was to ensure a comprehensive cost/schedule/risk evaluation of each submission in response to the Request for Proposal for the Inner Harbor Navigation Canal Hurricane (IHNC) Protection Design-Build Project. The design-build scope of work included all architectural, engineering, construction, project management, quality control and other related services to design and construct a line of defense that would provide hurricane protection from surges and waves at the 100-year level. The areas to be protected included areas along the IHNC in Orleans and St. Bernard Parishes, Louisiana. Design-build value estimated at $600 million.

Redevelopment Evaluation: Decision Tree Framework Analysis

Confidential Client

2008

Developed decision tree model to help client evaluate various redevelopment options for its large idle manufacturing plant. Decision tree model considered remediation cost uncertainties, potential future liabilities, and the impact of potential revenue from sale of the property under various redevelopment scenarios. The various pathways through the decision tree were combined within a Monte Carlo simulation framework to comprehensively understand and quantify risks and associated risk drivers.

Multi-Criteria Decision Model: Sediment Removal Strategy
Confidential Client, New Jersey
2008
Developed multi-criteria decision analysis (MCDA) model to evaluate different sediment removal options for a contaminated river. The MCDA model considered various aspects of the removal process including sediment removal options, sediment excavation and transport alternatives, water treatment and sediment management options. The different combinations of feasible alternatives were evaluated within the MCDA model and evaluated using a number of different criteria (e.g. long-term effectiveness and permanence, safety, human health risks, costs, carbon footprint, public acceptance) and corresponding weighting factors within a probabilistic framework. Model results were used to finalize dredge design and support decision-making process to management and regulators.

Section 316(b) Cost Evaluation
Confidential Client, New Jersey
2008
Evaluated potential costs of several cooling water intake alternatives for a confidential utility client.

Economic Impact Assessment
Confidential Client, Texas
2008
Evaluated potential economic impacts (employment, local/state taxes) of a uranium in-situ recovery project. Analysis involved development of an IMPLAN model and the results were used to evaluate potential costs and benefits of the project.

Multi-Criteria Decision Model: Twelvemile Creek, South Carolina Dam Removal and Restoration Option Evaluation
Schlumberger, South Carolina
2008
Developed multi-criteria decision analysis (MCDA) model to help Schlumberger identify the optimum approach in removing several dams and performing restoration at Twelvemile Creek to address natural resource damages from historical PCB releases. The MCDA model helped to evaluate uncertainties in terms of sediment volume and impact on project effectiveness, timeframe and duration of various options, and potential public and worker safety associated with different options. The model considered these different criteria and uncertainties and facilitated a structured and sound decision-making process for the project team.

Probabilistic Cost Model
Confidential Client, Europe
2008. Project Cost: $20,000
Developed probabilistic cost model to evaluate various remediation strategies for a large

remediation site in Western Europe. Costs were evaluated within a Monte Carlo uncertainty analysis framework.

Tunnel Risk Analysis

City of Columbus, Department of Public Utilities, Division of Sewerage and Drainage

2008

Facilitated risk analysis workshop to identify, classify and evaluate various risk items related to construction of a series of underground tunnels.

Health and Safety Benchmarking Study

Confidential Client, New Jersey

2008. Project Cost: $20,000

Managed and develop on-line survey to collect various health and safety information for benchmarking study. Key aspect of the study was to evaluate different driving practices and accident rates among participants.

Environmental Reserve Estimation

Confidential Client, Various Locations

2008

Evaluated and estimated environmental reserves for a portfolio of sites for a confidential utility client. Evaluation applied probabilistic techniques and methods to capture risks and uncertainties for the entire portfolio. Assessment results were used for financial reporting.

Economic Impact Assessment

State of Alaska

2008

Developed IMPLAN model to evaluate and estimate potential employment impacts in Alaska from proposed construction of liquefied natural gas (LNG) plant and natural gas pipeline. Assessment was part of an evaluation of the Alaska Gasline Inducement Act, AGIA, Alaska's law designed to advance construction of a natural gas pipeline from the North Slope to a market where the gas would be sold. AGIA passed in August 2008 (House Bill 3001) making it the largest construction project in the history of North America.

Probabilistic Environmental Cost Estimation

Confidential Client, New York

2008 Project Cost: $100,000

Managed and developed probabilistic environmental remedial cost models for a number of manufactured gas plant (MGP) sites. The cost models applied a Monte Carlo simulation approach to account for uncertainties in capital costs, operations and maintenance costs, and investigative costs. In addition, the models also incorporated potential future liability events and associated costs. Model results were used for rate case review and insurance cost recovery.

User Charge System Evaluation

Confidential Client, New Jersey

2007-2008. Project Cost: $80,000

Managed the review and assessment of proposed revisions to a user charge system model for a sewer treatment system. Also evaluated the impacts of the revisions to the different user classes.

Probabilistic Cost Model and Cost-Benefit Analysis

Confidential Client, Canada

2007. Project Cost: $50,000

Developed probabilistic cost model to evaluate range of costs for large remediation site in Canada. Costs were evaluated within a Monte Carlo uncertainty analysis framework. In addition, assessment evaluated potential costs and benefits of several alternative designs and comparing incremental costs and benefits within a cost-benefit framework.

Economic Impact Assessment

Confidential Client, Wyoming

2007

Evaluated potential economic impacts of several proposed mining sites. Analysis involved application of IMPLAN model and data to estimate impacts on employment and local/state taxes. Results were applied to evaluate potential costs and benefits of mining sites.

Multi-Criteria Decision Model: Redevelopment Evaluation

Confidential Client, Michigan

2007

Developed quantitative multi-criteria decision analysis model to evaluate different remediation options and redevelopment alternatives for a large automotive company. Criteria evaluated in the model included potential environmental remediation costs, revenue, cash flow, media attention and economic impacts. Assessment also involved development of weighting factors of the criteria for evaluating the strategic alternatives. Model incorporated combination of survey techniques and Monte Carlo uncertainty analysis.

Probabilistic Remediation Cost Model
Confidential Client, New Jersey
2007. Project Cost: $1,753,226
Developed probabilistic model of potential remediation costs associated with a contaminated property. Results were used to determine costs of remediation for use in negotiating purchase price of property. Model combined use of Monte Carlo and decision tree framework.

Probabilistic Liability Cost Assessment
Confidential Client, Various Locations
2006, 2007, Project Cost: $25,000
Assessed potential liability costs associated with a substandard building product. Developed probabilistic cost model to estimate product liability costs associated with a substandard building product. Results of the model are used for financial reporting of a class action suit and non-class action liabilities.

Probabilistic Insulation Assessment
Confidential Client, Various Locations
2006, Project Cost: $14,000
Developed probabilistic model to estimate product liability costs associated with a substandard building product. Results of the model are used for financial reporting of a class action suit and non-class action liabilities.

Risk Analysis and Statistics
Confidential Client
2006
Developed risk analysis and related statistics for various chemicals of concern based upon exposure units. Information was used for human health and ecological risk assessment purposes.

Summary Statistics and Information Development
Confidential Client, Lawrenceville, Illinois
2006
Developing summary statistics and information for various chemicals of concern based upon exposure units. Information was used for human health and ecological risk assessment purposes.

Multi-criteria Decision Analysis: Airport Deicing Alternatives
Confidential Client, Oregon
2006-2007, Project Cost: $100,000
Developed multi-criteria decision analysis model to evaluate different deicing alternatives at a large airport terminal. Cost assessment and other criteria factors were evaluated within a Monte Carlo uncertainty analysis framework. Results were used to assist with selection of final

alternative.

Cost-Benefit Analysis: Alternative Intake Technology Assessment

PSEG, New Jersey

2006, Project Cost: $800,000

Managed the Alternative Intake Technology Assessment (AIT) and assisted with the Comprehensive Demonstration Study (CDS) preparation of PSEG's 2006 Salem Nuclear Generating Station (Delaware River Estuary) NJPDES filing in relation to Section 316(b) of the Clean Water Act. The AIT assessment involved developing both cost-benefit and cost-cost assessments of several potential fish protection alternatives including sound deterrent system, seasonal flow reduction alternatives, fish intake modifications and closed-cycle cooling retrofit. The analyses involved evaluation of potential costs (capital, operations and maintenance, power impacts) and potential benefits (recreational, commercial, non-use). Also developed Monte Carlo model that evaluated the uncertainties related to both costs and benefits.

Societal Benefits of Fluoropolymers and Fluorotelomers

DuPont (E. I. du Pont de Nemours), Wilmington, Delaware

2006, Project Cost: $300,000

Managed the evaluation of societal benefits of fluoropolymers and fluorotelomers. These substances, which have special properties that have many important manufacturing and industrial uses, are made (or byproducts) using PFOA (perfluorooctanoic acid or "C8"). The USEPA is currently investigating PFOA properties and its potential risk to human health and the environment over the long-term.

Emissions Standards Evaluation

Confidential Client

2006

Evaluated various alternative emissions standards for off-road engines. Assessment involved cost-effectiveness and cost-benefit analyses.

Alternative Resource Plan

Nevada Power Company and Sierra Pacific Power Company, Nevada

2006, Project Cost: $400,000

Managed the assessment of potential environmental costs and economic benefits (economic impacts) of alternative utility resource plans for submission to the Public Utilities Commission (PUC) of Nevada on behalf of the clients (both subsidiaries of Sierra Pacific Resources). Assessment involved evaluation of potential external costs (health effects) and economic impacts of 10 alternative resources plans being considered in 2006 Integrated Resource Plan. Results of the assessment were submitted to PUC as an expert report.

Probabilistic Model

Confidential Client, Italy

2006, Project Cost: $224,000

Developed probabilistic model of potential remediation costs associated with site.

Automobile Emissions Standards Evaluation

Confidential Client, California

2006

Evaluated effects of proposed California automobile emissions standards.

Terminal (Engineering Evaluation/Cost Analysis) Multi-Criteria Decision Analysis

Confidential Client, Oregon

2005, Project Cost: $120,000

Conducted framing session and developed multi-criteria decision analysis model to evaluate different removal alternatives of contaminated sediments at terminal. The goal of the model was to select the optimum remedial alternative in terms of evaluation criteria and project uncertainties. The evaluation criteria included short-term costs, long-term costs, revenue generation, agency acceptance, community acceptance, human health risks, and site disruption costs. Cost assessment and other criteria were developed within a Monte Carlo uncertainty analysis framework. The model results were used to convince upper-level management, regulatory agencies and various project stakeholders that the best, most cost-effective and protective alternative was selected. The alternative identified by the model has been accepted by the USEPA for implementation.

Cost-Benefit Analysis: Section 316(b) Assessment

Dynegy Northeast Generation, Inc., New York

2005, Project Cost: $300,000

Managed cost-benefit assessment of various fish protection alternatives at Danskammer Generating Station located on the Hudson River. Assessment was related to NPDES permit associated with Section 316(b) of the Clean Water Act. The results of this assessment were presented within a pre-filed testimony and also in a rebuttal testimony submitted to the New York State Department of Environmental Conservation (NYSDEC). Analysis involved evaluation of the potential costs and benefits of closed cycle cooling towers and NYSDEC draft permit conditions. Cost components analyzed included capital costs, operations and maintenance costs, and power-related impacts while the benefits components included commercial and recreational benefits.

Benefits Assessment of Potential Fish Protection Alternatives
Confidential Client, Midwest United States
2005, Project Cost: $40,000
Managed the development of potential benefits related to potential fish protection alternatives at a confidential power plant in the Midwest. Assessment was part of NPDES permitting.

Assessment of Potential Costs and Benefits of Fish Protection Alternatives
Confidential Client, New York
2005, Project Cost: $100,000
Involved in the assessment of the potential costs and benefits of different fish protection alternatives at a confidential generating station located on the Hudson River. Assessment was related to NPDES permit associated with Section 316(b) of the Clean Water Act. Evaluated potential costs (capital, operations and maintenance, power impacts) and benefits (commercial and recreational) from various alternatives.

Groundwater Contamination Natural Resource Damage Assessment (NRDA)
Confidential Client, New Mexico
2005, Project Cost: $853,000
Critiqued NRDA groundwater contamination for the South Valley Superfund site. Reviewed and replicated plaintiffs' spreadsheets. Evaluated and critiqued plaintiffs' analyses. Also assisted with the development and analyses of affirmative report of potential losses. Prepared trial exhibits and support materials for trial.

Remedial Assessment
Confidential Client, Northeast United States
2005, Project Cost: $700,000
Used a combination of decision tree analysis and Monte Carlo simulation techniques to develop cost model to identify key alternatives for large dredging project on a major waterway. Model was used to identify range of costs for different alternatives and key cost drivers of the project.

EHS Risk Management Survey
Confidential Client, Various Locations
2005, Project Cost: $224,000
Developed, implemented and administered environmental health and safety (EHS) surveys for worldwide production sites. Surveys were deployed via on-line tools. Also analyzed survey results and identified potential high-risk sites.

Wetlands Evaluation

Confidential Client, Harrison, New Jersey

2005, Project Cost: $40,000

Evaluated potential benefits of wetlands and recreational activities from development of waterfront area.

Cost Cap Insurance Evaluation

Confidential Client, Pittsburgh, Pennsylvania

2004, Project Cost: $32,000

Developed probabilistic model to evaluate costs of remediation for purchasing cost-cap insurance. Results of the model were used to estimate the feasibility of purchasing cost-cap insurance under various scenarios.

Externality Assessment

WE Energies, Milwaukee, Wisconsin

2003, Project Cost: $415,000

Assessed potential health-related damages from the proposed Elm Road generating station facilities. Applied damage-cost approach to evaluate potential health impacts from air emissions (particulate matter, nitrogen oxide, sulfur dioxide). Results were presented in rebuttal testimony.

Count Study of Ocean Recreators

Wood Tatum Sanders & Murphy and Fowler, Rodriguez & Chalos (counsel), Coos Bay, Oregon

2002, Project Cost: $550,000

Developed and supervised a count study of ocean recreators on the U.S. West Coast. Supervised and trained a total of seven part-time employees hired through local employment agency. Also prepared count and administration protocols. Analyzed data and used it to estimate recreation damages to evaluate potential diminution in the value of the Oregon coast from remnants of the New Carissa shipwreck. Results of the study was later presented in trial proceeding.

Selected Publications

Ung, P. B., et al. 2008. Alaska Natural Gas Pipeline: Employment Impacts Modeling. Prepared for State of Alaska, Department of Natural Resources, Division of Oil and Gas, May.

Ung, P.B., et al. 2006. Environmental Costs and Economic Benefits of Electric Utility Resource Selection. Prepared for Nevada Power Company, June.

Ung, P.B., et al. 2006. Societal Benefits Assessment for Fluoropolymers and Fluorotelomers. Prepared for DuPont Fluoroproducts and DuPont Chemical Solutions Enterprise, April.

Ung, P.B., et al. 2006. Assessment of Alternative Intake Technologies: Costs and Benefits of Fish Protection Alternatives at the Salem Facility. Prepared for Public Service Electric & Gas Incorporated, January.

Ung, P.B., et al. 2005. Values for Wetlands and Recreational Open Space Relevant to the Harrison, New Jersey Waterfront Site. Prepared for AKRF, Inc., October.

Selected Presentations

Ung, P.B. 2010. "Environmental Liability Estimation: Using Probabilistic Tools for Better Decision-Making." Presented at Palisade Risk Conference, November, Las Vegas, Nevada.

Ung, P.B., S. Suthersan, K. Beil and A. Troschinetz. 2010. "Greening" Decision-Making: Application of Economic and Decision Analysis Techniques towards Greener Cleanups." Presented at the 2010 Green Remediation Conference, June, Amherst, Massachusetts.

Gattenby, J. K. Beil, A. Troschinetz and P.B. Ung. 2010. "The BalancE3 Tool –Quantifying Sustainability in a Common Currency for Remedy Selection and Corrective Action Optimization." Presented at the Battelle Seventh International Conference on Remediation of Chlorinated and Recalcitrant Compounds, May, Monterey, California.

Ung, P.B. 2009. "Environmental Liability Estimation." Presented at Palisade Energy Risk Analysis Forum, May, Houston, Texas.

Ung, P.B., D.J. Fergusan, P. Doody, and C. Moody. 2009. "Using Multi-Criteria Decision Analysis (MCDA) to Identify the Optimum Approach for Dam Removal and Stream Restoration in Twelvemile Creek, South Carolina." Presented at the Fifth International Conference on Remediation of Contaminated Sediments, February, Jacksonville, Florida.

Ung, P.B. and L. Hostetter. 2008. "Applying Probabilistic Methods to Quantify Uncertainties in the Request for Proposal (RFP) Process." Presented at Palisade User Conference North America, November, Jersey City, New Jersey.

Ung, P.B. and T. Havranek. 2007. "Environmentally Impaired Property Transaction Analysis: Combining Decision Trees and Monte Carlo Simulation." Presented at Palisade User Conference North America, October, Miami Beach, Florida.

Ung, P.B. and M.A. Wilson. 2007. "Accounting for Ecosystem Goods and Services in Coastal Estuaries." Presented at Challenges of Natural Resource Economics and Policy (CNREP 2007): the 2nd National Forum on Socioeconomic Research in Coastal

Systems, May, New Orleans, Louisiana.

Ung, P.B. and D. Mac Nair. 2007. "Trade-Off Analysis for Valuing Socio-economic and Ecosystem Impacts." Presented at Challenges of Natural Resource Economics and Policy (CNREP 2007): the 2nd National Forum on Socioeconomic Research in Coastal Systems, May, New Orleans, Louisiana.

Ung, P.B., and D. MacNair. 2003. "A Simplified Approach for Estimating the Aesthetic Impact of a Shipwreck: Combining RP and SP Data." Presented at Camp Resources XI, August, Wilmington, North Carolina.

Ung, P.B., R. Dunford, G. Mauseth, and J. Cook. 2003. "Challenges in Using Habitat Equivalency Analysis for Scaling Compensatory Restoration." Presented at the International Oil Spill Conference, April, Vancouver, British Columbia.

Contributions to Testimony in Regulatory and Judicial Proceedings

Pre-filed Direct Testimony of David Harrison, Jr., Before the Public Utilities Commission of Nevada, on behalf of Sierra Pacific Power Company, Application for Approval of Thirteenth Amendment to its 2005-2024 Integrated Resource Plan, July 14, 2006.

Pre-filed Direct Testimony of David Harrison, Jr., Before the Public Utilities Commission of Nevada, on behalf of Nevada Power Company, Application for Approval of the 2007 - 2026 Integrated Resource Plan, June 30, 2006.

Testimony of David Harrison, Jr., Ph.D., in the Matter of Central Valley Chrysler Jeep, Inc. et al. v. Witherspoon, on behalf of the Alliance of Automobile Manufacturers, May 2, 2006.

Rebuttal Testimony of David Harrison, Jr., Ph.D., in the Matter of the Renewal/Modification of the State Pollution Discharge Elimination System Permit of Dynegy Danskammer Generation Station, on behalf of Dynegy Northeast Generation, Inc., November 7, 2005.

Direct Testimony of David Harrison, Jr., Ph.D., in the Matter of the Renewal/Modification of the State Pollution Discharge Elimination System Permit of Dynegy Danskammer Generation Station, on behalf of Dynegy Northeast Generation, Inc., October 17, 2005.

Direct Testimony of William Desvousges, Ph.D., in the Matter of Application of Wisconsin Electric Power Company; Wisconsin Energy Corporation; W.E. Power, LLC for a Certificate of Public Convenience and Necessity for Construction of Three Large Electric Generation Facilities, the Elm Road Generating Station, and Associated High Voltage Transmission Interconnection Facilities to be Located in Milwaukee and Racine Counties, Docket No. 05-CE-

130, September 8, 2003.

Direct Testimony of Richard Dunford, Ph.D., in the Matter of State of Oregon v. Taiheiyo Kaiun Co., Ltd., et al., Circuit Court of the State of Oregon for Coos County, Case No. 01 CV 0383, on November 6, 2002.

Direct Testimony of Richard Dunford, Ph.D., in the Matter of State of New Mexico v. General Electric Company. et al. U.S. District Count for the District of New Mexico, Case No. CIV 99-1254, Case No. CIV 99-1118 (Consolidated by Order on June 14, 2000), on February 26, 2002.

Direct Testimony of William Desvousges, Ph.D., in the Matter of State of New Mexico v. General Electric Company. et al. U.S. District Count for the District of New Mexico, Case No. CIV 99-1254, Case No. CIV 99-1118 (Consolidated by Order on June 14, 2000).

ARCADIS

Education

MS, Statistics, University of Illinois, Urbana, IL, 1985

MS, Aquatic Ecology, Central Washington University, Ellensburg, WA, 1979

BS, Biology, University of Illinois, Urbana, IL, 1977

Years of Experience

Total - 23

With ARCADIS - 3

Matthew K. Butcher

Senior Scientist

Mr. Butcher has 23 years of experience as a consulting scientist and statistician, specializing in data analysis for environmental contamination projects and ecological risk assessments. He has experience in a wide variety of statistical methods, including the statistical design of sampling programs, regression and variance analyses, multivariate analyses (including fingerprinting methods), kriging and other spatial statistics, bootstrapping, time series analysis, nonparametric statistics, and graphical data reduction. His analytical experience in human health and ecological risk assessments includes uncertainty analysis using Monte Carlo simulation, interval analysis, fuzzy arithmetic, and probability bounds.

Mr. Butcher is also trained as an aquatic biologist and has extensive experience in collecting and identifying aquatic macroinvertebrates in southeastern, Midwestern, and northwestern United States. As a statistician and biologist, Mr. Butcher has analyzed the effects of habitat characteristics on aquatic species assemblages. He has conducted aquatic habitat and macroinvertebrate community assessments for clients in locations throughout the United States. He managed a biological field laboratory in South Carolina, and has managed ecological risk assessments in Ohio, Washington, and Alaska.

Project Experience

Groundwater Recovery Analysis

Reichold Chemical, Inc, Tacoma, Washington

Analyzed time series and spatial data to evaluate test performance of a groundwater recovery system for this RCRA site. Also developed an experimental design approach for optimizing a groundwater treatment system.

Clark Fork River Superfund Site NRDA

ARCO, Montana

Provided statistical support at the site. Conducted time series analyses of flow data, identifying instinct flow regimes and estimating flow values throughout the years of available data. These analyses were combined with water and sediment chemistry data for metals to estimate starting conditions for surface water modeling. Estimated frequencies of exceedance of water quality criteria from the modeling results using a probabilistic approach.

Big Mountain RRS RI/FS and Moses Point RI/FS

Department of Defense and Federal Aviation Administration, Alaska

Managed ecological risks assessments at abandoned Department of Defense and Federal Aviation Administration facilities in remote areas of Alaska. Both aquatic and terrestrial communities were considered in the assessments. Participated in all aspects of the assessments, including study design, field work, and data analysis and reporting.

Ward Cove Pulp Mill Dioxin Fingerprinting

Ketchican Pulp Company, Alaska

Analyzed PCDD/PCDF data from a variety of media and locations in the vicinity of a pulp mill near Ketchikan, Alaska to determine the source of individual roof-catchment drinking water systems near the mill. Using discriminant analysis, successfully demonstrated that the sources of dioxins within the project area did not arise from the mill.

Decommissioning of the La Frambois Landfill

Portside Lagoon and Landfill, LLC, Washington

Served as project manager and provided strategic direction during the decommissioning of the landfill. Responsible for the design of the sampling program, interpretation of its results and subsequent negotiations with regulatory agencies.

Bartlesville RI/FS

National Zinc, Bartlesville, Oklahoma

Using kriging and other spatial analyses, developed a method to identify "hot spots" of high metals concentrations in residential yards at the site. The technique detected yards that were likely to have localized high concentrations by using a single composite sample from a given yard collected during the remedial action. Kriging results were also used to develop different zones within the site that were addressed differently in remediation sampling.

Community Arsenic Kriging Analysis

ARCO, Montana

Analyzed patterns of arsenic concentrations in soil samples in the region surrounding Butte, Montana using kriging. For this effort, the kriging algorithm incorporated site-specific details such as topography and wind patterns that affected the spatial correlations within the data.

Eagle Harbor Superfund Site RI

USEPA, Bainbridge Island, Washington

Analyzed sediment, groundwater, and spatial data collected at the site. Used kriging to estimate sediment chemical concentrations and detect sources of those chemicals under surface sediments.

Wood Treatment Facility Characterization

Union Pacific Railroad, Dalles, Oregon

Developed sampling strategies, wrote sampling plans, and analyzed data for the definition of soil contamination at a wood treatment facility. In addition, conducted statistical analyses comparing CLP Level 3 analytical data to less expensive field laboratory data. The results were used to demonstrate the validity of inclusion of field data in the remedial investigation.

Lake Okeechobee Water Chemistry Analysis

South Florida Water Management District, Florida

Analyzed a historical database of water chemistry data. Developed numerical and graphical methods to characterize temporal and spatial changes in water quality in Lake Okeechobee.

ATOFINA Natural Resources Damage Assessment

ATOFINA, Washington

Conducted HEAs and evaluations of options in restoration projects as part of the strategy for offsetting NRD claims. Presented these results to the client and NOAA personnel.

Dioxin Characterization

Briggs Nursery Inc, Olympia, Washington

Designed sampling programs for the characterization of dioxin in surface soils, street runoff, water, and sediments in the vicinity of the nursery. Using these data and data from the literature, demonstrated that dioxins in ponds on the nursery property resulted from nearby streets' runoff, and not other possible sources arising from nursery activities.

Cambridge Vanadium Smelter River Ecological Risk Assessment

SMC, Ohio

Project manager/aquatic ecologist managed an ecological risk assessment based on aquatic macroinvertebrate communities. The result of the study was the demonstration of effects of vanadium in sediments on macroinvertebrate communities. Participated in all aspects of the assessment, including study design, field work, and data analysis and reporting.

Creel Survey

Duke Energy, North Carolina

Designed a fish-catch survey for a joint effort between an industry and the State of North Carolina. Sampling events were coordinated for the 1-year study to optimize efficiency of the sampling crews while maintaining statistical validity.

Probabilistic Risk Analysis

National Institutes of Health, Stony Brook, New York

While on sabbatical, participated in a NIH research project on probabilistic methods in risk assessment.

Ecological Risk Screening Assessment at Olympic View Sanitary Landfill

Confidential Client, Washington

Conducted an ecological risk screening assessment to determine the potential for risk to the ecological communities in the vicinity of the landfill. Site conditions were considered in the identification of potentially complete exposure pathways to ecological receptors. The process included the selection of exposure pathways, receptor species, exposure models, and model assumptions. A semi-aquatic species (the muskrat) was selected as the representative receptor species for this risk assessment.

Michoud Facility RI/FS

Martin Marietta, Louisiana

Analyzed data, using kriging and graphics, from a close support laboratory in near real time at the Michoud Facility. Also provided daily recommendations to field crews in the location of samples.

Report on Ohio River Mussel Populations

Elkem Metals Company, Ohio

Provided an expert report on the estimation of mortality of certain mussel species in response to a chemical spill in the upper Ohio River. The opinions in the report were based on ecological models and biometry.

Briggs Nursery RI/FS

Briggs Nursery Inc., Olympia, Washington

Served as task manager for an RI/FS conducted at a former nursery. Was responsible for supervision of field investigations, ecological risks assessments, work plan and report preparation, interpretation of the regulations of the state, and negotiations with the Washington State Department of Ecology, City of Olympia, and Grays Harbor County.

Macroinvertebrate Community Analysis

PacifiCorp, Oregon

As part of a relicensing application for a hydroelectric production facility, managed a project to characterize macroinvertebrate communities in the Rogue River watershed in Oregon. Designed the study, collected the samples, and wrote the interpretative report.

Macroinvertebrate and Fish Community Analysis

Various Clients, Various Locations in US

Applied a variety of statistical techniques in the characterization of macroinvertebrate communities in freshwater systems throughout the United States. These techniques included the use of a multivariate classification system, cluster analysis, multidimensional scaling, principal components analysis, and graphical methods. Also designed a metric to measure habitat and water quality degradation in a North Carolina river.

Thermal Equilibrium Study

National Science Foundation (NSF), Eastern US

Managed a field laboratory as part of a multi-year NSF project for the Stroud Water Research Center (then part of the Academy of Natural Sciences of Philadelphia). The laboratory was responsible for collecting, rearing, identifying, and analyzing aquatic insects.

Statistical Sampling and Analysis
US Air Force, Alaska
Developed sampling strategies and analyzed data for the definition of soil contamination at Eielson AFB in Fairbanks, Alaska. Much of this work was conducted on site, with sampling layouts and analytical approaches being adaptively modified during the field sampling event.

Refinery Effluent Dioxins Fingerprinting
Tosco Refining Company, California
Petroleum refining has been identified as a potential source of PCDD/PCDFs. Applied principal components analysis to homologue profiles of data from sources within the facility and other stormwater outfalls in San Francisco Bay to provide a cost-effective approach for identifying PCDD/PCDF sources in the vicinity.

Mammal Tissue Sampling
Federal Aviation Administration, Alaska
Served as project manager/ecological risk assessor. Designed and conducted a sampling program at Moses Point near Elim, Alaska to determine the potential for accumulation of certain metals in small mammals located around former FAA facilities.

Bioassay Variability Study
Washington State Department of Ecology, Washington
Conducted statistical analyses collected from a round robin study designed to assess inter and intralaboratory variability in several marine bioassay methods.

Clark Fork River Ecological Risk Assessment
ARCO, Montana
Used regression analysis in a phytotoxicity study of selected metals in soil to estimate the root uptake factors and biomass reduction rates for these metals; data for ancillary variables were combined with the metals data in nonlinear regression relationships. Principal component analysis was used in conjunction with the results of the multiple regression analyses to reduce the number of variables required to model the phytotoxic functions.

Monte Carlo Analyses
Various Clients
Performed Monte Carlo simulations for risk assessments and the estimation of error propagation. Used the Monte Carlo simulations to estimate the uncertainties associated with sediment quality criteria calculated by the USEPA.

Oil Well Statistical Analysis

ARCO, Alaska

Provided statistical analysis of large data sets (observations from about 100 wells) to determine the extent and nature of contamination from drilling and operation of oil wells in Alaska.

Expert Technical Review of Spatial and Fingerprinting Analyses

Confidential Client, Washington

Served as statistician and provided expert technical review of spatial and fingerprinting analyses conducted on sediment chemical data from the Duwamish River.

Hudson River Macroinvertebrate Community Analyses

Confidential Client, New York

Provided statistical analyses of macroinvertebrate data to detect community changes along the upper Hudson River. Also wrote a briefing document on the macroinvertebrate communities present in the upper Hudson River, their importance to natural resource damage assessment and their toxicity response to certain chemicals.

Natural Resources Damage Assessment

Confidential Client, California

An essential component of the NRDA process is the estimation of injuries to the natural resources. In this project, used a statistical model to relate site-specific bioassay data to benthic macroinvertebrate community injuries. Used these injury assessments to equate natural resource damages to restoration options in an economic framework using habitat equivalency analyses (HEAs). Presented these results in meetings and report letters to the State of California.

Everglades Mercury Study

Confidential Client, Florida

Using a non-linear multiple regression model and kriging in a two-phased approach, estimated mercury concentrations in fish as a function of sediment and water column chemical concentrations.

Onondaga Lake RI/FS

Confidential Client, New York

Provided statistical analysis support to components of the RI/FS. Estimated total anthropogenic mercury in lake sediments by kriging the mercury flux in sediments.

Selected Publications

Noel, L.E., M.K. Butcher, M.A. Cronin and B. Streever. In review. Assessment of effects of an oil pipeline on caribou movements in arctic Alaska. Rangifer.

Noel, L.E., S.R. Johnson, G.M. O'Doherty, and M.K. Butcher. 2005. Common eider (Somateria mollissima v-nigrum) nest cover selection and depredation on central Alaskan Beaufort Sea Barrier Islands. Arctic.

Noel, L.E., S.R. Johnson, and M.K. Butcher. 2004. Snow Goose nesting and brood-rearing distributions in the Sagavanirktok River Delta, Alaska, 1980-2002. Waterbirds 27:388-395.

Peek, D.C., M.K. Butcher, W.J. Shields, L.J. Yost, and J.A. Maloy. 2002. Discrimination of aerial deposition sources of polychlorinated dibenzo-p-dioxin and polychlorinated dibenzofuran downwind from a pulp mill near Ketchikan, Alaska. Envl. Sci. & Tech. 36(8): 1671-1675.

Moore, M.L., M.K. Butcher, K. Connor, D.J. Paustenbach, and D.B. Mathur. 1999. Fingerprinting analysis of PCDD/PCDF sources in a surface water outfall near a petroleum refinery. Organohalogen Compounds. 40: 219 - 222.

Pastorok, R.A., M.K. Butcher, and R.D. Nielsen. 1996. Modeling wildlife exposure to toxic chemicals: trends and recent advances. Hum. Ecol. Risk Assess. 2(3):444-480.

Pastorok, R.A., R.D. Nielsen, and M.K. Butcher. 1996. Future directions in modeling wildlife exposure to toxic chemicals. Hum. Ecol. Risk Assess. 2(3):570-579.

Schoof, R.A., M.K. Butcher, C. Sellstone, R.W. Ball, J.R. Fricke, V. Keller, and B. Keehn. 1995. An assessment of lead absorption from soil affected by smelter emissions. Environ. Geochem. Health. 17:189-199.

ARCADIS

Education
BS, Chemical Engineering, Clarkson University, Potsdam, NY, 1982

Years of Experience
Total - 28
With ARCADIS - 21

Professional Registrations
Professional Engineer, IL, since 2000
Professional Engineer, SC
Professional Engineer, KY, since 1995
Professional Engineer, MI, since 2000
Professional Engineer, NJ, since 2000
Professional Engineer, NY, since 1990
Professional Engineer, PA, since 2000
Professional Engineer, TN, since 2000
Professional Engineer, TX, since 2000

Professional Associations
American Institute of Chemical Engineers
National Society of Professional Engineers (NSPE)
Western Dredging Association

J. Paul Doody, PE

Senior Vice President

Mr. Doody has more than 28 years of professional experience most of which specializing in environmental engineering, remedial design activities, construction projects, RI/FS activities, treatability studies, and risk assessments. While specializing in managing and remediating impacted aquatic systems, Mr. Doody's experience also includes engineering services at manufacturing plants and other industrial facilities.

Project Experience

Remedial Design (RD) for Dredging
Confidential Client, Northeast United States
Lead design engineer for remedial design for dredging, processing, transport, and disposal of PCB-containing sediment from a major waterway. This has included overseeing and being in charge of development of work plan; development and implementation of work plans for engineering data collection, habitat delineation and assessment, and treatability studies; development of preliminary design, intermediate design, and final design (i.e. design reports, plans, specifications) packages; review and comment on performance standards; and review and comment on agency reports regarding siting of sediment processing facility.

Remedial Investigations/Assessments
Confidential Client, Russellville, Kentucky
Ongoing
Project manager for ARCADIS' activities relative to Confidential Client 's former die casting facility. The primary project activity has been related to investigating and remediating the Town Branch Creek, which included executing remedial investigations in 1990, 1999, and 1995; developing risk assessments; developing remediation work plans; developing remedial design documents; performing remediation oversight and management; and attending meetings with the Kentucky Department of Environmental Protection (KDEP). Remediation of 3.5 miles of creek and associated floodplain soils was implemented by ARCADIS.

In addition to Town Branch activities, responsible for design and installation of wastewater treatment system for removal of PCBs from die cast wastewater; investigation and cleanup within the die cast facility; design and installation of spring collection and treatment; and litigation support for environmental issues.

Remedial Investigation/Feasibility Study (RI/FS)

Confidential Client, Northern New York

1995

Project manager for the completion of a remedial investigation/feasibility study (RI/FS) at a large PCB-impacted river site. The RI involved preparing a work plan for the second phase of the RI, sampling and analysis, and developing the RI report. Negotiated a Non-Time Critical Removal Action (NTCRA) for the removal of sediment containing the highest PCB levels at the site. Also managed the preparation of bid documents (i.e., performance specifications), an engineering evaluation/cost analysis (EE/CA), and environmental monitoring plan (EMP) for the NTCRA, along with managing the EMP implementation as an independent quality assurance team. Information from monitoring activities associated with the NTCRA was used in the FS for the site.

Remedial Investigation/Feasibility Study (RI/FS)

Confidential Client, Wisconsin

Prepared and submitted a draft alternatives array document (AAD) to the U.S. Environmental Protection Agency (USEPA) Region 5 for the remediation of a river system Superfund site in the Great Lakes Region. Required by the USEPA Region 5 for Superfund RI/FS activities, the AAD presents the initial phases of the FS (i.e., initial technology screening and development of remedial alternatives).

Remedial Investigation/Feasibility Study (RI/FS)

Monroe County, Rochester, New York

Managed an RI/FS for a site on the Genesee River impacted by coal tar residuals. Activities included soil, groundwater, and sediment sampling; engineering evaluation of potential remedial scenarios; and developing an RI/FS report for submittal to the New York State Department of Environmental Conservation (NYSDEC). Affected media at the site includes soils, groundwater (with nonaqueous phase liquids [NAPLs]), and sediment.

Remedial Investigation/Feasibility Study (RI/FS)

PH Glatfelter, Wisconsin

1993, Project Cost: $200,000

Project manager for the completion of an RI/FS for Lower Fox River sediment deposit in Little Lake Butte des Morts. Reviewed draft reports for the RI/FS and assisted the client in creating its strategy and positions, and preparing formal comments for submission to the Wisconsin Department of Natural Resources (WDNR). Managed the consolidation of RI/FS efforts previously performed by the WDNR into one comprehensive RI/FS document consistent with the National Oil and Hazardous Substances Contingency Plan. All data previously collected by the WDNR was reviewed for data quality and augmented with the collection of additional data. The entire RI/FS was completed in six months and submitted to the WDNR for review.

Remedial Design

Confidential Client, New York

1995

Managed the implementation of treatability studies for PCB-containing soil, sediment, and sludge at a large Superfund site. Developed and negotiated the work plan, coordinated sample collection and study execution (studies performed by treatment contractors), and developed a final report for submittal to the USEPA. Studies were performed as part of the RD at the site with evaluation of biological treatment, solvent extraction, thermal extraction, and incineration. Also coordinated several aspects of RD activities at a large Superfund site. Managed the development of an RD work plan, a comprehensive sampling and analysis plan, and a Request for Modification of Treatment Threshold Requirements. Documents were submitted to the client for review, and then to regulatory agencies.

Remedial Design/Remedial Action and Project Oversight

Tennessee Gas Pipeline Company, New York

1996

At two compressor stations, served as project manager preparing contract documents, plans, and specifications for remediation of impacted soil and drainlines; negotiating the RD with the NYSDEC; performing site oversight during the RA; and completing the documentation report. Served as the primary New York State contact for the four compressor stations at which ARCADIS conducted investigation and remedial efforts.

Excavation and Containment

Confidential Client, Wisconsin

1992

Prepared an operations plan for the excavation and containment of river sediment containing PCBs. The plan described the methods to be used for accessing various sediment deposits, dredging or armoring the sediment, as well as transportation and placement of dredged materials into a confined treatment facility. Other activities described in the plan include decontamination procedures and monitoring.

Engineering Evaluation/Cost Analysis

Confidential Client, Michigan

Provided technical review for the EE/CA prepared for the Manistique River and Harbor. The EE/CA evaluated the effectiveness, implementability, and cost associated with six remedial alternatives. The alternatives included no action, in-place containment, and sediment dredge, cap, treatment, and disposal.

Technical Attachments to Comments on Proposed Plan to Dredge

Confidential Client, New York

2001

Managed development of information for several key technical attachments to a client's comments on a USEPA proposed plan to dredge PCB-contaminated sediment from a large river system. The attachments included an environmental impact assessment, logistics of the dredging operations, assessment of resuspension issues, and realistic clarification of sediment dredging at other sites.

Technical Attachments for Proposed Plans for Two Operable Units
Confidential Client, New York
1990
Prepared technical attachments for a client's comments to the USEPA's proposed plans for two operable units of a large PCB Superfund site. The technical attachments covered topics such as PCB health effects, PCB fate and transport, in-place sediment containment, dredging limitations, innovative PCB treatment technologies, mobile incineration issues, and groundwater remediation.

Evaluation of Remedial Alternatives
Confidential Client, Northern New York
1990
Evaluated alternatives (including the development of detailed cost estimates) for the remediation of approximately 750,000 cy of soil and sediment containing PCBs at a Superfund site (aluminum foundry). Based on the nine CERCLA criteria, developed costs and provided recommendations to the client.

Evaluation of Dredging Options
Mercury Marine, Cedarburg, Wisconsin
1995
As part of an RI/FS program, developed cost estimates for hydraulic dredging and dewatering of 7,500 cy of sediment from Ruck Pond.

Design, Installation, Operation, and Maintenance of Systems Used to Recycle Deionized Rinse Water
East Fishkill, New York
1986
Responsible for the design, installation, operation, and maintenance of several systems used to recycle deionized rinse water from semiconductor manufacturing operations. Dilute rinses (typically second and/or third rinses) were collected, treated, and reused in several buildings at a large semiconductor manufacturing facility. Treatment consisted of cation/anion and mined bed deionization, reverse osmosis, granular-activated carbon, and cartridge filtration.

Site Assessment
Confidential Client, Kentucky
1991

Prepared a work plan for the site assessment of a 46-acre compressor manufacturing facility. The work plan included a site description, description of potential issue areas, and proposed investigations associated with each issue area.

Design and Construction of an Air Meteorological Tower and Air Monitoring Stations

East Fishkill, New York

Managed the design and construction of an air meteorological tower and air monitoring stations, which required approval of the NYSDEC and town planning and zoning boards. The air meteorological tower and instrumentation were installed to allow use of more site-specific information in air dispersion modeling.

Testing of Waste Drain Piping and Tanks

East Fishkill, New York

1986

Managed the testing of all waste drain piping and tanks at an industrial facility. Designed and prioritized testing schemes, and coordinated the shutdown of all facilities to enable televisual inspection and hydrostatic/pressure testing. Based on results of the inspection and testing, developed conceptual designs for, and justified implementation of, overhead "contained" gravity drains to replace all underground chemical waste drains.

Spill Response

East Fishkill, New York

1986

Previously served as spill response team leader for a major U.S. company. Developed hazardous material handling procedures, conducted training programs, and developed a spill response document that established guidelines for spill cleanup action. Confirmed that all chemical spills adversely affecting the environment were properly remediated.

Installation of Temporary Biological Treatment System

East Fishkill, New York

1982

Designed and coordinated the installation of a temporary biological treatment system consisting of bioreactors, chemical feed systems for nutrient addition and pH adjustment, and an extensive in-situ lagoon aeration system for treatment of an ethylene glycol spill. The glycol-contaminated wastewater, which had been diverted into a 1.5-million gallon emergency holding lagoon, was treated by the system and discharged to the existing sanitary waste treatment without violating the existing State Pollutant Discharge Elimination System (SPDES) permit.

Conceptual Design Alternatives for Remediation

East Fishkill, New York

1986

Developed conceptual design alternatives for the remediation of well water contaminated with volatile organic compounds (VOCs) and bacteria at a major industrial facility. Technologies evaluated included ultraviolet (UV) irradiation, ozonation, chlorination, activated carbon adsorption, and air stripping. Developed cost estimates and recommended a treatment strategy, consisting of a pilot study followed by design and construction of a full-scale system.

Landfill Characterization and Cleanup
East Fishkill, New York
1986
Coordinated the characterization and cleanup of a former landfill area contaminated with VOCs. The cleanup involved: excavating approximately 3,000 cy of soil and debris; separating large debris, manually and through use of front end loaders and backhoes; placing contaminated soil into 20-ton trailers; and disposal of the material as hazardous waste.

Implementation of Soil Removal and Disposal
Confidential Client, Hopewell, New Jersey
Managed project in which the soil was contaminated with low-level radium 226, VOCs, and metals (primarily copper). Continued activity includes investigating and remediating a separate parcel containing similar constituents.

Waste Piping and Exhaust Systems
Confidential Client, Colorado Springs, Colorado
Managing, planning, and decommissioning of waste piping and exhaust systems at a semiconductor fabrication facility.

Treatability Studies
Confidential Client, Wisconsin
1992
Managed bench-scale treatability studies using several innovative technologies for potential treatment of PCB-containing sediment from a river system Superfund site in the Great Lakes Region.

Spill Prevention Control and Countermeasure (SPCC) Plan
Confidential Client, Upstate New York
Reviewed, revised, and certified plan for a large foundry facility.

Hazardous Waste Reduction Plan
Confidential Client, New York
Evaluated requirements for the HWRP at a foundry facility and prepared the client's response to the NYSDEC regarding the plan. Based on the source of hazardous waste and discussions with the NYSDEC, it was determined that an HWRP was not required for the facility.

Remedial Recommendations

Confidential Client, Eastern Massachusetts

1995

Managed the preparation of recommendations for remediating an 1800s-era manufacturing facility. Project included reviewing existing data on site, developing and evaluating several remedial alternatives, and recommending the most pragmatic alternative.

Selected Publications

Doody, J.P., and B.S. Cushing. 2002. An evaluation of environmental dredging for remediation of contaminated sediment. In Handbook of Complex Environmental Remediation Problems, McGraw-Hill Handbooks.

Peer Reviewer of National Research Council's 2007 Report on "Sediment Dredging at Superfund Megasites – Assessing the Effectiveness"

Presentations

Doody, J.P. 2001. "Defining the Effectiveness of Environmental Dredging." Presented at the WEDA XXI-Plan C Session, 27 June, Houston, Texas.

Doody, J.P. 2001. "Evaluation of the Effectiveness of Environmental Dredging at Contaminated Sites." Presented at the USEPA Forum on Managing Contaminated Sediments at Hazardous Waste Sites, 31 May, Washington, D.C.

Doody, J.P. 2000. "Environmental Dredging Effectiveness: Completed Projects." Presented at the Society of Environmental Toxicology and Chemistry Conference (SETAC) 2000, 15 November, Nashville, Tennessee.

Doody, J.P. 2000. "Environmental Dredging Effectiveness: Case Studies and Lessons Learned." Presented at the University of Massachusetts Contaminated Soils Conference, 16 October, Amherst, Massachusetts.

Doody, J.P. 2000. "Pros and Cons of Potential Remedial Technologies for Contaminated Sediment." Presented at the University of Massachusetts Contaminated Soils Conference, 16 October, Amherst, Massachusetts.

Doody, J.P. 2000. "Environmental Dredging: An Evaluation of Its Effectiveness in Controlling Risks." Presented at the 32nd Annual Mid-Atlantic Industrial and Hazardous Waste Conference RPI, Rensselaer Polytechnic Institute (RPI), 27 June, Troy, New York.

Doody, J.P. 1999. "Effectiveness of Sediment Removal: An Analysis of EPA Region V's Claims." Presentation to the National Academy of Sciences/National Research Council Panel, September, Green Bay, Wisconsin.

Doody, J.P. 1998. "Practical Issues Associated with Management of Contaminated Sediment." Presented at the 14th Annual Conference on Contaminated Soils, University of Massachusetts, 21 October, Amherst, Massachusetts

Doody, J.P. 1998. "Overview of Sediment Remediation Technologies." Presented at the NCASI Contaminated Sediment Workshop, 14 July.

Doody, J.P., R. Romagnoli, H.M. VanDewalker, and W.A. Ackner. 1998. "The Future Challenges of Environmental Dredging." Presented at the 15th World Dredging Conference, 1 July, Las Vegas, Nevada.

Doody, J.P., and J.A. Goebel. 1998. "Remediation and Third Party Litigation: Town Branch Creek, Russellville, Kentucky." Presented at the Sediment Management Seminar 1998, 10 February, New Orleans, Louisiana.

Doody, J.P., D.S. Foster, and R. Romagnoli. 1995. "Sediment Remediation: How Much Does It Really Cost?" Presented at the Superfund XVI Conference & Exhibition, 6-8 November, Washington, D.C.

Doody, J.P., R.K. Goldman, and R.E. Carpenter. 1994. "Practical Issues Associated with Management of PCB-Contaminated Sediment." Presented at the New York State Water Environment Association, June.

Messur, S.D., J.P. Doody, and D.S. Foster. 1993. "The Sheboygan River and Harbor: A Case Study." Presented at the 1993 PCB Forum, March.

Doody, J.P., D.S. Foster, and D.E. Penniman. 1991. "A Summary of the Treatability of Sediments Using Innovative Technologies." Presented at the Hazardous Materials Control 91 (Formerly Superfund), December.

ARCADIS

Derek B. Edge, MS

Technical Expert

Education

MS, Environmental Science (Emphasis on Toxicology), University of Houston, Houston, TX, 1997

BS, Biology (Emphasis in Marine Science), San Diego State University, San Diego, CA, 1991

Years of Experience

Total - 18

With ARCADIS - 10

Professional Associations

Society for Environmental Toxicology and Chemistry

Mr. Edge has more than 18 years of experience designing, implementing, interpreting, and managing field and laboratory studies assessing the environmental impacts of various types of commercial, industrial, military, and municipal activities. This work has been conducted in support of litigation-related activities, and in support of other types of regulatory-driven requirements including NEPA, Clean Water Act, RCRA, and CERCLA. Mr. Edge has conducted work to address sediments, surface water, and point and non-point sources of inorganic and organic contaminants, and non-contaminant stressors. His experience includes working in freshwater, estuarine and marine systems. Mr. Edge's technical expertise includes biological survey and habitat evaluation, environmental impact assessment and environmental management plan preparation, NPDES permit compliance and negotiation, aquatic and marine toxicological field and laboratory investigation, natural resource damage assessment, net environmental benefit analysis, ecological risk assessment, water and sediment quality criteria development and review, total maximum daily load development, and toxicity identification evaluation.

Project Experience

West Beach Landfill and Wetlands RI and FS

US NAVY SW DIV

Project Manager and primary author of an ecological risk assessment for Southwest Division Naval Facilities Engineering Command (SWDIV) at Installation Restoration (IR) Site 2, West Beach Landfill and Wetlands. The ERA addressed approximately 77 acres of upland habitat, and 33 acres of wetland habitat including two wetland ponds. The purpose of the ERA was to support the completion of RI activities, and to support recommendations for consideration in the FS process.

San Francisco Bay PCB TMDL

Confidential Industrial Client

Project Manager provided technical and strategic support to successfully argue against a proposed 303(d) listing for sediment toxicity in San Francisco Bay, and developed formal comments on a number of technical elements of a draft TMDL for San Francisco Bay for PCBs

NAB Coronado Remedial Investigation Work Plan

ST GEORGE CHADUX

Project Manager for the development of a Remedial Investigation Workplan for several IR sites at Naval Amphibious Base Coronado. Issues addressed include groundwater and groundwater impacts to surface water resources, surface runoff and associated potential impacts to sediment and surface water, surface and subsurface soil contamination, nature and extent of contaminants in sediment, benthic invertebrates, fish, aquatic plant material, and sediment toxicity. The work plan additionally addressed baseline human health and ecological risk assessment approaches and inputs.

NPDES Permit Negotiation (30124)

Confidential Client, Northeast United States

2004, Project Cost: $100,000

Provided technical and strategic support for negotiation and renewal of a complex multi-discharge NPDES permit for a large former industrial facility. Addressed issue related to wet and dry event permit requirements, reasonable potential analysis, whole effluent toxicity limits, numerical chemical criteria, mixing zones and dilution factors.

Tank Farm Liability Assessment (66611)

Confidential Client, Central Coast, California

2003, Project Cost: $125,000

As project manager and principal investigator, evaluated potential ecological risk and natural resource damage liabilities at a large former petroleum storage site. This evaluation included assessment of potential remediation, restoration and re-development costs, as well as compensatory restoration and preservation to offset natural resource damages. Wetland and upland habitats, plants, birds and other wildlife were evaluated. The results of this assessment were incorporated with other inputs (e.g., engineering, construction, and monitoring) into a strategic decision framework and a probabalistic cost model. The decision framework and probabalistic cost model were then used to develop an overall strategy for the site.

Remedial Alternative Selection Process

Confidential Client, Kalamazoo, Michigan

2002, Project Cost: $100,000

As project manager and primary author, developed a report evaluating potential ecological impacts associated with implementing sediment remediation strategies to support the remedial alternative selection process as required by the National Contingency Plan (NCP). To support this decision-making process, evaluated potential impacts to river, wetland, and riparian habitats and biota from the large-scale implementation of bank stabilization, sediment capping, river-wide dredging, and dam removal. Also developed a restoration/enhancement plan to mitigate remediation-associated impacts in a 50-mile river/wetland corridor. Evaluated in-stream, emergent wetland, forested wetland and upland riparian forest habitats. Identified impacts included prevention of bank undercutting and stream meandering, changes to in-stream morphology, sediment resuspension, downstream sedimentation, channelization, flow alteration, temperature changes, erosion, deposition, wetland destruction, habitat fragmentation, species isolation, non-native species invasion and alteration of habitat microclimate.

Assimilative Capacity, TMDLs, Bioaccumulative Compounds

Confidential Client, San Francisco, California

2002, Project Cost: $50,000

Conducted work to address assimilative capacity issues in San Francisco Bay. In the context of the NPDES program, assimilative capacity is directly related to the ability of dischargers to receive dilution credits in NPDES permits for persistent, bioaccumulative and toxic compounds (PBTs). There is a current movement within the State Water Resources Control Board (SWRCB) to achieve short-term load reductions by removing dilutions credits in NPDES permits prior to developing TMDLs for PBTs. This move constitutes an effective "short cut" of the TMDL process. When TMDLs are developed, they will represent the assimilative capacity of a given system to receive additional load of a given compound. This work involved defining and evaluating assimilative capacity and developing an approach and a decision model (for submission to the SWRCB) to address PBTs during the period in which TMDLs will be developed.

Consulting and Negotiation with Regulatory Agencies

Confidential Client, Los Angeles, California

2002, Project Cost: $200,000

Project manager and senior technical resource provided strategic consulting and negotiating with regulatory agencies. Developed a study plan addressing sediment and surface water to evaluate system impairment, evaluate copper fate and transport, determine total and dissolved copper conversion factors, and to derive a site-specific water-effect ratio. Provided input on technical, regulatory and policy issues.

Offshore ERA

Department of the Navy, EFA West, San Francisco Bay, California

2000, Project Cost: $300,000

Served as task manager and primary author of a workplan, sampling and analysis plan (SAP), quality assurance project plan (QAPP), and conducted an offshore ERA at a former fuel storage depot on San Francisco Bay. Developed a weight-of-evidence approach using sediment chemistry, sediment toxicity, benthic indices, and measurement of tissue concentrations of contaminants. Also negotiated a technical risk assessment approach with involved agencies and was responsible, as task leader and primary author, for developing and finalizing the risk assessment report.

Litigation Support

Confidential Client, Northeast United States

2001, Project Cost: $150,000

Served as the project manager providing litigation support to the client in a case alleging eminent and substantial endangerment due to ongoing releases of, and ecological risks posed by, PCBs occurring at an industrial site in a major waterway. Additionally, coordinated several senior-level "expert" scientists in PCB chemistry, fate and transport, bioaccumulation, and toxicity to develop expert reports in support of potential litigation, and to perform a technical review of the plaintiff's expert reports. Co-authored an expert report that described the presence, type, and occurrence of habitat, exposure media, potentially exposed ecological receptors, likelihood of exposure, potential for ecological effects, and relative contribution of the site to significant exposure of ecological receptors.

San Francisco Bay Mercury TMDL
Confidential Client, San Francisco, California
2000, Project Cost: $50,000
Reviewed the draft TMDL for mercury in San Francisco Bay. Also provided input to development of a strategy to engage the regulatory agencies and other stakeholders in the TMDL process, and to address potential Natural Resource Damage (NRD) issues in the context of the TMDL process.

Litigation Support (40431)
Provided technical support in anticipation of litigation associated with a TMDL. Under attorney-client privilege, designed and implemented sediment and surface water studies to assess contaminant levels, future loading, total-dissolved conversion factors, loading, bioavailability, and the potential for additional assimilative capacity. Prepared technical reports for attorneys and worked with attorneys to develop a strategy to interact/work with agencies in the context of the TMDL process.

Toxicity Identification Evaluations
Confidential Client, Houston, Texas
1996, Project Cost: $40,000
Served as principal investigator and/or project manager on routine and nonstandard TIEs and associated bioassay testing. Interpreted and applied toxicological and ecological data derived from, or related to, site-specific water criteria, water effects ratio studies, and ERA. As project scientist, responsible for test design, protocol development and interpretation of results.

Toxicity Identification Evaluations
DuPont, Houston, Texas
1996, Project Cost: $50,000
Served as principal investigator and/or project manager on routine and nonstandard TIEs and associated bioassay testing. Interpreted and applied toxicological and ecological data derived from, or related to, site-specific water criteria, water effects ratio studies, and ERA. As project scientist, responsible for test design, protocol development and interpretation of results.

Toxicity Identification Evaluations (TIEs)
Shell, Houston, Texas
1996, Project Cost: $150,000

Served as principal investigator and/or project manager on routine and nonstandard TIEs and associated bioassay testing. Interpreted and applied toxicological and ecological data derived from, or related to, site-specific water criteria, water effects ratio studies and ERA. As project scientist, was responsible for test design, protocol development, and interpretation of results.

Toxicity Identification Evaluations
Dow, Houston, Texas
1996, Project Cost: $80,000
Principal investigator and/or project manager on routine and nonstandard TIEs and associated bioassay testing. Interpreted and applied toxicological and ecological data derived from, or related to, site-specific water criteria, water effects ratio studies, and ERA. As project scientist, was responsible for test design, protocol development and interpretation of results.

Environmental Impact Analysis and Environmental Management Plan
Petrolera Santa Fe Ecuador (PSFE), Ecuador
1999, Project Cost: $250,000
Participated in the development of the EIA and EMP for oil and gas exploration activities, including two-dimensional (2-D) and three-dimensional (3-D) seismic survey, in an Ecuadorian tropical rain forest.

Environmental Impact Analysis and Environmental Management Plan
ARCO, Oriente Region, Ecuador
1998, Project Cost: $200,000
Participated in the development of the EIA and EMP for oil exploration, production and distribution activities in a tropical rain forest in the Oriente region.

Marine and Estuarine Sediments Evaluation
US Navy, San Diego, California
1995, Project Cost: $150,000
Served as staff scientist and field team leader collecting and evaluating marine and estuarine sediments with respect to acute and chronic toxicity, bioaccumulative potential and chemical concentrations.

Marine and Estuarine Sediments Evaluation
Port of Oakland, Oakland, California
1994, Project Cost: $75,000
Served as staff scientist and field team leader collecting and evaluating marine and estuarine sediments with respect to acute and chronic toxicity, bioaccumulative potential and chemical concentrations.

Marine and Estuarine Sediments Evaluation

Port of Los Angeles, Los Angeles, California
1993, Project Cost: $100,000
Served as staff scientist and field team leader collecting and evaluating marine and estuarine sediments with respect to acute and chronic toxicity, bioaccumulative potential, and chemical concentrations.

Marine and Estuarine Sediments Evaluation
Port of Waikiki, Honolulu, Hawaii
1993, Project Cost: $150,000
Served as staff scientist and field team leader responsible for collecting and evaluating marine and estuarine sediments with respect to acute and chronic toxicity, bioaccumulative potential and chemical concentrations.

Marine and Estuarine Sediments Evaluation
Port of Long Beach, Long Beach, California
1995, Project Cost: $200,000
Served as staff scientist and field team leader collecting and evaluating marine and estuarine sediments with respect to acute and chronic toxicity, bioaccumulative potential and chemical concentrations.

Marine and Estuarine Sediments Evaluation
Port of San Diego, San Diego, California
1993, Project Cost: $150,000
Served as staff scientist and field team leader collecting and evaluating marine and estuarine sediments with respect to acute and chronic toxicity, bioaccumulative potential and chemical concentrations.

Remedial Measures Work Plan
Confidential Client, Southeast Texas
1995, Project Cost: $100,000
Task manager developed a remedial measures work plan for submission to the Texas Natural Resource Conservation Commission (TNRCC). The plan described work required to determine the nature and extent of contamination and associated ecological and human health risk at a 16.5-acre wetland adjacent to an industrial site. Worked as part of a multidisciplinary team to review existing data; develop work plan strategy; evaluate sources of contamination, stressors, exposure pathways, and receptors; and design a screening-level ERA.

Subtidal Biological Surveys
Southern California Edison, San Diego, California
1993, Project Cost: $100,000

Performed subtidal biological surveys of fish, invertebrates, kelp and sea-grass populations; conducted water-quality monitoring; and mapped thermal plumes using infrared aerial photography as required by a National Pollutant Discharge Elimination System (NPDES) cooling-water discharge permit. Conducted off-shore surveys of nekton and plankton from a research vessel.

Marine Baseline Studies

Conoco, Gulf of Paria, Venezuela

1998, Project Cost: $300,000

Served as task manager and field team leader to design and perform marine baseline studies in a 900-square-mile oil lease block in the Gulf of Paria. The work was conducted in support of an environmental impact assessment (EIA) developed for submission to MARNR, the Venezuelan environmental regulatory agency. Worked with Venezuelan scientists to develop and implement field studies in Spanish-speaking field and office environment

Grounded Vessel Evaluation

Confidential Client, Mexico

1998, Project Cost: $150,000

Evaluated a grounded vessel carrying 10,000 gallons of diesel fuel, which was 30 miles off the coast on a large coral reef (Banco Chinchorro), and conducted a preliminary assessment of the reef to determine physical damage by collecting water samples to evaluate the presence or absence of diesel fuel in the water. Analyzed the data to determine injuries to natural resources in the area of concern to negotiate a natural resource damage (NRD) claim. Interacted with officials from the Mexican EPA (PROFEPA) to determine the most appropriate course of action to minimize further impacts to the coral reef.

Subtidal Diving Survey

Port of San Diego, San Diego Bay, California

1994, Project Cost: $50,000

Project manager and field team leader on a subtidal diving survey of an eel grass community post-construction of a bayside boardwalk in San Diego Bay. Authored and submitted the proposal, conducted field work and prepared the summary report of findings.

Ecological and Toxicological Investigations

US Navy, San Francisco Bay

1999, Project Cost: $250,000

Worked as part of a multidisciplinary, multiconsulting company team comprising a sediment work group, which conducted studies at various Naval facilities in San Francisco Bay to support risk-based facility closure and/or property transfer. At various stages of the process, served as the ecological risk assessment team leader, a task leader to develop an approach to integrate various lines of evidence using a weight-of-evidence approach, and as a member of the bioassay evaluation team. Additionally, provided strategic input and technical support for the development of regionally applicable approaches to complete the remedial investigation, risk assessment (ERA and human HHRA]) and feasibility study portions of the program.

Ecological and Radiological Studies

San Onofre Nuclear Power Plant, San Onofre, California

1995, Project Cost: $175,000

Conducted ecological and radiological studies on kelp bed communities in the receiving waters of the cooling-water discharge from the plant. Collected organ and tissue samples from fish, surveyed kelp and invertebrate communities, conducted dye studies to determine ocean current characteristics, and assisted in annual report preparation.

ERA Guidelines Review

Confidential Client, Houston, Texas

1998, Project Cost: $50,000

Reviewed currently available ERA guidelines from several federal, regional and state regulatory agencies. Reviewed and critiqued guidelines for completeness, clarity, applicability and consistency with USEPA federal guidance. Proposed an ERA framework conceptual model and checklist for screening investigations.

Technical White Paper

Developed a technical white paper that considered the appropriateness and applicability of Threshold and Probable Effect Concentrations (TECs and PECs) and Equilibrium Sediment Guidelines (ESGs) for Polynuclear Aromatic Hydrocarbons (PAHs). Conducted a technical review of each approach to develop a technical basis for making recommendations regarding the appropriate interpretation and use of TECs and ESGs to conduct a screening step (i.e., for the purpose of focusing additional ecological or toxicological studies).

Presentations

Edge, D.B. 2004. The Application of a Net Environmental Benefit Analysis (NEBA) Framework to Achieve Environmental Resource and Risk Management Objectives in Wetlands. Presented at 25th Annual Meeting of the Society of Environmental Toxicology and Chemistry, Portland, Oregon.

Edge, D.B. 2002. The Application of ERA and NRDA Concepts to Evaluate Sediment and Surface-Water Resources Based on Attainment of Beneficial Uses. Presented at International Association for Sediment Water Science (IASWS) 9th International Symposium on The Interactions Between Sediment and Water, Banff, Canada.

Edge, D.B. 2001. Refining The TMDL Process: The Need for a Different Level of Up-front Problem Definition. Presented at

Society of Environmental Toxicology and Chemistry, Southern California Regional Chapter (SoCal SEATC).

Edge, D.B. and J.L. Holder. 1999. Using a Weight of Evidence Approach to Integrate Lines of Evidence and Evaluate Uncertainty. Presented at 20th Annual Meeting of the Society of Environmental Toxicology and Chemistry, Philadelphia, Pennsylvania.

Edge, D.B. 1999. Applying a Weight of Evidence Approach to Risk Assessments. Presented at Navy and Marine Corps Site Cleanup Conference, Port Hueneme, California.

Edge, D.B., and J.L. Holder. 1999. "Navigating Ecological Risk Assessment Using a Weight of Evidence Approach." Presented at the Navy Ecological Risk Assessment and Management Forum, 10-11 March, San Bruno, California.

Edge, D.B., S.M. Lixey and C.L. Howard. 1996. Bioassay Exposure Characterization: Time or Endpoint Dependent? Presented at 17th Annual Meeting of the Society of Environmental Toxicology and Chemistry, Washington, D.C.

Edge, D.B. 1995. "A Marine Toxicity Identification Evaluation: When Phase I Becomes a Research Project." Presented at the Society of Environmental Toxicology and Chemistry 16th Annual C

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Appendix B

Rates Used for this Work

RATES USED FOR THIS WORK

Philip A. Spadaro,LG	
Principal Scientist/Senior Vice President	$300.00
Poh Boon Ung	
Principal Economist	$246.00
Mathew K. Butcher	
Senior Scientist	$246.00
J. Paul Doody, PE	
Senior Vice President	$286.00
Derek B. Edge, MS	
Technical Expert	$246.00

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Appendix C

Bivalve Normality Results
(Exponent 2003)

Table G-3. Bivalve normality results

Station	Batch	Bivalve Combined Survival and Normality (percent)				
		Replicate 1	Replicate 2	Replicate 3	Replicate 4	Replicate 5
Reference						
2441	Batch 2	69	77	60	64	59
2433	Batch 2	24	58	66	39	47
2440	Batch 2	61	71	66	64	88
2231	Batch 1	88	86	80	77	80
2243	Batch 2	62	24	75	8	79
NASSCO						
NA01	Batch 2	44	6	10	80	77
NA03	Batch 2	85	90	67	84	90
NA04	Batch 2	60	77	83	80	71
NA05	Batch 2	92	79	82	80	84
NA06	Batch 1	62	38	65	91	86
NA07	Batch 1	81	82	93	57	91
NA09	Batch 2	5	0	1	0	0
NA11	Batch 1	90	84	84	35	79
NA12	Batch 2	65	0	0	0	2
NA15	Batch 2	75	89	74	88	84
NA16	Batch 2	1	12	0	0	3
NA17	Batch 2	66	80	77	47	79
NA19	Batch 2	0	0	0	0	8
NA20	Batch 1	71	65	65	81	89
NA22	Batch 2	0	2	0	7	0
Southwest Marine						
SW02	Batch 1	90	67	90	65	77
SW03	Batch 1	82	74	88	90	70
SW04	Batch 1	65	33	84	46	63
SW08	Batch 1	87	84	88	83	86
SW09	Batch 1	78	82	72	76	81
SW11	Batch 2	84	47	74	77	84
SW13	Batch 1	19	0	41	70	0
SW15	Batch 1	0	0	16	16	9
SW17	Batch 2	0	0	0	0	69
SW18	Batch 2	16	54	74	60	76
SW21	Batch 1	2	71	78	80	78
SW22	Batch 2	1	0	0	4	1
SW23	Batch 2	52	3	14	1	2
SW25	Batch 2	39	4	1	0	0
SW27	Batch 2	72	1	4	11	9