FINAL

TECHNICAL MEMORANDUM
ECOLOGICAL RISK ASSESSMENT
MARTIN STATE AIRPORT
Middle River, Maryland

LOCKHEED MARTIN

Tetra Tech
Environmental Engineers & Scientists
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Final Technical Memorandum
Ecological Risk Assessment
Martin State Airport
Middle River, Maryland

July 2004

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1.0 INTRODUCTION

On behalf of Lockheed Martin Corporation, Tetra Tech has prepared this Technical Memorandum presenting the purpose, methods, and analyses proposed to address the potential for ecological risk at Martin State Airport (MSA), Middle River, Maryland, as required by Maryland Department of the Environment (MDE). This memorandum was finalized based on comments received from Maryland Department of the Environment (MDE) dated June 18, 2004. The overall objectives of the ecological risk screening approach are to characterize the ecological habitat, identify the ecological receptors of concern (ROC) and constituents of potential concern (COPC), so as to assess potential risks to the environment. This approach will provide a determination whether a risk to the ecological habitat or receptors is sufficient to require further evaluation or potential mitigation.

The following Memorandum summarizes our approach for evaluating ecological risks that might result from potentially contaminated soil, sediments or groundwater at MSA, based on environmental data collected from the Site. Following EPA's guidance for ecological risk assessment (ERA) under CERCLA and Superfund (USEPA, 1997) as well as EPA's latest guidance (USEPA, 1998), this Memorandum addresses a screening ERA initially, in which relatively conservative assumptions are used to evaluate potential risks to a wide range of relevant receptors. A finding of potential risk in this screening ERA does not necessarily imply actual risks to biota. Such a result may necessitate further evaluation and use of more site-specific exposure data to address uncertainties (stemming from the conservative assumptions used to evaluate risk), and to develop a more accurate assessment of risk. A finding of little or no potential for risk in this ERA, however, would provide convincing evidence that ecological systems on or adjacent to MSA are unlikely to be adversely affected by chemicals present in the soil, sediments or groundwater. The decision to proceed to any additional ERA Steps is made as a part of the risk management decisions, specifically using Scientific Management Decision Points (SMDP) built into the EPA ERA Process (USEPA, 1997).

2.0 OVERALL APPROACH

The screening level ERA comprises the first three steps of EPA's eight-step process of ecological risk assessment (Figure 1). Although MSA is not a listed Superfund site, the ERA process developed for such sites is an applicable and efficient process for assessing risks due to chemical contamination at any site. The screening level process, as applied to the MSA site, consists of the following steps:

1. Problem Formulation and Ecological Effects Evaluation;

2. Exposure Estimate and Risk Calculation;
3. SMDP to determine whether data are sufficient to make a risk decision or to go to Step 3.

This Technical Memorandum also documents a more refined food web assessment for terrestrial and aquatic receptors at the MSA site in accordance with Step 3 of EPA's ERA guidance (Figure 1).

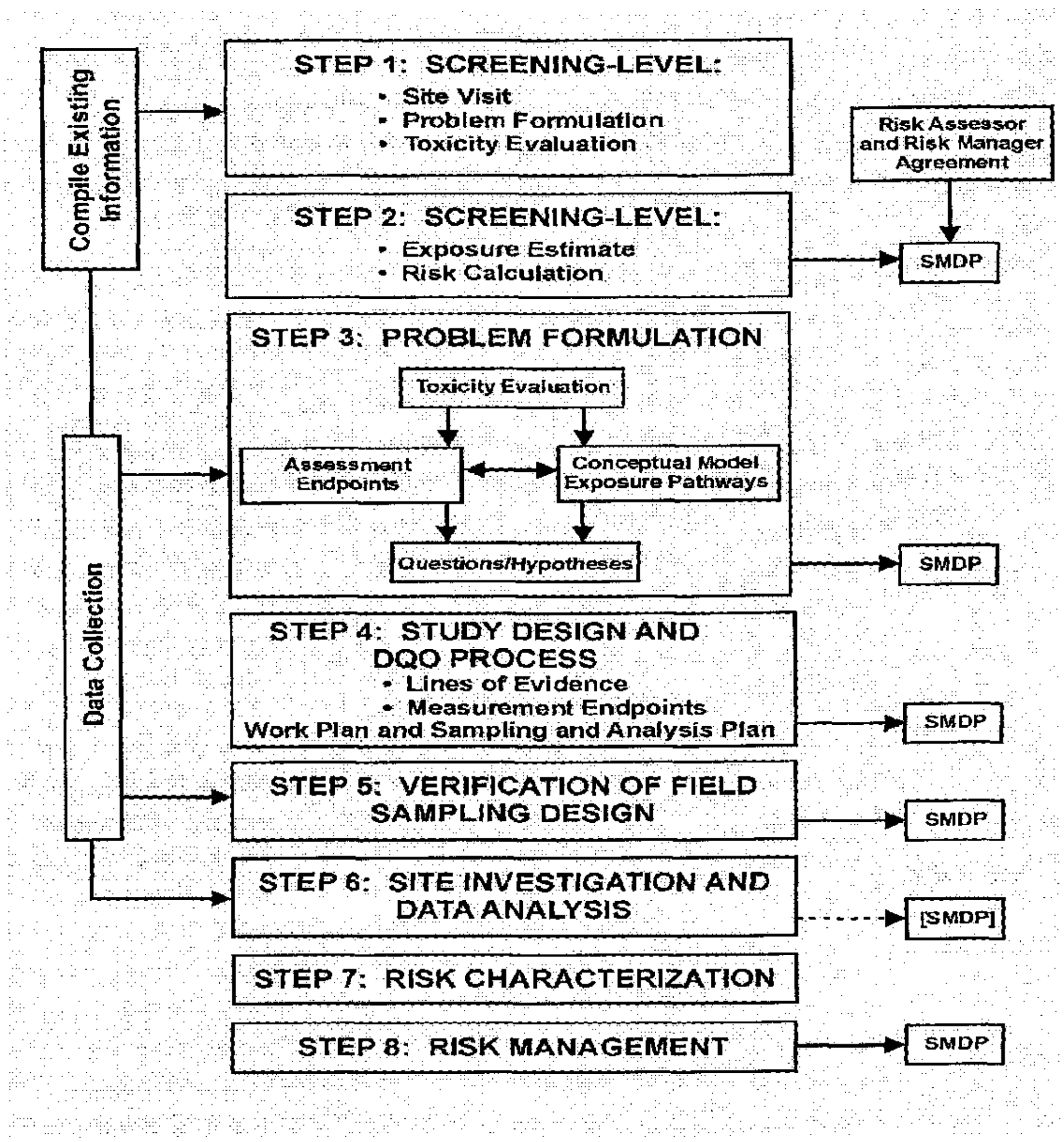

Figure 1. The EPA Eight-Step Ecological Risk Assessment Process for Superfund.

3.0 PROBLEM FORMULATION AND ECOLOGICAL EFFECTS EVALUATION

The problem formulation represents the scoping stage of all ecological risk assessments. Existing information is examined, the site visited, receptors of concern identified, a conceptual model for the site developed to identify potential exposure pathways, and preliminary assessment and measurement endpoints are identified.

Problem formulation and ecological effects evaluation consists of several elements:

- Environmental setting of the site
- Selection of receptors of concern (ROC)
- Development of a conceptual site model (CSM)
- Assignment of assessment and measurement endpoints

The details of the problem formulation are discussed below.

3.1 Environmental Setting

Tetra Tech's final report for the data gap investigation and modeling (Tetra Tech, 2004) summarizes existing knowledge of the site and much of its current setting. A site visit by Tetra Tech ecologists on November 25, 2003 was also used to gather additional pertinent information concerning habitat types present.

Plant species at MSA can be divided into four distinct habitats including field habitat, forest stand, wetland-pond margin and riparian forest. Field habitat consists of open areas with no canopy or woody plants. All of the Taxiway Tango area consists of open short grass fields between the runways and directly adjacent to the runway area. Forest stands consisting of habitat with large canopy trees and a sparse layer of herbaceous understory, make up the majority of habitat associated with the MSA site, particularly near the Drum area and the area surrounding the two ponds. The forest is mixed deciduous with white oak (*Quercus alba*) and sweetgum (*Liguidambar styraciflua*) as the dominant canopy species. Other species observed include tulip poplar (*Liriodendron tulipifera*), black cherry (*Prunus sylvatica*), and red maple (*Acer rubrum*). The understory of the forest stand consisted of several smaller trees such as flowering dogwood (*Cornus florida*), American holly (*Ilex opaca*), ironwood (*Carpinus caroliniana*) and various herbaceous species. Riparian forest differs from the other forest stands by having a dominance of black cherry trees with some pines, dogwood, and staghorn sumac. Most of the trees are younger than those in the more upland forest habitat with thicker understory vegetation. This habitat is present in the southeastern part of the site along Frog Mortar Creek. The ponds are associated with some adjacent wetland habitat consisting of the emergent plant *Phragmites* as well as sedges and some willow trees. No submerged aquatic vegetation was observed in our site visit, however, the plants have the potential for being present as these ponds are apparently fed by surface water (small stream originating to the north of the MSA site of concern) and perhaps by surficial groundwater as well. These ponds are purportedly around 5 feet deep at maximum.

Given the variety of forest, field, and aquatic habitats available, many bird species are likely to occur at MSA including geese, ducks (wading, diving, and wood ducks), herons, finches, sparrows, robins, warblers, hawks, kingfishers, and woodpeckers. Mammals such as deer, fox, moles, shrews, rabbits, woodchucks, squirrels, and raccoons are also likely to occur at this site, given the proximity to a large water body (Frog Mortar Creek), the site's relative lack of human activity, and the range of habitats available. Turtles were observed in one of the ponds during our site visit and it is likely that amphibians such as frogs are present as well. Other likely reptiles at this site include snakes (i.e. black snakes).

3.2 Receptors of Concern

Ecological ROCs are species or guilds of species that are important to the ecology of the site and that may be susceptible to chemical constituents released at the site. Selection of ROCs is systematic, representative, and ecologically-based to ensure that assessment endpoints are adequately addressed. Criteria used to identify ecological ROCs include the following:

- Presence – known or expected to occur onsite
- Susceptibility – exposure pathway is likely complete and of sufficient duration/magnitude
- Representative – of the food web and/or guild
- Data Availability – sufficient and appropriate type of toxicity and exposure information
- Societal Importance – species merits public attention

In some instances, particularly during a screening ERA, the selected ROCs represent an ecological guild (a group of species using similar resources such as food or habitats in a similar manner) (USEPA, 1997).

Ecological ROCs can be classified into three broad categories: (1) ecologically important, (2) of recreational or commercial importance, and (3) threatened and endangered species. Ecologically important species include species characteristic of certain trophic levels (e.g., primary producers, herbivores, carnivores) or species that provide a keystone role in terms of the structure or function of a given ecosystem. Species that are recreationally important would include species such as trout, deer, and crabs. In the following section, potential ROCs are discussed and rationales for their selection are provided. Both ecologically and recreationally important species are good candidates for this ERA as both are applicable. Current information suggests that threatened and endangered species do not occur at this site and so are not applicable to this ERA. Tetra Tech will contact appropriate Maryland agencies (e.g., Department of Natural Resources) to confirm whether any threatened and endangered species have been recorded at this site or in the immediate vicinity. If any species do occur, these will be added to the list of ROCs presented in this Memorandum.

Over the past 10 years, soil, sediment, and groundwater samples have been analyzed for many contaminants. Based on the wealth of data collected at this site thus far, groundwater appears to be the major pathway by which biota may be exposed to contaminants. This is consistent with the fact that the main reason for investigating the site was the presence of buried drums and not surface releases (MES, 1994). As a result, environmental sampling at this site has consistently focused on subsurface soil (1 foot depth and below) and groundwater media. Based on the types of releases that occurred historically at this site, surface soils are unlikely to harbor elevated levels of contaminants. However, as a conservative measure, this ERA will use contaminant concentrations measured at 1 foot depth (the most shallow strata that has been sampled in previous investigations) to evaluate risks to terrestrial flora and fauna resulting from soil media.

Receptors chosen for this screening ERA represent various trophic levels and habitats for which water or soil exposure of contaminants directly or indirectly is possible. For water-related pathways, these will include species representing pond plants, invertebrates, and fish, brackish water invertebrates, and aquatic birds and mammals spanning several trophic levels. For terrestrial-based exposure pathways, several avian and mammalian species will be analyzed representing small soil inhabitants, mid-size and larger animals spanning several trophic levels, and plants.

Surface Water Receptors—Surface water receptors of concern include aquatic plants and warm-water fish such as bluegills and catfish. These receptors may be impacted by COPCs in the ponds found at the site.

Freshwater Sediment Receptors—Freshwater sediment receptors of concern include benthic macroinvertebrates that may live in the sediments found in the two ponds.

Saltwater Sediment Receptors—Saltwater sediment receptors of concern include benthic invertebrates such as blue crab and polychaete worms, which could occur in Frog Mortar Creek.

Aquatic Avian Species—Numerous avian species are likely to utilize the aquatic habitats at the site. Three aquatic avian receptors of concern will be examined in this ERA including the mallard duck, representative of omnivorous receptors, the blue heron, which feeds on benthic invertebrates and fish, and the belted kingfisher, which eats fish exclusively.

Aquatic Mammalian Species—Mammals can be expected to utilize the aquatic and wetland habitat at the site. The omnivorous raccoon has been selected as a receptor that could be found near both the pond and the Creek.

Soil Receptors—Soil receptors of concern include terrestrial invertebrates and plants which could occur in the drum area as well as Taxiway Tango area.

Terrestrial Avian Species —Numerous avian species are likely to utilize the terrestrial habitats at the site. Thus terrestrial avian receptors of concern will be examined in this ERA including the American robin, representative of omnivores receptors, the morning dove, representative of herbivore receptors, and the red-tailed hawk, a carnivore.

Terrestrial Mammalian Species—Mammals can be expected to utilize the terrestrial areas, drum area, and Taxiway Tango. Three small mammals will be examined (herbivorous meadow vole, omnivorous white-footed mouse, and invertivorous short-tailed shrew) as well as the carnivorous red fox.

3.3 Ecological Conceptual Site Model (CSM)

The CSM is an end product of the Problem Formulation within Step 1 (Figure 2). It contains a description of the physical and ecological characteristics of the site, potential exposure scenarios, ROC, and assessment and measurement endpoints.

A major element in a CSM is a description of the exposure scenarios. This consists of four elements.

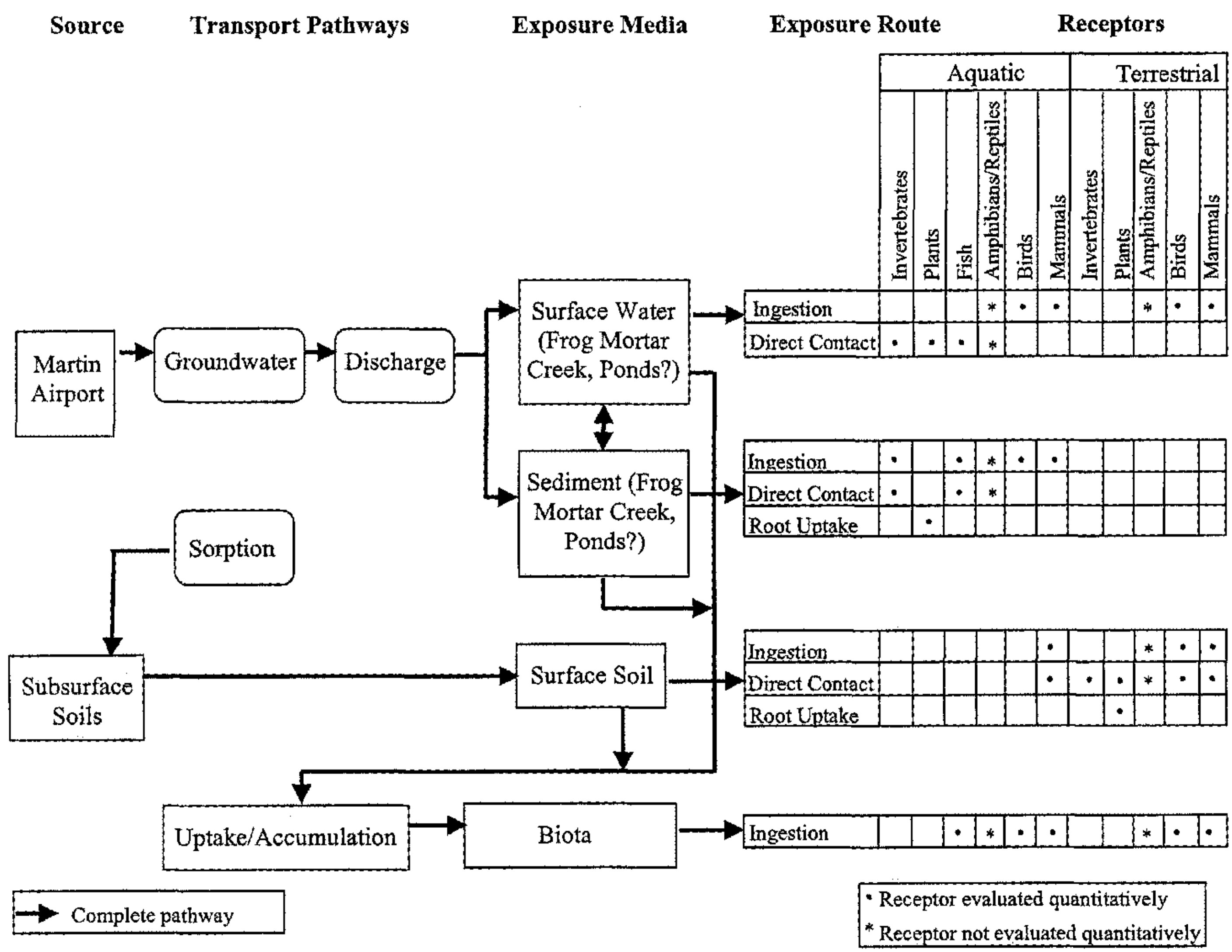

Figure 2. Conceptual Site Model for Martin State Airport.

- Source of COPC release and release mechanism(s)
- Transport medium and mechanism of transfer from primary to subsequent media
- Point (or area) of potential ROC contact with the COPC
- Route of uptake by the ROC (bioconcentration, ingestion of soil, sediment, or food)

As mentioned previously, although groundwater is believed to be the major transport path of contaminants at the site, terrestrial pathways are included as well. Ecological receptors can be exposed to groundwater only through exposure in surface water to which groundwater flows. The majority of the groundwater flow is likely to reach ecological receptors via sediments and water in the two ponds on site and perhaps Frog Mortar Creek, adjacent to the site. Results of groundwater modeling analyses will be used to locate areas of greatest potential exposure near the creek. Ponds and creek surface water sampling in these areas will be used to estimate potential concentrations of COPCs to be used in risk analyses. Thus, biota might be exposed via direct contact with contaminated sediments or water in the ponds and in the Creek. Terrestrial receptors may be exposed via direct contact with contaminated soils or indirectly through uptake within the food chain.

In addition to direct contact to contaminated water or soil, biota may be exposed to COPCs sequestered in secondary source material that may be released via several mechanisms, including incorporation into the food web. Through the process of trophic transfer, or trophic magnification in the case of bioaccumulative COPCs, biota can serve as vectors for COPC transport up the food chain and expose higher level animals through ingestion. Piscivorous birds, the omnivorous raccoon, and avian and mammalian predators that eat small mammals are species that could show such effects and these will be evaluated.

Thus, exposure pathways and routes examined in this screening ERA include:

- Direct Contact with Surface Water—This route of exposure is applicable for aquatic plants and animals that live in the water column.

- Direct Contact with Sediment—Applicable for benthic organisms that live in sediment.

- Ingestion of Food by Aquatic Birds and Mammals (i.e., plants and biota that have taken up constituents from sediment and surface water)—Omnivores and predators that forage in the aquatic habitats may ingest plants or animal prey that have bioaccumulated COPCs from sediment and surface water.

- Incidental Ingestion of Sediment or surface water by Aquatic Birds and Mammals—Herbivores and predators that forage in the aquatic habitats may incidentally ingest some sediment or surface water with their food.

- Direct Contact with Soil—This route of exposure is applicable for terrestrial plants and animals.

- Ingestion of Food by Terrestrial Birds and Mammals (i.e., plants and biota that have taken up constituents from the soil) —Predators and their prey that forage in the site area may ingest plants or animal prey that have bioaccumulated COPCs from the soil.

- Incidental Ingestion of Soil by Terrestrial Birds and Mammals—Receptors that forage in the site area may incidentally ingest some soil with their food.

Based on available information, there are complete exposure pathways for sediment, surface water, and soil (including shallow subsoils) at this site. From these environmental media, some COPCs could bioaccumulate in plants and prey animals that may be eaten by other consumers.

3.4 Assessment and Measurement Endpoints

USEPA (1998) guidance stresses the importance of ecologically significant endpoints. The selection of assessment endpoints is based on the fundamental knowledge of the local ecology. Based on the ROCs observed during the site visit, existing habitat, and the above observations, the following ecological assessment endpoints are defined (Table 1):

1. Protection of aquatic organisms that live in the water column in the ponds and the Creek adjacent to the site by determining that COPCs in these media do not have adverse effects on survival, growth, and reproduction.

2. Protection of benthic organisms that live in the sediment in the ponds and Creek adjacent to the site by determining that COPCs in these media do not have adverse effects on survival, growth, and reproduction.

3. Protection of birds, represented by the omnivorous aquatic mallard duck, the carnivorous heron, and the piscivorous aquatic belted kingfisher, by determining that ingestion of COPCs in food items and sediment does not have unacceptable adverse impacts on survival, growth, and reproduction of higher trophic levels.

4. Protection of mammals, represented by the omnivorous aquatic raccoon by determining that ingestion of COPC in food items and sediment does not have unacceptable adverse impacts on survival, growth, and reproduction of higher trophic levels.

5. Protection of terrestrial organisms that live in the soil, by determining that COPCs in the soil do not have adverse effects on survival, growth, and reproduction.

6. Protection of birds, represented by the invertivore/omnivore American robin, the herbivorous morning dove, and the carnivorous red-tailed hawk, by determining that ingestion of COPCs in food items and soil does not have unacceptable adverse impacts on survival, growth, and reproduction of higher trophic levels.

7. Protection of mammals, represented by the herbivore, meadow vole, the omnivore, white-footed mouse, the invertevore, short-tailed shrew and the carnivore, red fox, by determining that ingestion of COPC in food items and soil does not have unacceptable adverse impacts on survival, growth, and reproduction of higher trophic levels.

Measurement endpoints are measurable ecological characteristics that are related to the assessment endpoints (USEPA, 1998). Because it is difficult to "measure" assessment endpoints, measurement endpoints were chosen that permit inference regarding the above-described assessment endpoints. Measurement endpoints selected for this risk assessment include (Table 1):

- Media Chemistry for Surface Water—The measurement of chemical constituent concentrations in surface water provides the means, when compared to water quality criteria, for drawing inferences regarding the protection of aquatic organisms that live in the water column. On July 7, 2004, two surface water samples were collected in Frog Mortar Creek, in areas close to the site that the model predicted have the highest groundwater contributions. These samples were analyzed for the same chemicals as in groundwater: total and dissolved metals, VOCs, and SVOCs. In addition, one surface water sample was collected on July 7, 2004 from each of the two ponds on the site and analyzed for the same constituents.

Table 1. Screening Level Ecological Risk Assessment Endpoints at Martin State Airport.

Assessment Endpoint	Null Hypothesis	Measurement Endpoint	Specifics of Assessment
Ecological health of aquatic water column communities	Surface water does not exhibit a detrimental effect on aquatic plant and organism survival and growth	Evaluation of surface water chemistry with respect to water quality criteria	• Comparison of surface water concentrations to water quality criteria.
Ecological health of benthic invertebrate communities	Sediment does not exhibit a detrimental effect on invertebrate survival and growth	Evaluation of sediment chemistry with respect to sediment screening values	• Comparison of sediment concentrations to sediment screening values.
Long term health and reproductive capacity of omnivorous aquatic avian species (mallard duck)	Ingestion of COPC in prey does not have a negative impact on growth, survival, and reproductive success of the species	Evaluation of dose in prey based on sediment data and dietary exposure models	• Vegetation and invertebrate dose approximated by multiplying maximum sediment concentration by BCF or BAF for COPC. • The risk associated with the calculated dose will be evaluated by comparison to Toxicity Reference Values (TRVs).
Long term health and reproductive capacity of carnivorous aquatic avian species (blue heron)	Ingestion of COPC in prey does not have a negative impact on growth, survival, and reproductive success of the species	Evaluation of dose in prey based on sediment data and dietary exposure models	• Food dose approximated by multiplying maximum sediment concentration by BCF or BAF for COPC. • The risk associated with the calculated dose will be evaluated by comparison to Toxicity Reference Values (TRVs).
Long term health and reproductive capacity of piscivorous aquatic avian species (belted kingfisher)	Ingestion of COPC in prey does not have a negative impact on growth, survival, and reproductive success of the species	Evaluation of dose in prey based on sediment data and dietary exposure models	• Food dose approximated by multiplying maximum sediment concentration by BCF or BAF for COPC. • The risk associated with the calculated dose will be evaluated by comparison to Toxicity Reference Values (TRVs).
Long term health and reproductive capacity of omnivorous aquatic mammalian species (raccoon)	Ingestion of COPC in prey does not have a negative impact on growth, survival, and reproductive success of the species	Evaluation of dose in prey based sediment data and dietary exposure models	• Dose from food approximated by multiplying maximum sediment concentration by BAF or BCF for COPC. • The risk associated with the calculated dose will be evaluated by comparison to Toxicity Reference Values (TRVs).

Table 1 (continued). Screening Level Ecological Risk Assessment Endpoints at Martin State Airport.

Assessment Endpoint	Null Hypothesis	Measurement Endpoint	Specifics of Assessment
Ecological health of terrestrial plant communities	Soils are not exhibiting a detrimental effect on plant survival and growth	Evaluation of soil chemistry with respect to vegetation screening values	• Comparison of surface and sub-surface soil concentrations to vegetation screening values
Ecological health of terrestrial invertebrate communities	Soils are not exhibiting a detrimental effect on invertebrate survival and growth	Evaluation of soil chemistry with respect to soil invertebrate screening values	• Comparison of surface and sub-surface soil concentrations to soil invertebrate screening values
Long term health and reproductive capacity of omnivorous avian species (American robin)	Ingestion of COPC in food does not have a negative impact on growth , survival , and reproductive success of the species	Evaluation of dose in food based on surface soils data and dietary exposure models	• Vegetation and invertebrate dose approximated by multiplying surface and sub-surface soil concentration by BCF/BAF. • The risk associated with the calculated dose will be evaluated by comparison to Toxicity Reference Values (TRVs).
Long term health and reproductive capacity of herbivorous avian species (Morning Dove)	Ingestion of COPC in food does not have a negative impact on growth , survival , and reproductive success of the species	Evaluation of dose in food based on surface soils data and dietary exposure models	• Vegetation dose approximated by multiplying surface and sub-surface soil concentration by BAF • The risk associated with the calculated dose will be evaluated by comparison to Toxicity Reference Values (TRVs).

Table 1 (continued). Screening Level Ecological Risk Assessment Endpoints at Martin State Airport.

Assessment Endpoint	Null Hypothesis	Measurement Endpoint	Specifics of Assessment
Long term health and reproductive capacity of carnivorous avian species (Red-Tailed Hawk)	Ingestion of COPC in prey does not have a negative impact on growth, survival, and reproductive success of the species.	Evaluation of does in prey based on surface soils data and dietary exposure models.	• Small mammal dose approximated by multiplying surface and sub-surface soil concentration by BAF. • The risk associated with the calculated dose will be evaluated by comparison to Toxicity Reference Values (TRVs).
Long term health and reproductive capacity of small herbivorous mammalian species (Meadow vole)	Ingestion of COPC in food does not have a negative impact on growth , survival , and reproductive success of the species	Evaluation of dose in food based on surface soils data and dietary exposure models	• Vegetation dose approximated by multiplying surface and sub-surface soil concentration by BCF • The risk associated with the calculated dose will be evaluated by comparison to Toxicity Reference Values (TRVs).
Long term health and reproductive capacity of small invertivorous mammalian species (Short-tailed shrew)	Ingestion of COPC in food does not have a negative impact on growth , survival , and reproductive success of the species	Evaluation of dose in food based on surface soils data and dietary exposure models	• Soil invertebrate dose approximated by multiplying surface and sub-surface soil concentration by BAF • The risk associated with the calculated dose will be evaluated by comparison to Toxicity Reference Values (TRVs).

Table 1 (continued). Screening Level Ecological Risk Assessment Endpoints at Martin State Airport.

Assessment Endpoint	Null Hypothesis	Measurement Endpoint	Specifics of Assessment
Long term health and reproductive capacity of small omnivorous mammalian species (white-footed mouse)	Ingestion of COPC in food does not have a negative impact on growth , survival , and reproductive success of the species	Evaluation of dose in food based surface soil data and dietary exposure models	• Dose from vegetation and invertebrates approximated by multiplying surface and sub-surface soil concentration by BCF/BAF. • The risk associated with the calculated dose will be evaluated by comparison to Toxicity Reference Values (TRVs).
Long term health and reproductive capacity of large carnivorous mammalian species (red fox)	Ingestion of COPC in prey does not have a negative impact on growth , survival , and reproductive success of the species	Evaluation of dose in prey based surface soil data and dietary exposure models	• Dose from prey approximated by multiplying surface and sub-surface soil concentration by BAF • The risk associated with the calculated dose will be evaluated by comparison to Toxicity Reference Values (TRVs).

- Media Chemistry for Sediment—The measurement of chemical constituent concentrations in sediment provides the means, when compared to appropriate sediment screening values, to assess the protection of benthic organisms that live in the sediment. On July 7, 2004, two sediment samples were collected and analyzed from Frog Mortar Creek in the same locations as the surface water samples. Sediment samples from the two ponds were previously collected and analyzed in 2000 and the data validated. These data will be used in the ERA to evaluate the sediment pathway.

- Media Chemistry for Soil—The measurement of chemical constituent concentrations in soil provides the means, when compared to appropriate soil screening values, to assess the protection of benthic organisms that live in the soil. Extensive soil data are available from the past three years to evaluate risks due to the soil pathway.

4.0 COPC SCREEN

Soil, groundwater, and sediment data previously collected have been validated and are available for analysis. These previously collected data will be used in the screening ERA for each media type (water, sediment, and soil). If results of the Step 3 baseline ERA indicate significant data gaps, or limitations with existing data that substantially affect risk characterization, then additional data collection for those media affected may be considered at that point. In accordance with EPA ERA guidance, the average of field duplicates will be used as the concentration for those particular samples when they occur, and one-half the detection limit will be used as the value of non-detects for statistical purposes.

The screening process that identifies COPCs is environmentally conservative so as not to eliminate analytes that could pose potential ecological risk. This potential is minimized by using conservative assumptions and appropriate screening values during the COPC screening process. Analytes remaining after the screening process are COPCs. Widely accepted and comprehensive TRVs for surface soils are limited. Many sources have developed soil contaminant levels for a human health perspective, but only a few sources have developed TRVs with protection of ecological receptors as a goal. USEPA Region 3 BTAG screening levels (USEPA, 1995) and scientific literations such as Efroymson et al. (1997a, 1997b), MHSPE (1994), and USEPA (2000) will be used as sources for soil TRVs.

The protection of aquatic organisms will be assessed by comparing maximum water concentrations observed with water quality criteria (WQC) for the protection of aquatic life when available (USEPA, 1999). Region III BTAG recommendations will be used (USEPA, 1995) as a second source for water screening values for contaminants if national EPA criteria are unavailable. In the absence of screening values in either of these sources, Suter and Tsao (1996) will be used to identify surface water screening values. Comparing the maximum observed water concentration with the screening value determines surface water COPCs. When the Screening Value Ratio (SVR) is greater than 1.0, the analyte is determined to be a COPC.

In the case of sediments, there are no national EPA criteria for the protection of benthic organisms. The primary source used for this assessment of sediment COPCs will be Smith et al. (1996), which are based on NOAA's ER-L and ER-M values. In the absence of values from this source, Region III BTAG recommended values (USEPA, 1995) followed by consensus-based sediment screening values recommended by McDonald et al (2000) will be used.

For each media type, analytes not detected in any samples will be eliminated in this screening as well as those analytes with maximum concentrations less than the appropriate media screening value. All other analytes including those for which no known screening value exists, will be carried forward to Step 2 of the ERA process.

5.0 STEP 2 RISK ASSESSMENT

A Step 2 food web ERA will be conducted, as described below. A Step 2 risk assessment intentionally uses conservative exposure assumptions designed to retain and properly evaluate all contaminants that might pose a risk to ROCs.

5.1 Direct Exposure of Plants, Invertebrates, and Fish to Surface Water or Sediments

Based on the CSM previously described, aquatic receptors at the site are potentially exposed to COPCs in surface water or sediment, either through direct contact, or via dietary food web. In either case, the starting point for the evaluation of aquatic receptors is the maximum concentration in the water or sediment. Separate analyses will be performed for water and sediment.

A relevant pathway for aquatic plant communities is chronic exposure to surface water contaminants that may exhibit a detrimental effect on plant survival and growth. For non-bioaccumulative contaminants, maximum water or sediment concentrations will be compared with no effect levels for aquatic plants. It is assumed that the COPCs are 100 percent bioavailable to the plants for uptake. Risk of non-bioaccumulative chemicals to aquatic plants is based on a calculation of an Ecological Quotient (EQ):

EQ = Maximum Water or Sediment Concentration / Toxicity Reference Value

Similarly, a relevant pathway for aquatic invertebrate communities and fish is chronic exposure to water or sediment contaminants that may exhibit a detrimental effect on survival and growth. For non-bioaccumulative contaminants, maximum water or sediment concentrations will be compared to threshold levels for aquatic fauna. Again, it is assumed that the COPCs are 100 percent bioavailable to the invertebrates for uptake. Risk to aquatic fauna is based on a calculation of an Ecological Quotient similar to that used for plants.

5.2 Direct Exposure of Plants and Invertebrates to Surface Soils

Based on the CSM previously described, terrestrial receptors at the site are potentially exposed to COPCs in surface soil, either through direct contact, or via dietary food web. In either pathway, the starting point for the evaluation of terrestrial receptors is the maximum concentration in the surface soil.

A relevant pathway for terrestrial plant communities is the chronic exposure to surface soil contaminants that may exhibit detrimental effects on plant survival and growth. For non-bioaccumulative COPCs, maximum soil concentrations will be compared with no effect levels for terrestrial plants. Similar to the calculation for aquatic plants, an EQ will be calculated for terrestrial plants assuming that COPCs are 100 percent bioavailable for uptake by the plants.

Similarly, a relevant pathway for terrestrial invertebrate communities is chronic exposure to soil contaminants that may exhibit detrimental effects on survival and growth. Therefore, an EQ will be calculated for terrestrial soil invertebrates by comparing maximum soil concentration to threshold levels and assuming 100% bioavailability of COPCs.

5.3 Indirect Exposure of Higher Trophic Levels to COPCs (Food Web Analyses)

Bioaccumulation factors (BAF) for the avian and mammalian ROCs and bioconcentration factors (BCF) for fish from published sources will be used. In the absence of a trophic level BAF, a BAF =1.0 will be used in accordance with EPA guidance (USEPA 1997). The BCF is used to approximate the chemical concentrations found in pryitons (fish) living in water at a certain chemical concentration. The equation used to estimate this concentration is:

$$[X]_{fish} = [X]_{surface\ water}\ x\ BCF_{surface\ water}$$

where:

$[X]_{fish}$ = the concentration of chemical X in fish (wet weight),
BCF = the bioconcentration factor,
and $[X]_{surface\ water}$ = the concentration of chemical X in surface water.

The BAF is used to approximate the chemical concentrations found in prey items (fish, invertebrates, small mammals) living in sediment or soil at a certain chemical concentration. The equation used to examine this concentration is:

$$[X]_{prey} = [X]_{media} \times BAF_{media}$$

where:

$[X]_{prey}$ = the concentration of chemical X in prey,
$[X]_{media}$ = the concentration of chemical X in the appropriate media (sediment or soil),
BAF = the bioaccumulation factor.

Higher trophic organisms are exposed indirectly to the contaminants in the medium of concern via the food source. Fish as a food source can be exposed to the surface water contaminants directly and the sediment contaminants indirectly (via dietary uptake of benthic macroinvertebrates).

The dose of a given contaminant potentially available for a given receptor depends on its diet, the potential concentration of the contaminant in each food item type, and the time the receptor spends foraging in a given contaminated area.

For the Step 2 ERA, we assume that upper trophic level ROCs eat the most contaminated food item 100% of the time and that they spend all of their time at the site. Therefore, separate analyses are conducted to determine the most contaminated food or prey item for those ROCs having more than one type of potential food. This food or prey item is then used to calculate the ROC dose for each COPC. Similarly, in Step 2, the area use factor is set equal to 1.0 indicating that the ROC spends all of its time (or foraging area) within the site and thus potentially exposed 100% of the time. These assumptions are consistent with EPA guidance for Step 2 ERAs.

For aquatic and terrestrial upper trophic levels, dose is generally calculated as:

$$Dose_{total} = Dose_{food} + Dose_{sediment/soil} + Dose_{water}$$

where:

$Dose_{total}$	=	Total daily dose of COPC received by receptor; mg COPC/kg-body wt./day
$Dose_{food}$	=	Daily dose of COPC received by receptor; mg COPC/kg-body wt./day from most contaminated food items
$Dose_{sediment\ or\ soil}$	=	Daily dose of COPC received by receptor; mg COPC/kg-body wt./day from incidentally ingested sediment
$Dose_{water}$	=	Daily dose of COPC received by receptor; mg COPC/L/day from ingestion of water.

The total dose from food is given by:

$$Dose_{food} = F_f \, x \, U \, x \, C_f$$

where:

F_f (wet basis)	=	Total daily feeding rate in kg food/kg-body weight of ROC/day
U	=	Habitat usage factor (fraction of habitat range represented by site) for receptor; assumed to be 1.0 for this food web
C_f	=	Concentration of COPC in food; calculated using the maximum dose as determined by most contaminated food item (mg

chemical/kg food)

The total dose from incidental sediment or soil is given by:

$$Dose_{sediment\ or\ soil} = F_S \times U \times C_S$$

where:

F_s	=	Total daily incidental sediment or soil feeding rate in kg sediment or soil/ kg-body weight of ROC/day (wet basis)
U	=	Habitat usage factor (fraction of habitat range represented by site) for receptor; assumed to be 1.0 for this food web
C_s	=	Concentration of COPC in sediment or soil; mg chemical/kg sediment or soil (dry basis)

The total daily sediment or soil feeding rate is given by:

$$F_S = F_f \times F_{sediment\ or\ soil}$$

where:

F_s	=	Total daily incidental sediment or soil feeding rate in kg sediment or soil/day (wet basis)
F_f	=	Total daily feeding rate in kg food/day (wet basis)
$F_{sediment\ or\ soil}$	=	Fraction incidental sediment or soil ingestion as a proportion of food ingestion rate

Lastly, the total dose from water is given by:

$$Dose_{water} = F_W \times U \times C_W$$

where:

F_w	=	Total daily water ingestion rate in water/kg-body weight at ROC/day
U	=	Habitat Usage Factor (fraction of habitat range represented by site) for receptor; assumed to be 1.0 for this food web.
F_w	=	Concentration of COPC in water; mg chemical/L water

Information necessary for this calculation includes: organism body weight (BW), food ingestion rate (F_f), fraction incidental sediment or soil ingestion as a proportion of food ingestion rate ($F_{sediment}$), water ingestion rate (F_w) and analyte concentrations of ingested materials. Ingested media include both abiotic (sediment or soil) and biotic (food item) materials. Information specifically relevant to the ecology of the ROC (i.e., body weights, food ingestion rates, water ingestion rates, and incidental sediment or soil ingestion rates) will be obtained from published sources (i.e. USEPA, 1993).

6.0 TOXICITY ASSESSMENT

Risk to aquatic species are based on comparison to water quality criteria (USEPA, 1999), or other appropriate water toxicity tests. Those used for the Step 2 ERA are the same as reported for the screen. Similarly, benthic invertebrate risk is estimated based on toxicity values found for these organisms such as Smith et al. (1996).

USEPA (1997) guidance specifies that a screening ecotoxicity value should be "equivalent to a documented or best conservatively estimated chronic No Observed Adverse Effect Level (NOAEL)." Since there is wide variation in the literature on NOAELs, risks will be also calculated for conservatively estimated Lowest Observed Adverse Effect Levels (LOAELs) to provide some frame of reference for the results.

Sample et al. (1996) will be used as the primary source for NOAEL and LOAEL TRVs for mammals and birds. When analyte/receptor combinations are not located in Sample et al. (1996), the scientific literature will be used to select alternative toxicity values.

As noted in Sample et al. (1996), the current state of avian toxicology indicates that the use of allometric relationships, used to relate the body weight of the toxicity test organism to that of the receptor of concern, are not appropriate. Consequently, toxicity values for avian ROCs taken from Sample et al. (1996) are the same regardless of the receptor of concern, and are equivalent to that found in the test species (pheasant, chickens, and ducks). An allometric conversion will be performed to modify the toxicity value from the test species to mammalian ROCs (Sample et al. 1996). This is due to the finding that smaller animals, which are commonly used as test species in toxicity tests, have higher metabolic rates, and detoxify contaminants faster than larger animals.

7.0 STEP 3 ECOLOGICAL RISK ASSESSMENT

The Step 2 exposure assessment consists of a conservative food web model and exposure assessment analysis. COPCs which have HQs less than 1.0 for all ROCs will be considered to present acceptable risk to ecological resources and will not be further evaluated in Step 3. COPCs for which no toxicity data (TRVs) are available, cannot be eliminated in Step 2 and are carried through Step 3 as well. These COPCs represent one type of uncertainty in the ERA that are evaluated (TRVs) by examining in greater detail the spatial pattern and distribution of concentration values in a given media and then comparing these data to available effects data in the literature. Remaining COPCs that have TRVs will be subjected to Step 3 Problem Formulation (USEPA, 1997). This refinement of the exposure assessment is presented below. The risk calculations in the food-web models will be revisited using refinements of exposure assumptions used in the Step 2 ERA, including more realistic ROC exposure assumptions, dietary composition, adjustment of dry weight concentrations to wet weight concentrations, and area use factors of the ROCs.

7.1 Step 3 Exposure Assessment

The purpose of the Step 2 exposure assessment is to quantify the degree of contact between ecological ROCs and COCs identified at the site. The Step 3 exposure assessment allows for more realistic exposure assumptions than those found in the conservative Step 2 exposure assessment. Factors that are used in Step 3, according to EPA guidance are:

Proper Wet to Dry Weight Conversions for the Food Webs. The Step 2 exposure assessment assumes that incidental sediment consumption is based on dry weight soil concentrations at wet weight ingestion rates. In Step 3, incidental sediment ingestion will be quantified based on wet weight sediment concentrations and the average percent moisture of the sediments.

Proper Area Use Factors (AUFs) for Each ROC. The Step 2 exposure assessment assumed that all ROCs obtained all their food, water, and sediment from the site for their entire lifetime, and that their habitat range is no larger than the site itself. Some ROCs selected for this ERA, such as kingfishers and herons have habitat ranges much larger than this. Proper area use factors based on published literature will be used in Step 3 analyses.

Use of Appropriate Exposure Concentrations. The Step 2 exposure assessment includes the assumption that ROCs are exposed to the maximum detected concentration found across the site. In Step 3, all exposures will be estimated based on the arithmetic mean concentration in a given media, consistent with USEPA guidance (1997).

Use of More Realistic ROC Exposure Assumptions. The Step 2 food web maximizes exposure by using the smallest body weight for the highest food ingestion rates found in the literature. The Step 3 exposure assessment utilizes mean or median body weights and food consumption rates for aquatic receptors.

Use of Dietary Composition for ROCs. In Step 2, exposure in higher trophic levels is based on the most contaminated food item only. In Step 3, exposure is based on realistic diet composition for each ROC. Small mammals, soil invertebrates, and vegetation bioaccumulate constituents of concern (COCs) to a different extent dependent on the chemical's physical properties. Realistic diets will be utilized for the Step 3 exposure assessment. The fraction of diet for each ROC that is invertebrate, vegetation, small mammal, or fish is multiplied by the calculated invertebrate, vegetation, small mammal, or fish dose, summed for all food fractions. This becomes the total dose to the ROC from all food fractions.

The Step 3 ERA will include a section summarizing all uncertainties remaining in the ERA process, including those contaminants for which toxicity thresholds are lacking as mentioned previously. To the extent possible, risks from these contaminants will be evaluated in terms of their frequency of detection (i.e., how common are they at the site), where they were found (i.e., how spatially limited), and available toxicity information for closely related chemicals.

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