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Jim:

Our comments on the Draft Aquatic Injury Report are contained in detail in the accompanying report. For ease of interpretation we appended the document with comments in color. Blue font indicates general comments. Red font indicates suggested wording.

In general, our main concern is that background contamination plays a large role in defining the area and magnitude of the assumed injury. Overall, a small amount of polycyclic aromatic hydrocarbons (PAHs) are in the ATHOS oil (0.6 %). An even smaller amount of PAH ended up on the bottom of the river, with only the soluble fractions responsible for toxicity. Yet it is PAH toxicity that is being used as the measure of injury, and the PAH values in samples used to define the injured area and the magnitude of injury do not have any discernable ATHOS PAH in them. We disagree with the trustees that the assessment of source allocation has too much uncertainty and welcome review of these data by the trustees' forensic chemist consultants at Newfields Environmental Forensics.

We also do not believe that a single bioassay from Tinicum Island (an area of known high background contamination) performed on different dates is an adequate measure of injury magnitude. It is not certain that differences in survival are due to natural spatial variation or background contamination. The trustees assessment of initial service loss requires a PAH sediment load that does not appear to be possible even if all of the PAH in the entire volume of spilled oil covered the bottom of the river in only the area the trustees assume was injured.

We continue to believe that the sediment data collected in tributaries for this assessment are counter to the trustee's conclusions in the shoreline injury report that suggest the entire aerial extent of tributaries were injured, including subtidal areas with no evidence of ATHOS oil.

Our specific comments are contained in the accompanying copy of the draft report.

Greg E. Challenger
Polaris Applied Sciences

The organization of this report reflects key injury quantification issues. Following the Introduction (Chapter 1) are sections describing Injury Determination (Chapter 2), Injury Quantification (Chapter 3) and a Summary of Results (Chapter 4). This report also includes several appendices. Appendix A is a technical appendix that provides additional information related to the derivation of whole sediment chemistry - toxicity relationships from local and national data sets cited in this report. Appendices B - E include several documents produced by the Aquatic TWG as part of damage assessment activities and cited in this analysis.

1.2 Oil Characteristics

NOAA (2006) provides the analytical results of the physical and chemical properties of the spilled oil. In general, the oil is a heavily biodegraded crude oil, mostly (95%+) comprised of thousands of compounds that are not individually quantified, but referred to generally as the unresolved complex mixture (UCM). The UCM is comprised of compounds that fall into several categories, including branched alkanes and cycloalkanes, complex aromatics, resin/NSO compounds, and asphaltenes (Frysinger *et al.* 2003). Three specific sub-classes of chemicals of potential concern (COPCs) have been quantified by laboratory analysis, including: 1) monocyclic aromatic hydrocarbons (MAHs), primarily including benzene, toluene, ethylbenzene and xylenes (collectively identified as BTEX compounds); 2) polycyclic aromatic hydrocarbons (PAHs); and 3) trace metals. MAHs (BTEX) comprise approximately 0.02% of the oil, while PAHs comprise approximately 0.6%. The metals with the highest concentrations in the source oil sample were vanadium and nickel (averaging 445 ppm and 57 ppm, respectively; n=2) (Donlan *et al.* 2005a: see Appendix B).

The fresh source oil was "evaporatively weathered" by heating it to 90°C under vacuum and less than three percent was lost by evaporation after four hours. Therefore, the weathered oil after evaporation was still expected to float. However, in the field, samples of oil were found to adhere to sediments and not refloat (Michel *et al.* 2004). Based on the low concentrations of MAH and naphthalenes, and after reviewing the GC/MS total ion chromatogram, it is highly probable that evaporative losses from this oil resulted in minimal change in product volume and density because of the relatively low proportion of these compounds in the oil. The behavior of oil-borne PAHs in the environment is generally well understood. Once released into the environment, the concentration of total PAH in the oil will decrease due to various environmental weathering processes that include volatilization, dissolution (transport of soluble hydrocarbons from the oil to the water column), and biodegradation (National Research Council 2003; Stout *et al.* 2002). The rate of weathering is dependent on many factors; however, the more soluble and volatile hydrocarbons (*e.g.*, naphthalenes) may be lost within days to weeks after an oil spill, whereas the 3-6 ring PAH compounds (*e.g.*, chrysenes) may persist for months to years (Donlan *et al.* 2005a: see Appendix B).

1.3 Aquatic Resources of Potential Concern

Aquatic resources of concern potentially affected by the oil spill include water column and benthic resources, ranging from interstitial-sediment dwellers to larger mobile predators. The River supports numerous adult and larval fish and shellfish, including the federally-endangered shortnose sturgeon (*Acipenser brevirostrum*) that winter in certain areas of the Delaware River. The waters around Little Tinicum Island are also known to contain high numbers of pre-spawn and spawning striped bass (*Morone saxatilis*) in April and May. The Bay supports commercial and natural oyster beds (*Crassostrea virginica*), commercial blue crab (*Callinectes sapidus*), horseshoe crab (*Limulus polyphemus*), and whelk (*Busycon* spp.) fisheries, as well as a variety of recreational fisheries. Other aquatic resources include red-bellied turtles *(Pseudemys rubriventris)* and eastern painted turtles (NOAA 2006). Amphipods (e.g., *Gammarus* spp.), aquatic earthworms (*e.g.*, *Limnodrilus*), midge larvae (*e.g.*, *Chironomus*) and other types of sediment infauna are commonly found within the study area (Hartwell *et al.* 2001). Observed zooplankton include a variety of copepods. Table 1 provides summary biological information for many of the resources found in benthic habitats in this region of the river.

1.4 Potential Exposure Pathways

Aquatic organisms may be injured due to smothering effects from oil or from toxicity due to various constituents of the oil. Significant physical impacts associated with smothering and fouling are possible. Analysis during the spill response indicated that the heavy crude oil had the potential to adhere to sediments and lose buoyancy (Michel *et al.* 2004). As noted above, most of the oil (95+%) is comprised of UCM (Donlan *et al.* 2005a: see Appendix B). Such compounds can become attached to bottom sediments as a non-aqueous phase liquid (NAPL), limiting oxygen transfer and contributing to physical smothering effects (Rick Greene, personal communication). Because of the characteristics of the spilled oil, physical smothering effects are considered a potentially important mechanism of harm for this spill.

In addition to physical effects, several of the constituents present in the crude oil released during the *Athos* oil spill have the potential to have toxic effects on aquatic biota, including impacts on survival, reproduction, growth. COPC sub-classes that have been quantified by laboratory analysis included MAHs and PAHs. While most of the oil MAHs are present in the source oil at low concentrations (approximately 0.02%) relative to other oils and typically are lost within hours to days after an oil spill (Donlan *et al.* 2005a: see Appendix B). While this class of compounds is of potential significance with respect to toxicity to water-column species immediately following the spill, the low MAH content of the oil and available field data suggest a limited potential for acute, toxic impacts to water column and benthic resources.

PAHs are associated with a wide range of effects in aquatic organisms, and comprise approximately 0.6% of the source oil (Donlan *et al.* 2005a: see Appendix B). The acute toxicity of PAHs is primarily associated with their action as non-polar narcotics. That is, PAHs tend to enter the organism and bind irreversibly to lipophilic sites within the cell. Binding to sites on cell membranes tends to disrupt surface membrane processes, inhibit ion and gas exchange, and increase the movement of water across the membrane. In fish, hypoxia and osmotic imbalances may result from impaired membrane function. In tissues, changes in membrane permeability can disrupt neurological and muscular function. Together, these effects can lead to metabolic dysfunction, immobility, and death. While non-polar narcosis is the primary mode of toxicity for PAH with three or fewer aromatic rings, many high molecular weight PAHs may also be associated with mutagenic, carcinogenic, and teratogenic effects (Eisler 1987).

The amount of PAH in 265,000 gallons at 0.6% is approximately 1,590 gallons. If 90% of the oil stranded on the shorelines, evaporated, or was lost downriver as fugitive oil, this injury report addresses the equivalent of approximately 160 gallons of PAH under the water surface, some of which would have exposed the bottom. We understand the physical fouling effects of the UCM are possible, but the method of injury assessment relies solely on the toxicity from PAH. This is relevant when making assumptions about the possible area of injury in a river with a long history of PAH contamination. This topic is discussed in more detail later in the document.

While the PAH content of the source oil also is low relative to other oils, if present in sufficient concentrations it could have toxic effects. Additionally, high-molecular weight PAHs within the oil can persist for months to years in the environment, increasing the opportunity for chronic exposure of organisms to toxic compounds in the oil (Donlan *et al*. 2005a: see Appendix B). The estimated narcotic potency of the PAH mixture was 41.9 acute toxicity units and 213 chronic toxicity units. About 33 percent of this toxicity was due to naphthalenes, another 37 percent was due to fluorenes and phenanthrenes, 17 percent was due to dibenzothiophenes, and the balance was due to other specific PAHs (Greene 2005a: See Appendix E). Although little information is available on the toxicity of UCMs, there is some toxicological data available that suggests that these substances may contribute to the toxicity of crude oil (*e.g.*, Neff *et al*. 2000, Donkin *et al*. 2003).

1.5 <u>Post-Spill Data Collection</u>

In the weeks and months following the incident, a variety of data were collected to assess potential spill-related impacts to aquatic resources. Data collected by the Trustees and RP to facilitate injury assessment are briefly summarized below. Additional, more detailed information is available in the cited documents.

1.5.1 Water Chemistry

In the first two weeks following the incident, 66 surface water and 13 bottom water samples were collected to characterize PAH concentrations. One sample had a total PAH concentration of 26,634 ng/L (near Marcus Hook), but the remaining samples all measured less than 5,000 ng/L total PAH (NOAA 2006).

Such a large disparity is likely the result of particulate oil in the sample.

1.5.2 Submerged Oil Surveys

Submerged oil was confirmed in locations near the discharge origin in the first two weeks following the incident, using Vessel-Submerged Oil Recovery System (V-SORS) monitoring.[2] In particular, the heaviest subtidal oiling noted with V-SORS was on the south side of Tinicum Island. Additionally, two trenches containing pooled oil were found near the discharge site, covering an approximate area of 317 square feet. Snare samplers were deployed at various

[1] Two values are given in the laboratory data for sample WMH #1-S (also listed as WMH #1-5) from Marcus Hook. The two values are 26,634 ng/L and 293 ng/L, and only one sample is listed in the collection log with no explanation for the duplicate values.

[2] The Vessel-Submerged Oil Recovery System (V-SORS) consists of a pipe with attached chains and snare. The V-SORS is towed behind a vessel on the bottom at slow speeds. It is pulled up regularly and inspected for oil.

locations within the River and visually inspected for the presence of oil with depth, and the amount of oil on the snare (estimated as percent coverage). In general, most of the subsurface, mobile oil occurred several feet off the bottom, though small amounts of oil were present on the snares suspended in the middle and upper water column. Highest amounts of oil were detected by snares around Tinicum Island (Michel *et al.* 2004).

1.5.3 Shoreline Surveys

Shoreline Cleanup Assessment Team (SCAT) surveys identified and classified shoreline oiling between the Tacony-Palmyra Bridge and the mouth of the Delaware Bay.[3] In total, oiling was noted on approximately 280 miles of shoreline in the mainstem of the Delaware River. Substantial additional oiling was noted in tributaries (Shoreline Assessment Team 2006). Tarballs, tarmats, and similar products of discharged oil have been observed and collected that, based on laboratory analysis, appear to be associated with the *Athos* incident (Coast Guard 2006).[4]

Search teams surveying oiled shorelines recovered 23 dead fish, including two bullhead catfish (*Ameiurus nebulosus*), five striped bass, fifteen white perch (*Morone americana*), and one gizzard shad (*Dorosoma cepadianum*) that were oiled to varying degrees (E. Marek, personal communication[5]). Necropsies or other cause of death analysis would be required to determine the cause of mortality of these fish and when these fish were exposed to oil (*e.g.*, pre- or post-mortality) (NOAA 2006).

We believe that many hundreds of people deployed to work along the shorelines of the Delaware River for many months during any period of the year would likely find a similar number of dead fish. For this reason it is likely they could have been oiled post-mortem.

1.5.4 Fish and Oyster Tissue Chemistry

Fish and oyster samples were collected from the Delaware River within three weeks of the incident. The Trustees and RPs collected oysters (*Crassostrea sp.*), perch, catfish, and gizzard shad from the Delaware River for tissue analysis (fillet and whole-body) to determine potential risks to fish and shellfish based on contaminant body burden and to piscivorous wildlife that might consume the tainted fish and shellfish (*e.g.*, aquatic mammals such as river otters, as well as birds such as ospreys, eagles, belted kingfishers, and great blue herons). Concentrations of total PAHs in oyster tissue from 7 and 9 December 2004 ranged from 15.7 to 28.5 ng/g wet weight (WW). Fish samples collected on 9 and 16 December 2004 ranged from 88.9 to 464.3 ng/g tPAH WW (whole body, catfish); 72.1-238.9 ng/g tPAH WW (fillet, perch and shad); and 205.6 to 1143.6 ng/g tPAH WW (carcass, perch and shad). Later samples were also collected. Oyster samples from February 2005 had total PAH concentrations ranging from 12 to 29 ng/g WW. Fifteen striped bass were also collected in May and July 2005 from the Delaware Bay and

[3] While most of the specified length was canvassed, oiling was only noted between the Betsy Ross Bridge and just south of the Smyrna River.

[4] Samples also were analyzed by the Coast Guard that appear to be from other, non-Athos sources.

[5] Eric W. Marek, Special Agent, USFWS, Office of Law Enforcement, Elizabeth, NJ.

the Delaware River near Tinicum Island and north of the Schuylkill River. The average total PAH concentrations ranged from 9.7 to 130.6 ng/g WW for fillets and 11.5 to 291.5 ng/g WW for carcasses of striped bass (NOAA 2006).

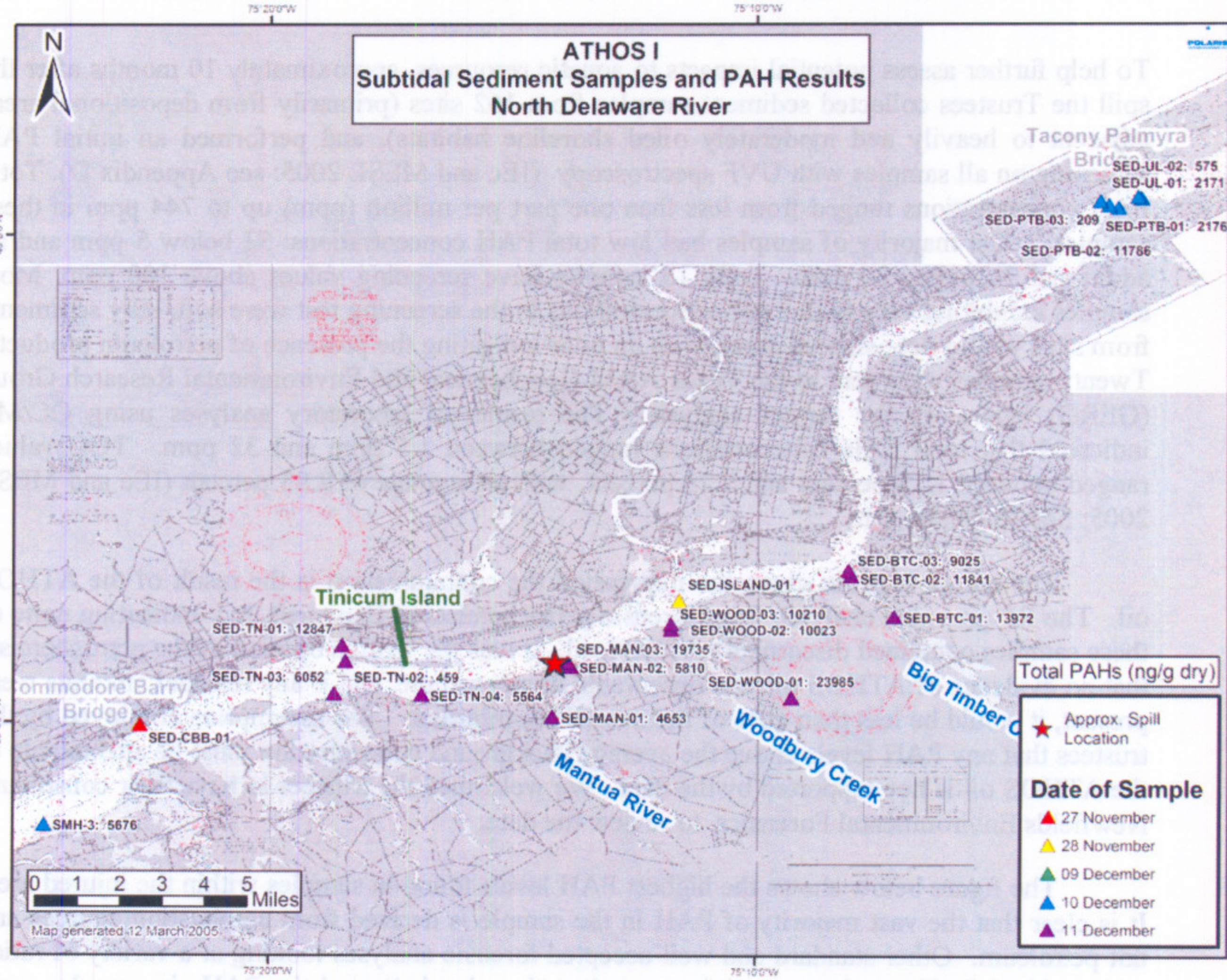
The reader is left to believe PAH contamination is the result of the ATHOS oil, when we know that most, if not all, is a result of background contamination. We understand background contamination is mentioned elsewhere, but it deserves mention that a large portion of PAHs found in all samples is derived from combustion sources and is not petrogenic. It is our recollection that source allocation could not identify an ATHOS signature in oyster or rockfish.

1.5.5 Sediment Chemistry

Both intertidal and subtidal sediment samples were collected in the three weeks following the incident. Of the 28 subtidal sediment samples collected, the highest total PAH concentration observed (calculated based on the levels of 13 parent PAHs as per NOAA's National Status and Trends (NS&T) methods) was 12.9 mg/kg dry weight (DW) in Woodbury Creek.[6] Subtidal sediment samples provide a limited overview of the potential degree and spatial extent of oiling in the Delaware River mainstem. With the exception of four samples near Tinicum Island, *the majority of the samples were collected in tributaries or outside the area that may be most affected by the discharge* (e.g. south of Marcus Hook, north of the Tacony-Palmyra Bridge) (NOAA 2006).

The areas sampled in shoreline, tributary, and subtidal habitats are within areas the trustees have included as being injured in the shoreline and aquatic injury assessment reports. Numerous subtidal and nearly all intertidal samples were collected in areas the trustees consider injured. Six subtidal samples were collected in the areas considered impacted within this report (below), two adjacent to the spill site and 4 near Tinicum Island. None of the 6 samples collected after the spill within the assumed area of injury demonstrate levels of ATHOS oil consistent with the trustees assumption of service loss presented later in this report.

[6] The NS&T total PAH value is used for subtidal and intertidal sediment chemistry results, to enhance comparability with available pre-spill data sets and field-based toxicity thresholds identified in the technical literature. Compounds included in NS&T total PAH calculations and in laboratory total PAH calculations are listed in Table 2. Using laboratory total PAH values calculated as the sum of 51 PAHs, subtidal samples ranged from 209 to 23,985 ng/g tPAH DW and intertidal samples ranged from 948 to 44,022 ng/g tPAH DW.

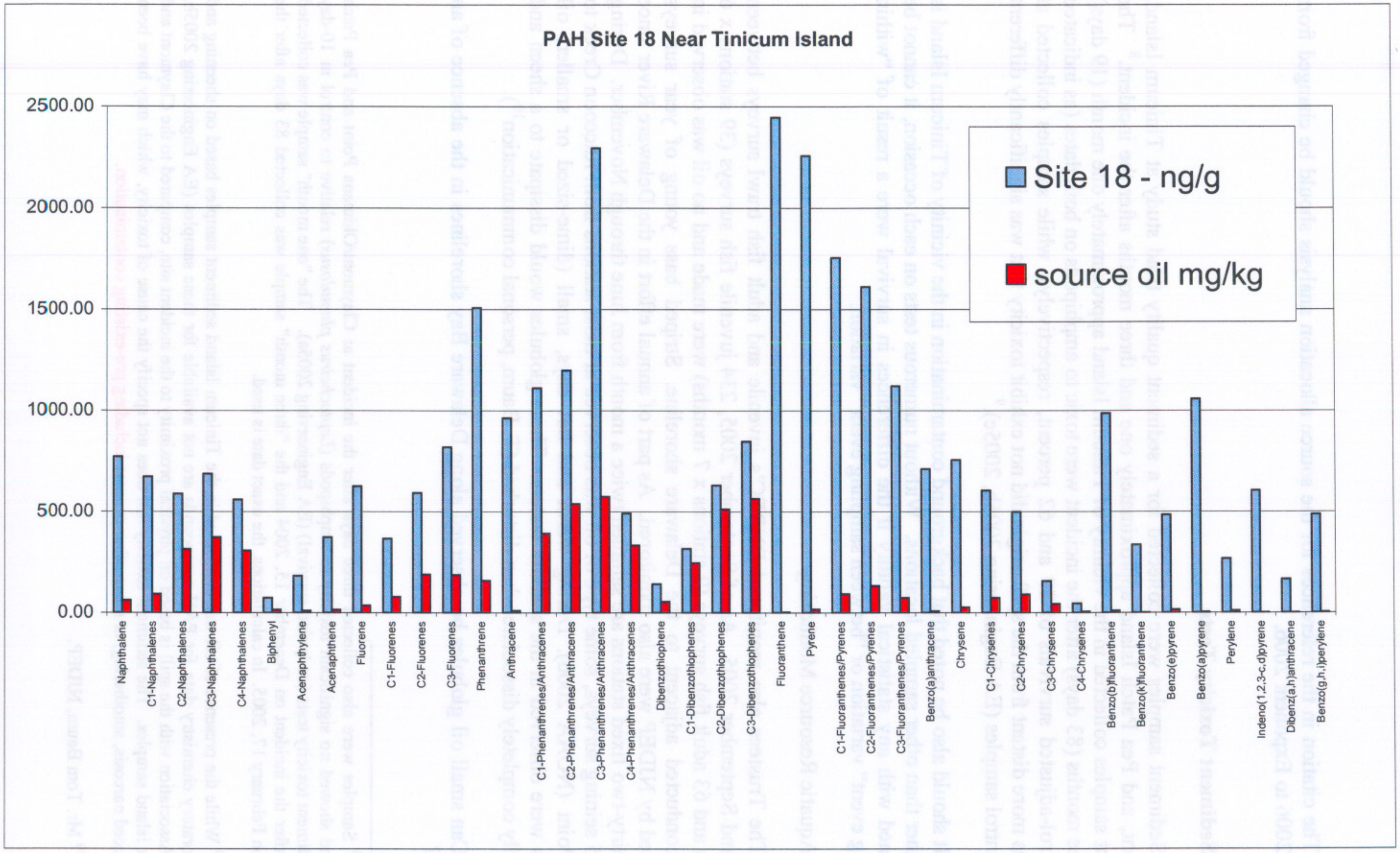

ATHOS I
Subtidal Sediment Samples and PAH Results
North Delaware River
N
Tacony Palmyra Bridge
SED-UL-02: 575
SED-UL-01: 2171
SED-PTB-03: 209
SED-PTB-01: 2176
SED-PTB-02: 11786
SED-BTC-03: 9025
SED-BTC-02: 11841
SED-ISLAND-01
SED-BTC-01: 13972
Tinicum Island
SED-WOOD-03: 10210
SED-WOOD-02: 10023
SED-TN-01: 12847
SED-MAN-03: 19735
SED-MAN-02: 5810
SED-TN-03: 6052
SED-TN-02: 459
SED-WOOD-01: 23985
SED-TN-04: 5564
SED-MAN-01: 4653
Commodore Barry Bridge
SED-CBB-01
Big Timber C
Woodbury Creek
Mantua River
SMH-3: 5676
0 1 2 3 4 5 Miles
Map generated 12 March 2005
Total PAHs (ng/g dry)
Approx. Spill Location
Date of Sample
27 November
28 November
09 December
10 December
11 December

To help further assess potential impacts to aquatic resources, approximately 10 months after the spill the Trustees collected sediment samples from 162 sites (primarily from depositional areas adjacent to heavily and moderately oiled shoreline habitats), and performed an initial PAH screening on all samples with UVF spectroscopy (IEc and MESL 2005: see Appendix D). Total PAH concentrations ranged from less than one part per million (ppm) up to 744 ppm in these samples.[7] The majority of samples had low total PAH concentrations: 52 below 5 ppm and an additional 76 below 20 ppm. Only 15 samples have screening values above 100 ppm. Most samples exhibiting very high PAH concentrations in the screening test were soft, silty sediments from sites within depositional areas, with an odor indicating the presence of petroleum products. Twenty samples were sent to the Texas A&M Geochemical and Environmental Research Group (GERG) laboratory for further analysis. The results of laboratory analyses using GC/MS indicated that total PAH concentrations ranged between 1.5 ppm and 32 ppm. TOC values ranged between 1.13 percent and 7.25 percent, with an average of 2.93 percent (IEc and MESL 2005: See Appendix D).

The reader is again given the impression the contamination is the result of the ATHOS oil. The RP provided analyses from forensic petrochemists at Exponent, Inc. indicating none of these samples contained discernable ATHOS oil. It was the written opinion of the petrochemists that no evidence of ATHOS oil was observable in any sample, and if any residual amounts were present, it would be less than 10% of the overall contribution. The assumption employed by the trustees that any PAH levels above the average background concentration must be attributable to the ATHOS oil is not supported by the data. We welcomed the trustees to have their consultant, Newfields Environmental Forensics, to review the data.

The figure below shows the highest PAH levels found in samples within the injured area. It is clear that the vast majority of PAH in the sample is derived from combustion sources and not petroleum. Other standard and well-accepted forensic analyses looking at a variety of ratios of individual PAHs, and pyrogenic/petrogenic ratios also indicated the PAHs in samples were not consistent with the spilled oil. It is not valid to attribute an ATHOS oil effect based on samples with only a discernable background PAH contribution. There is insufficient evidence of ATHOS oil in the samples to base an injury conclusion.

[7] Based on the calibration study performed on sediment samples collected during the preassessment activities, UVF PAH screening values appear to generally overstate the PAH concentration by a factor of 2 to 3, with a factor of up to 10 possible in areas with high concentrations of organic matter.


PAH Site 18 Near Tinicum Island
Site 18 - ng/g
source oil mg/kg
0.00
500.00
1000.00
1500.00
2000.00
2500.00
Naphthalene
C1-Naphthalenes
C2-Naphthalenes
C3-Naphthalenes
C4-Naphthalenes
Biphenyl
Acenaphthylene
Acenaphthene
Fluorene
C1-Fluorenes
C2-Fluorenes
C3-Fluorenes
Phenanthrene
Anthracene
C1-Phenanthrenes/Anthracenes
C2-Phenanthrenes/Anthracenes
C3-Phenanthrenes/Anthracenes
C4-Phenanthrenes/Anthracenes
Dibenzothiophene
C1-Dibenzothiophenes
C2-Dibenzothiophenes
C3-Dibenzothiophenes
Fluoranthene
Pyrene
C1-Fluoranthenes/Pyrenes
C2-Fluoranthenes/Pyrenes
C3-Fluoranthenes/Pyrenes
Benzo(a)anthracene
Chrysene
C1-Chrysenes
C2-Chrysenes
C3-Chrysenes
C4-Chrysenes
Benzo(b)fluoranthene
Benzo(k)fluoranthene
Benzo(e)pyrene
Benzo(a)pyrene
Perylene
Indeno(1,2,3-c,d)pyrene
Dibenz(a,h)anthracene
Benzo(g,h,i)perylene

The citation in the references for the source allocation analysis should be changed from Polaris 2006 to Exponent 2006.

1.5.6 Sediment Toxicity Tests

Sediment samples were collected for a sediment quality triad study at Tinicum Island, Claymont, and Pea Patch Island approximately one and three months after the incident.[8] The sediment samples collected in the vicinity of Tinicum Island approximately one month (19 days) and three months (83 days) after the incident were toxic to amphipods on both dates (as indicated by control-adjusted survivals of 39 and 62 percent, respectively), while samples collected at locations more distant from the spill origin did not exhibit toxicity that was significantly different from control samples (EA Engineering 2005b, 2005c).[9]

It should also be noted that background contamination in the vicinity of Tinicum Island is also higher than other sampled locations. Without numerous tests on each occasion, it cannot be determined with any statistical validity if the differences in survival were a result of "within sampling event" variation or "between sampling event" variation.

Aquatic Resource Monitoring

The Trustees also monitored DNREC's juvenile and adult fish trawl surveys between March and September 2005. As of September 2005, 234 juvenile fish surveys (39 stations x 6 months) and 63 adult fish surveys (9 stations x 7 months) were made and no oil was observed in trawls conducted adjacent to the Delaware shoreline. Striped bass young of year surveys conducted by NJDEP were also monitored. As part of annual effort in the Delaware River since 1980, thirty-two fixed stations are sampled twice a month from June through November. During the 2005 seining surveys, some type of oil was observed at most stations from Raccoon Creek to Eagle Point (NOAA 2006). During warm and hot days, small (dime-sized or smaller) oil globules were observed in the shallow waters. These globules would dissipate to a sheen and eventually completely dissociate when disturbed (T. Baum, personal communication[10]).

Can small oil globules be observed along Delaware Bay shorelines in the absence of an oil spill?

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[8] Samples were also collected three days after the incident at Claymont/Oldmans Point and Pea Patch Island, and showed no significant toxicity to amphipods (*Leptocheirus plumulosus*) relative to control in 10-day whole sediment toxicity tests (endpoint: survival) (EA Engineering 2005a). The "one month" sample was collected 19 days after the incident on December 15, 2004 and the "three month" sample was collected 83 days after the incident on February 17, 2005. In calculations, the exact date is used.

[9] While the presence of oil was confirmed in the Tinicum Island sediment samples based on sheening and odor, laboratory chemistry data for PAH compounds are not available for these samples (EA Engineering 2005b, 2005c). Association with the spill is based on physical proximity to the incident site, compared to the Claymont and Pea Patch island samples. The sediment toxicity test does not specify the cause of toxicity, which may have been PAH-induced narcosis, smothering, or some other process including pre-existing contamination.

[10] Mr. Tom Baum, NJDEP.

Twenty-three dredge tows were made in the upper Delaware Bay on 18 March 2005 by DNREC to collect and observe horseshoe crab and knobbed whelks. Sampling was conducted by removing all live horseshoe crabs and whelks from half of the dredge contents. Live horseshoe crabs and whelks in the samples were counted and examined for the presence of oil. In 23 tows, a total of 136 horseshoe crabs and 477 knobbed whelks were examined. No oil was observed.

2 INJURY DETERMINATION

Multiple lines of evidence indicate that aquatic resources have been injured by the *Athos* oil spill. Under Oil Pollution Act of 1990 (OPA) regulations, injury is defined as "an observable or measurable adverse change in a natural resource or resource service".[11] To make the determination of injury, Trustees must also evaluate if an injured natural resource has been exposed to the discharged oil, and a pathway can be established from the discharge to the exposed natural resource.[12]

As noted above, aquatic resources clearly were exposed to *Athos* oil. Nearly 265,000 gallons of crude oil were spilled directly into the Delaware River. SCAT data document the presence of spilled oil along 280 miles of shoreline in the mainstem of the Delaware River. Substantial additional oiling was noted in tributaries. Submerged oil was confirmed in locations near the discharge origin in the first two weeks following the incident, using Vessel-Submerged Oil Recovery System (V-SORS) monitoring. Additionally, two trenches containing pooled oil were found near the discharge site, covering an approximate area of 317 square feet. Snare samplers were deployed at various locations within the Delaware River, and confirmed the presence of oil following the spill. Geographic (i.e., proximity to the spill source) and temporal trends in V-SORS and snare data are consistent with aquatic resource exposure to spill-related oiling. Tarballs, tarmats, and similar products of discharged oil have been observed and collected that, based on Coast Guard analysis, appear to be associated with the *Athos* incident.[13]

Analysis of available data confirms spill-related impacts to some aquatic resources, and negligible or no impacts to others.

- Impacts to sediment-dwelling organisms - As noted above, sediment samples collected in the vicinity of Tinicum Island approximately one month and three months after the incident were toxic to amphipods on both dates (as indicated by control-adjusted survivals of 39 and 62 percent, respectively), while samples collected at locations more distant from the spill origin were not. Observations of pooled oil on the river bottom clearly indicate some level of ecological impact. Likewise, V-SORS data indicate the presence of substantial subtidal oiling in some areas (greater than 50 percent coverage of towed snares in some cases), also

[11] 15 C.F.R. § 990.30.

[12] 15 C.F.R. § 990.51.

[13] Some samples analyzed by the Coast Guard appear to be from other, non-Athos sources.

consistent with some level of ecological impact. We don't believe this is confirmation of spill-related impacts. It may be, but there is no confirmation this is between-site variation, between-sampling variation, or an unrelated source of contamination in a single sample. The area sampled is known to have high and variable levels of background PAH contamination.

- Water column toxicity - Using chronic toxicity thresholds based on the narcotic potency of various PAHs to benthic aquatic organisms (Neff *et al.* 2005), two of 66 samples (at Marcus Hook and downstream of the mouth of the Schuylkill River) had exceedances, for both alkylated chrysenes and alkylated phenanthrene/ anthracenes. This is more likely particulate oil in a whole oil sample. Because the dissolution for this oil is so low, these samples did not likely have dissolved fractions that were near the levels indicted above. The dissolved fraction is responsible for aquatic toxicity. The NRDA SIMAP model did not indicate aquatic toxicity would occur.

- Impacts to fish and bivalves - With respect to contamination-related risks to fish and shellfish themselves, all fish and oyster PAH concentrations were below the level of concern (3.8 µmol PAHs/g lipid) for PAH-induced narcosis (DiToro *et al.* 2000). While 23 dead fish were collected following the spill, available information is insufficient to determine if these fish died because of oiling or died prior to the spill and were subsequently oiled. Were the 23 dead fish oiled? It is likely many hundreds of people working along the shorelines could find a similar number of dead fish in the absence of a spill.

- Impacts to piscivorous wildlife - With respect to potential impacts to fish-eating wildlife that might consume contaminated fish and shellfish, total PAH concentrations in fish and oyster tissue samples were below the relevant threshold of concern (i.e., a benzo[a]pyrene threshold of concern for dietary exposure in piscivorous mammals (Sample *et al.* 1996)).[14,15]

- Human health risks associated with consumption of fish - Although analysis of human health risks are outside of the scope of natural resource damage assessments (and addressed through other regulatory authorities), we note that PAH concentrations found in fish and shellfish were below levels used for setting consumption advisories.

[14] Total PAH concentration is used as a conservative substitute for calculating benzo[a]pyrene toxicity equivalents.

[15] A comparable published threshold in prey is not available for piscivorous birds. However, diet studies in mallards indicate that a chronic (7-month) exposure to a diet containing 4,000 mg PAH/kg food produced only the sub-lethal effect of increased liver weight (Eisler 2000). Given the significantly lower potential food-chain exposure associated with this spill (i.e., maximum observed prey concentration of approximately 1 mg PAH/kg food), risks to birds arising from PAH levels in fish and oyster tissues consumed by birds are negligible.

3 INJURY QUANTIFICATION

3.1 Overview

Habitat equivalency analysis (HEA) was used to quantify aquatic resource injuries. The principal concept underlying the HEA method is that lost habitat resources/services can be compensated through habitat replacement projects providing additional resources/services of the same type (NOAA 2000).

We have not seen the spreadsheet HEA model file for Aquatic Injury and cannot comment in that regard. We produced a HEA using the trustees variables and could only derive 85 lost discount service acre-years and not 97 as reported by the trustees.

Under the HEA method, Trustees determine the injury with metrics that can be used to scale appropriate compensatory restoration options. The size of a restoration action is scaled to ensure that the present discounted value of project gains equals the present discounted value of interim losses. That is, the proposed restoration action should provide services of the same type and quality, and of comparable value as those lost due to injury (NOAA 2000).

This report presents the Trustees' quantification of injuries to aquatic resources. Appropriate restoration alternatives will be scaled to this injury and evaluated in the Damage Assessment Restoration Plan (DARP). Under the HEA method, the injuries are quantified in terms of the percent loss of ecological services (compared to baseline levels) and the rate at which the lost services recover over time. Injury (percent service loss) is calculated for each year (or month) following the incident, with consideration of any restoration actions or natural recovery. Service-acres are calculated for each year, with a service-acre defined as the percent service loss multiplied by the area of the injury. Future (and past) losses are discounted relative to the current year, similar to investments, to provide discounted service-acre-years (DSAYs). These are summed from the beginning of service loss until recovery, to provide a present-day calculation of total injury.

The injury quantification is focused on potential impacts to sediment-dwelling biota, for several reasons. Field data confirm that benthic resources were exposed to and impacted by spilled oil. The characteristics of the spilled oil (a heavily biodegraded crude oil) and its behavior in the environment (e.g., tendency to adhere to sediments and not refloat) suggest that potential benthic impacts are of particular concern. In addition, sediment-dwelling biota are a key component of the aquatic food web, as they are an important source of energy for fish and aquatic-dependent wildlife. Finally, as discussed in the following sections of this report, substantial data are available that can be used to help quantify potential spill-related impacts to sediment-dwelling biota.

A multi-step process was used to apply the HEA methodology to aquatic resource injury quantification for this spill. First, we evaluated the spatial extent of injury. Next, we estimated baseline services, considering the potential impacts of background contamination. We then estimated service losses for different periods following the spill and develop a recovery curve for the impacted area. Finally, HEA calculations were performed using relevant inputs from the above analyses to estimate aquatic resource losses using a discounted service acre years (DSAY) metric.

The paragraph below should be part of the paragraph at the top of the page as it is another reason why only injuries to sediment dwelling organisms are being pursued.

Although the Trustees also considered quantifying injuries to other aquatic resources, in addition to sediment-dwelling organisms, available information suggests ~~such injuries likely are limited in magnitude.~~ injuries to these resources, if they occurred, are not likely measurable and observable since they are limited in magnitude. As noted in the previous chapter, comparison of PAH concentrations in post-spill water samples to relevant PAH toxicity thresholds suggests low risk to aquatic organisms. Likewise, spill-related risks to fish (based on tissue concentrations and collections of oiled, dead fish) and piscivorous wildlife (arising from dietary exposure to PAH-contaminated prey) appear to be low.

3.2 Spatial Extent of Injury

SCAT shoreline oiling data capture the movement of spilled oil in the days and weeks following the *Athos* incident. To estimate the spatial extent of injury, we made the simplifying assumption that subtidal impacts were most likely found in areas adjacent to heavy shoreline oiling, for several reasons. First, such areas are generally near the spill origin and depositional, based on information provided in Sommerfield and Madsen (2003). V-SORS tows in the vicinity of Tinicum Island, an area generally adjacent to or slightly downstream from heavily oiled shoreline locations, resulted in substantial oiling of towed snares, while tows near areas further from the spill origin and exposed to less shoreline oiling generally resulted in little to no oiling of towed snares. Toxicity testing conducted on sediment samples taken approximately one month and three months after the incident from a heavily oiled location near Tinicum Island found statistically significant ~~effects~~ differences, while testing from two other subtidal sediment locations with much less exposure to spilled oil did not.

However, the data are insufficient to determine whether or not the statistical difference in survival is due to a significant spill effect and subsequent recovery, or natural variability in the area sampled. This area has high background contamination and it is not possible to tell from a single sample on each date whether or not the differences are a result of spatial differences in background PAH contamination.

Operationally, injured areas were delineated using a Geographic Information System (GIS) computer program. Injury "polygons" were delineated from the waterward edge of the intertidal zone to the 18' depth contour in areas adjacent to heavily oiled shoreline locations (Figure 1). Use of the 18' depth contour as a boundary reflects the observation that the highest concentration samples from the September 2005 sediment sampling were found at depths shallower than 22'.[16]

[16] Readily available contours for GIS mapping are the 18' and 40' depths. All samples above 10 ppm from within the mainstem of the Delaware River were at a depth of 22' or less. Portions of the heavily oiled areas were

Using high concentrations of background PAH contamination in samples to define the area injured by the ATHOS is not appropriate. Using heavily oiled shoreline data to infer offshore injury is also not supported by evidence.

The Shoreline Assessment Team quantified injuries to shoreline resources, including intertidal habitats (Shoreline Assessment Team 2006). To ensure consistency in the delineation of the intertidal-subtidal boundary used in the shoreline and aquatic injury quantification analyses, and therefore avoid potential double-counting, injury polygons from both analyses were compared and the aquatic injury polygons adjusted as necessary to remove any overlap.

We did not delineate injury polygons inside the Delaware River navigational channel, although the presence of oiling on both shorelines clearly indicates cross-river movement of oil. We made this assumption primarily because benthic communities are not expected to be robust in the navigational channel due to annual dredging. In addition, September 2005 sediment samples collected in the channel several months after the spill but prior to the first post-spill dredging event did not exhibit substantial oiling. For these reasons, potential spill-related impacts in the navigational channel are expected to be limited.

This approach results in an estimated area of impact of 412 acres. Overall, we believe this estimate of spatial extent of impact makes appropriate use of available data and is well within reasonable bounds given the volume of oil spilled, documented indications of subtidal oiling and available sediment toxicity testing information. While we recognize that some subtidal areas adjacent to heavily oiled shoreline may not have been injured by the incident, other subtidal areas adjacent to shoreline habitat exposed to less oiling may have been injured. This approach clearly avoids double-counting with shoreline injury quantification, and takes into account the potential for physical smothering effects as well as oiling-related toxicity.

3.3 Service Loss and Recovery

To develop service loss estimates, we first evaluated the baseline condition of benthic resources in the study area. In light of baseline conditions, we developed estimates of spill-related service losses approximately one month, three months and ten months after the spill, and ultimately developed a recovery curve from these "anchor" points.[17]

3.3.1 Baseline Service Loss

Two broad sediment PAH studies were completed in the Delaware River in the ten years preceding the *Athos* incident. Under the Environmental Protection Agency Environmental Monitoring and Assessment Program (EMAP), PAH data for 2000 and 2001 are available for the Delaware River and Delaware Bay. However, EMAP sampling sites near the spill origin were

mapped to 22' manually, with a negligible increase in area (approximately one percent) compared to the 18' calculation, due to the steep slope at depths greater than 18'. Therefore, the 18' contour was used for the calculation.

[17] The HEA calculations are summed from a daily basis, and so the exact dates for the anchors (19 days, 83 days, and 295 days) are used in the calculations.

located in tributaries (Christina and Schuylkill rivers) and in the navigation channel, and so are unlikely to be representative of conditions in the mainstem Delaware River.[18]

In 1997, NOAA completed a broad triad study throughout the Delaware River and Bay to examine the spatial extent and severity of sediment toxicity (Hartwell *et al.* 2001). Sediment chemistry data, including total PAHs, as well as various toxicity tests and benthic invertebrate population studies, were conducted at 81 sites from the Delaware River at Trenton, NJ to the mouth of the Delaware Bay and adjacent open ocean.[19] Seventeen sites, described as the "mid-river region" are located in the mainstem of the river in the areas closest to the incident (Raccoon Creek to Petty's Island).[20] The average total PAH concentration for these 17 sites was 3.4 ppm (standard deviation 2.4 ppm, maximum 8.2 ppm tPAH and minimum 0.3 ppm tPAH). Average control-adjusted survival of amphipods (*Ampelisca abdita*) was 90.1 percent in 10-day mortality tests using sediments from these sites. These data suggest that amphipod populations were slightly depressed (i.e., by 10 percent) in the study area prior to the *Athos* spill. Based on these data, we make the simplifying assumption that a 10 percent reduction in benthic service levels is associated with baseline conditions (i.e., conditions that would have existed in the absence of the spill).

In our view, it is reasonable to rely on amphipods as an indicator organism for benthic service loss estimates due to the prevalence of data regarding their sensitivity to PAHs and the presence of these organisms in the Delaware River. Amphipods (most commonly *Gammarus tigrinus*) were often found in Delaware River sediment samples taken as part of the 1997 NOAA study (Hartwell *et al.* 2001).[21] We use amphipod mortality as our endpoint due to the wider availability of data for that endpoint and because we often see a strong relationship between contaminant concentrations and 10-day amphipod toxicity tests at other sites. In addition, data from studies conducted at other PAH-contaminated sites show that this endpoint is generally as sensitive as growth and/or reproduction of marine and estuarine amphipods at PAH-contaminated sites (Farrar *et al.* 2005).

Finally, we note that our baseline service loss estimate derived from the 1997 site-specific data from the NOAA study is also generally consistent with information from a larger database of matched sediment chemistry and toxicity data collected from industrialized waterways from around the country. This finding provides additional support for the use of a 10 percent baseline service loss estimate. See Appendix A for more information.

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[18] For completeness, we note that mean and median PAH concentrations for the eight EMAP samples located in the Christina River, the Schuylkill River and the Delaware River navigation channel, are 2.8 ppm and 1.5 ppm, respectively.

[19] Four separate toxicity tests were conducted: 10-day amphipod mortality using *Ampelisca abdita*, sea urchin fertilization impairment, Microtox, and induction of the cytochrome p450 1A1 gene.

[20] Eighteen sites are included in the mid-river region. However, the chemistry at one site is marked by the authors as suspect, and so the site is dropped from the current analysis.

[21] Other benthic fauna commonly found in study sediment samples included various worms, midges, isopods and Asian clams and other bivalves.

3.3.2 Service Loss Estimate: 1 Month Post-Spill

Sediment toxicity data are available from a heavily-oiled site near Tinicum Island collected approximately one month after the spill. Amphipod control-adjusted survival was 39 percent. Based on these data, we assume a 61 percent service loss (i.e., reduction in benthic productivity) one month after the spill to the estimated 412 acre area of impact (see Section 3.2 above). However, for reasons described in the previous section, baseline conditions are associated with an approximately 10 percent service loss, which we subtract from 61 percent to arrive at a 51 percent, spill-related service loss one month post-spill.

What the standard deviation of survival in the Hartwell study? What were the minimum survival results? Were the survival tests conducted in the same way and were the post-spill results within the overall range reported by Hartwell?

If we follow the assumption that approximately 10% of the 265,000 gallons of oil ended up on the bottom of the river, this equate to 160 gallons of PAH at 0.6%. The sediment sampler grabs the top inch or so of sediment. The trustees assume the ATHOS oil is associated with PAH of bottom sediments that equate to a 51% loss of services immediately following the spill. The trustees also assume a background PAH of 3.2 ppm is associated with a 10% service loss. Figure A-2 indicates that an overall service loss of 60 percent assumed by the trustees after the spill would result from sediment concentrations of over 100 ppm. There is not enough PAH in the entire volume of spilled oil from the vessel to raise the top inch (2.54 centimeters) of 412 acres from 3.2 ppm to 100 ppm.

3.3.3 Service Loss Estimate: 3 Months Post-Spill

Sediment toxicity data also are available from the site near Tinicum Island approximately three moths after the spill. Amphipod control-adjusted survival was 62 percent. Based on these data, we assume a 38 percent service loss (i.e., reduction in benthic productivity) three months after the spill to the estimated 412 acre area of impact. We subtract a 10 percent service loss to account for baseline resource conditions, and therefore arrive at a 28 percent, spill-related service loss three months post-spill.

Using a result from a single sample in an area with high and variable background PAH contamination is not technically sound. The maximum service loss could be estimated using a mass balance approach in the manner.

3.3.4 Service Loss Estimate: 10 Months Post-Spill

Subtidal sediment sampling was conducted in September 2005 to evaluate the potential extent of oiling 10 months after the release. A random stratified sampling plan was developed to collect samples that would be statistically representative of specific areas. For the depositional areas, a spatial grid was imposed to ensure coverage throughout the area, and a random location was chosen within each grid cell. Such an approach maximizes the ability to estimate the areal extent of contamination from the data. In the navigational channel, samples were collected at regular intervals in the study area. Samples from non-depositional areas are spread roughly evenly throughout the study area. Prior to collection, specific GPS "target" coordinates were identified for each sample. In total, 162 sediment samples were collected between upstream of the Schuylkill River and downstream of the Delaware Memorial Bridge, covering approximately 20,000 acres (30 square miles).

Screening PAH concentrations were determined for all samples using an ultraviolet fluorescence method (IEc and MESL 2005: See Appendix D). For twenty of the sediment samples, complete laboratory PAH and total organic carbon analyses were conducted.[22] The results from the laboratory were used to estimate total PAH concentrations (i.e., based on the levels of the 13 parent PAHs) from the screening PAH concentrations for the remaining dataset. Table 3 shows the estimated total PAH concentration at each sampling site. See MacDonald *et al.* (2005: See Appendix C) and IEc and MESL (2005: See Appendix D) for more information on the September 2005 sampling plan and results.

Overall, we found these data indicative of low levels of service loss at the time they were collected. Consistent with this general finding, we assigned a 10 percent spill-related service loss to the injured area 10 months after the spill. Our rationale underlying this approach is summarized below.

First, the September 2005 sediment data strongly suggest that substantial spill-related impacts were not present 10 months after the spill. Survey and analysis teams did not visually observe oiling residues in any of the 162 samples collected that might suggest ongoing ecological risks associated with physical, smothering effects. In terms of tPAH levels, for the 20 samples analyzed in the laboratory, the average total PAH (NS&T) concentration was 5.2 ppm (standard deviation 3.7 ppm, maximum 13.5 ppm and minimum 0.9 ppm tPAH).[23] For the entire 162 sample data set, the estimated average total PAH (NS&T) concentration was approximately 2.8 ppm (standard deviation 2.9 ppm, maximum 19.6 ppm and minimum 0.2 ppm tPAH).

While comparisons to available background data from Hartwell et al. (2001) need to be undertaken cautiously, tPAH concentrations generally are similar (average tPAH concentration for the 17 Hartwell sites was 3.4 ppm, standard deviation 2.4 ppm, maximum 8.2 ppm and minimum 0.3 ppm tPAH). Thus, across the entire study area, sediment tPAH levels 10 months after spill are difficult to distinguish from available pre-spill sediment tPAH concentrations (recognizing that pre-spill data were collected several years prior to the spill and include almost an order of magnitude fewer samples).

However, as noted previously, the area of impact estimated for this injury quantification analysis (412 acres) is defined to include those areas expected to be exposed to the greatest amount of oiling. Given the difficulty in precisely identifying such locations to estimate the total

[22] The 20 samples analyzed in the laboratory included 6 of the 15 samples with the highest screening concentrations (>100 ppm tPAH), 6 of the 11 samples with the next highest screening concentrations (>35 ppm tPAH, <100 ppm tPAH), 4 of the 21 samples in the >15 ppm but < 35ppm tPAH category, and 4 of the 116 samples with screening concentrations < 15 ppm tPAH.

[23] As noted above, the subset of samples sent for laboratory analysis was not randomly selected; selected samples reflected a range of expected contamination levels (based on field screening data), although included a greater-than-proportional number of highly contaminated samples.

area of impact, we make the reasonable, simplifying assumption that they are found near heavily oiled shorelines. The September 2005 data suggest that sediment samples collected 10 months after the spill within the segment of the Delaware River exposed to heavy shoreline oiling generally have higher tPAH concentrations than sediment samples from areas further from the spill origin, although none of it can be attributed to the ATHOS oil. For example, 12 of the 15 sediment samples (80 percent) with the highest estimated tPAH concentrations were from the river segment that includes heavily oiled shoreline locations (and the majority of vessel traffic, oil refineries and storage facilities in the region), although only about 55 percent of the sediment samples were collected from that river segment. Estimated average tPAH concentrations for samples from the river segment including heavily oiled shoreline locations were approximately 50 percent higher than those collected from locations more distant from the spill origin (3.3 vs. 2.1 ppm).

The analytical data do not support this conclusion and indicate the reason for higher PAH in the samples is due to higher background concentrations and not ATHOS oil.

In addition, we note that the estimated 412 acre area of injury represents less than five percent of the total area sampled in the September 2005 field study. The most contaminated five percent of September 2005 samples have estimated tPAH concentrations exceeding 9 ppm, a level associated with toxic effects to amphipods (control-adjusted mortality of approximately 20 to 25 percent) based on both Hartwell et al. (2001) and national whole sediment chemistry – toxicity data sets (see Figure A-2 in Appendix A). These data sets also suggest if the spill was responsible for adding even a few ppm tPAH at such locations, spill-associated increases in amphipod mortality would be modest but measurable.

The data indicate that the spill could only have added 10% or less, if any at all, which does not warrant a 51% service loss attribution.

Equilibrium partitioning and narcotic potency calculations for the 20 sample subset of the 2005 field effort submitted for laboratory analysis (Greene 2005c: See Appendix E) also are consistent with low toxicity risks. The equilibrium partitioning analysis first partitions PAH mass between the sorbed phase (carbon coating on sediment particles) and the dissolved phase (sediment pore water). The dissolved phase concentrations are then compared to the acute narcotic toxicity for the individual compounds. The ratios for the individual compounds are then summed to produce acute toxicity units. Finally, chronic toxic units are estimated as acute toxic units divided by an acute to chronic ratio from the literature. A toxic unit greater than one indicates that the PAH exposure concentration in the sediment pore water exceeds the narcotic toxicity threshold for benthic aquatic organisms. Sample 82, near Tinicum Island, was predicted to be chronically toxic to benthic organisms based on the equilibrium partitioning-based calculations. Two additional samples (Sample 8, between Woodbury Creek and Big Timber Creek, and Sample 18, near the mouth of the Schuylkill River) had chronic toxicity units just below 1.

Thus, in our view the September 2005 sediment data suggest that longer-term risks from PAH toxicity are limited, but not absent in areas of highest concentrations. In addition, it is reasonable to expect that benthic communities were continuing to recover from the initial, substantial reduction in productivity that occurred in the first few months following the spill.

Overall, in light of this information, we believe it is reasonable to assign a 10 percent, *Athos* spill-related service loss 10 months after spill to the relatively limited subtidal areas believed to be most exposed to *Athos* oiling. While impacts may be higher at some locations, we need to account for reductions in benthic productivity associated with baseline conditions, and so chose what we believe to be an appropriately modest level of spill-related service loss 10 months after the spill.

3.3.5 Service Loss Recovery Curve

Figure 3 shows the recovery curve used in our analysis, and is based on linear extrapolation and interpolation around the "anchor" points described above (i.e., service losses one month, three months and ten months post-spill). The curve has two linear portions: from immediately following the incident until Month 3 and from Month 3 through Month 10, continuing at the same slope until service loss is zero. The curve suggests that baseline conditions (i.e., no spill-associated service losses) are reached in 14 months, which is generally consistent with a substantial impact on productivity in the months immediately following the spill, and the need for some additional generations of benthic biota (many of which turn over every few months) to recover from the initial impact and likely low levels of longer term toxicity.

4 SUMMARY OF RESULTS

HEA inputs and results are summarized in Table 4. The basis for most of the inputs has been described in previous portions of this document. The discount rate of three percent used in HEA calculations is a standard figure used in natural resource damage analyses. As indicated in the table, HEA calculations based on the identified parameters result in an injury of 97 discounted service acre years (DSAYs). A separate report will identify and evaluate the type and size of restoration project(s) best suited to compensate for this loss.

Overall, we believe this analysis makes reasonable use of incident-specific data as well as relevant information from technical literature to quantify spill-related injuries to aquatic resources. We considered alternative injury quantification approaches, including use of mass balance calculations to estimate the concentrations of tPAH that might have been deposited by the spill in aquatic sediment. Preliminary mass balance calculations were performed in Donlan *et al*. (2005) (see Appendix 2), and suggest that the spill could have contributed levels of PAHs consistent with the analysis presented in this document. However, in our view such an approach will not lead to a more precise or otherwise enhanced quantification of injury compared to that presented in this document, due to substantial uncertainties in key mass balance parameters (e.g., the volume of spilled oil to which subtidal sediments were exposed, the depth to which spilled oil penetrated sediments in the months following the spill, the area of exposure, etc.) and the inability of such an approach to address the potential physical impacts associated with the heavy crude oil spilled in this incident.

Finally, the Trustees considered undertaking additional analyses to inform the injury quantification process, including chemical "fingerprinting" analyses. The Trustees note, for example, that the RP submitted a preliminary fingerprinting evaluation of the twenty 2005 sediment samples submitted for laboratory analysis (Challenger 2006). While the Trustees have technical concerns with the preliminary fingerprinting evaluation (e.g., limited number and uncertain representativeness of reference samples, uncertain explanatory power of the regression used in the analysis, and complexities introduced by substantial inter-sample variability), we note that the injury quantification presented in this document already assumes a modest spill-related injury 10 months after the spill. In the Trustee's judgment, further analysis on this or other topics is not warranted given the relatively modest injury quantification and limited likelihood that additional time, effort and expense will substantially improve the precision of associated estimates.

The source allocation information on the specific samples used by the trustees to estimate the injury area and magnitude indicate with substantial certainty that the fingerprint in the samples does not belong to the ATHOS I. The trustees do not present a sufficient technical argument to discount this conclusion. Did Newfields Environmental Forensics, the trustee's consultant, provide technical assistance to the trustees in rendering the conclusions regarding source allocation presented above? Can the responsible party inquire directly with Newfields regarding the source allocation analysis?

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Figure 3
Projected Recovery Curve for Subtidal Injury