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DRAFT ECOLOGICAL RISK ASSESSMENT REPORT REMEDIAL INVESTIGATION FIREFIGHTER TRAINING AREA, LIGHTER AMPHIBIOUS RESUPPLY CARGO (LARC) 60 MAINTENANCE AREA, AND AUTO CRAFT AREA FORT STORY VA

9/1/1996

MALCOLM PIRNIE

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DRAFT REPORT
REMEDIAL INVESTIGATION

ECOLOGICAL RISK ASSESSMENT

FIREFIGHTER TRAINING AREA
LARC 60 MAINTENANCE AREA
AUTO CRAFT BUILDING AREA

FORT STORY, VIRGINIA

PREPARED FOR:

U.S. ARMY CORPS OF ENGINEERS
BALTIMORE DISTRICT
BALTIMORE, MARYLAND

AND

U.S. ARMY TRANSPORTATION CENTER
FORT EUSTIS, VIRGINIA

CONTRACT DACA31-94-D-0017
DELIVERY ORDER NO. 17, 20 AND 24

SEPTEMBER 1996

MALCOLM PIRNIE, INC.
11832 Rock Landing Drive, Suite 400
Newport News, Virginia 23606

0285-588-330

REVIEW COMMENTS

DOCUMENT:	*Draft Remedial Investigation, Ecological Risk Assessment, Fort Story, Virginia*		
PREPARED BY:	Malcolm Pirnie	DATE OF DOCUMENT:	September 1996
PROJECT:	Fire Training Area LARC 60 Maintenance Area Auto Craft Shop	1383 NUMBER:	STOS930001 STOS930004 STOS930006
REVIEWED BY:	Dan Musel, Fort Eustis	DATE OF REVIEW:	9 January 1997

NO.	SECTION	PAGE	PARA.	COMMENTS
1	7.3	7-6	2	Potential Stressors, Exposure Pathways and Ecological Effects: VDEQ in the past has not excepted the use of regional soil data for background. Be prepared to back up the use of these regional values.
2	7.3	7-6	3	Potential Stressors, Exposure Pathways and Ecological Effects: Past experience with VDEQ has indicated they will not except the elimination of a contaminant by the comparison with background before the risk assessment is conducted. If a site is considered a hazard, then they will look at background concentrations and remove any contaminants at that time. Please be prepared to defend your method of deleting COPC by comparing them to background.
3	Table 7-6			Site Specific and Regional Background Concentrations: The text references the comparison to regional and site specific backgrounds concentrations for VOCs and PAHs. Please list these compounds and their respective values.
4	Tables 7-7, 7-8, 7-9, 7-10, 7-12			Include the regional and site specific values in these tables.
5	Table 7-13			Please shade a value for toluene and lead.
6	7.3.1	7-9	1	Surface Soils: The paragraph states there were several metals exceeding regional screening criteria and lack any screening criteria. However, the next sentence states they were consistent with site-specific and regional background levels and therefor not selected as COPC. This is confusing. Please clarify why they are greater then regional values in one sentence and consistent in another and not used as COPC.
7	7.3.1	7-9	1	Sediment: See comment #6. Values exceeded criteria but were consistent with background and were not used as COPC. Please clarify.
8	7.3.1	7.9	1	Surface Water: The paragraph indicates acetone was detected in two samples but at levels below regional criteria. Please indicate the regional criteria. Are the values background or some Virginia standard? Also include these values in Table 7-11.

REVIEW COMMENTS

NO.	SECTION	PAGE	PARA.	COMMENTS
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10	7.8.1	7-20	2	Hazard Quotients, FTA Site: The HQ for lead and thallium for the White-footed Mouse was greater then 1 as indicated on Table 7-26. However, the paragraph indicates there is unlikely a risk. Please clarify.
11	7.8.1	7-20	2	Hazard Quotients, Auto Craft Site: The HQ for zinc was greater then 1 for the Killdeer and the White-footed Mouse (Table 7-27) but the text indicates there is no risk. Please clarify.

USATC ENVIRONMENTAL

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7.1 OVERVIEW AND OBJECTIVES

This section presents an assessment of potential environmental risks associated with contaminants detected at 3 sites on Fort Story: FTA, LARC 60 , and Auto Craft Sites. The primary objective of the ecological risk assessment is to identify and characterize the potential risks posed to wildlife receptors as a result of contaminant releases. Secondary objectives are: to document dominant flora and fauna associated with the site; to determine the contaminants of potential concern being released from the site; to identify potential pathways for receptor exposure; and to determine if any response action might be necessary at the site, from an ecological perspective.

Statutory authority for this assessment is found in CERCLA as amended by the Superfund Amendments and Reauthorization Act (SARA). The evaluation follows guidance contained in the following documents:

- U.S. Environmental Protection Agency's (USEPA) *Risk Assessment Guidance for Superfund, Volume II, Environmental Evaluation Manual* (USEPA, 1989)
- *Framework for Ecological Risk Assessment* (USEPA, 1992)
- *Procedural Guidelines for Ecological Risk Assessments at U.S. Army Sites Volume I* (Wentsel et. al., 1994).

According to current USEPA guidance, the following steps were completed for the risk assessment at each site:

- Problem Formulation

  - Qualitative characterization of natural resources
  - Identification of chemicals of potential concern
  - Identification of potential exposure pathways
  - Identification of ecological endpoints
  - Development of conceptual ecological site model

- Exposure assessment providing quantitative or qualitative exposure scenarios for selected ecological receptors

- Ecological effects assessment summarizing toxicity reference values for selected ecological receptors
- Characterization of risk
- Estimation of risk uncertainty

Chemical analyses were performed on environmental media, including soil, sediment, surface water, and ground water, where applicable at each site. The conclusions derived from this study focus on identifying potential adverse risks to species, habitats, and populations in the environment, and is not a quantitative determination of risk. The risk assessment addresses potentially significant risks to the following biological groups and resources associated with the area: vascular vegetation, wildlife, threatened and endangered species, and wetlands. Significant habitats and wetlands on the base are identified. Cover types and species inventories for each investigated site and its immediately adjacent areas are also included.

As preceding sections of this RI have indicated, a substantial amount of site-specific data on chemical and physical information was developed to characterize the types, location, and concentrations of chemicals in the environmental media. Validated chemical analytical results were used in all ecological risk analyses. Contaminant toxicity levels to terrestrial and avian species were derived from technical literature. Chemical profiles for chemicals of potential concern are included in Appendix K.

7.2 Problem Formulation

Problem formulation is the first phase of ecological risk assessment and establishes the goals, breadth, and focus of the assessment (USEPA, 1992). The process involves a series of interrelated steps to identify potential stressors, pathways, and ecological effects. Ecological endpoints appropriate for the site are then derived, and an ecological conceptual site model is formulated. This model is a set of working hypotheses regarding the potential pathways and effects of site-related stressors on ecosystems of concern.

Problem formulation is based on information collected during the Remedial Investigation. This phase of the ecological risk assessment is presented in four parts: ecosystems of concern; potential stressors, exposure pathways, and ecological effects; ecological endpoints and; the conceptual model.

Initially, field studies were conducted and the ecology of the sites and surrounding areas were characterized. This characterization involved the identification of plant and animal communities as well as observations of any actual or potential effects of chemical and/or physical stress on these biological resources.

The second step in problem formulation involves the identification of the interrelationships between potential stressors, exposure pathways, and ecological effects for the identified ecosystems of concern. Chemical and/or physical stressors are identified, potential pathways for migration of contaminants from the site to the ecosystems of concern are discussed, and potential ecological effects are summarized.

7.2.1 Ecosystems of Concern

Firefighter Training Area

Site Description

The FTA site has been highly disturbed by past activities such as the existence of a hospital, firefighting activities, and current activities such as heavy equipment operation training. The woods adjacent to the site are used for infantry training and several small burned areas are evident. Additionally, since 1995, approximately 12,000 square feet of the site has been used for land farming of contaminated soil from an adjacent UST excavation. These soils are contaminated with several VOCs and the contaminants are being allowed to volatilize naturally. An impermeable liner was placed underneath and around the soil so that contaminants could not migrate from the land farming area.

Flora and Fauna

In April 1996, Malcolm Pirnie biologists conducted an inventory of vegetative species occurring within and adjacent to the site. The former Fire Training Pit has been dismantled and is currently covered by gravel. A few weed species grow through the gravel. The remaining southern end of the site is covered with low-growing vegetative species thriving in a sandy soil environment. The northern end of the site has sandy soil and is primarily unvegetated. Pine forests border the site on the west and south, with a road and a vegetated berm separating the forest from the site. A low area occurs in the forest to the south of the site, but standing water does not usually collect in the area. The woods contain several tall vegetated sand dunes and run south and west to Shore Drive. Dominant vegetation at the former FTA site is listed in Table 7-1.

Table 7-1
Dominant Vegetation at the FTA Site
Fort Story, Virginia

Common Name	Scientific Name
Vegetation at the FTA Site	
Clover	*Trifolium sp.*
Grasses	*Poa sp.*
Aster	*Aster sp.*
Mustard	Family *Cruciferae*
Pixie	*Diapensia sp.*
Wild Onion	*Allium canadense*
Common Dandelion	*Taraxacum officinale*
Vegetation in the Adjacent Woodland Area	
Live Oak	*Quercus virginiana*
Loblolly Pine	*Pinus taeda*
Water Oak	*Quercus nigra*
Sweet Bay	*Magnolia virginiana*
Lowbush Blueberry	*Vaccinium angustifolium*
Red Maple	*Acer ruburm*
American Holly	*Ilex opaca*
Sweet Gum	*Liquidambar styraciflua*
Common Greenbrier	*Smilax rotundifolia*
Broom Sedge	*Andropogon virginicus*
Virginia Pine	*Pinus virginiana*
Black Locust	*Robinia pseudo-acacia*
Black Cherry	*Prunus serotina*
European Honeysuckle	*Locinaria xylosteum*
Southern Cane	*Arudinaria gigantea*
Wax Myrtle	*Myrica cerifera*

Indicators and observations of wildlife usage in the FTA site included the following: Eastern Cottontail (*Sylvilagus floridanus*), Eastern Bluebird (*Sialis sialis*), and the European Starling (*Sturnus vulgaris*). Greater Yellowlegs (*Tringa melanoleuca*) were observed foraging in a temporary pool immediately adjacent to the land farming area. Observations of wildlife usage in the wooded area adjacent to the site included the following: Raccoon (*Procyon lotor*), Common Mole (*Condylura cristata*), Gray Squirrel (*Sciurus carolinensis*), Blue-gray Gnatcatcher (*Polioptila coerulea*), Killdeer (*Charadrius vociferus*), Pine Warbler (*Dendroica discolor*), and Cardinal (*Richmondena cardinalis*). A detailed list of wildlife species expected to occur in the vicinity of Fort Story is included as Appendix L.

LARC 60 Maintenance Area

Site Description

The LARC 60 site is an active heavy equipment maintenance and operation area which includes three subsites: the Sandbox and adjacent wash rack, an oil/water separator, and a former UST area. Because the majority of the site is covered with asphalt, concrete, or has little to no vegetative cover, there are limited habitats for wildlife. The Sandbox is an unvegetated sandy area that is used as a heavy equipment operating area. A small wooded island occurs within the western end of the Sandbox. A chain link fence borders the northern end of the Sandbox, and a mixed pine/deciduous forest is located beyond the fence. There is a drainage ditch immediately north of the fence which collects storm water runoff from the Sandbox, the adjacent wash rack, and the wooded area. The oil/water separator is located at the west end of Building 1083 and is surrounded by asphalt paving. This area would not be attractive to wildlife. The former UST area is covered with gravel and sand and a few weedy species. The remaining area between the subsites is covered with buildings, asphalt, or concrete pavement. Wildlife species most frequently associated with the site would probably nest in the wooded area to the north of the Sandbox or to the west of the former UST site. Because of the proximity of the sites and similar lack of vegetation, the three subsites were assessed together.

Flora and Fauna

In April 1996, Malcolm Pirnie biologists conducted an inventory of vegetative species occurring within and immediately adjacent to the LARC 60 site. A few weedy species grow on the sand and gravel surface of the former UST area. These species are listed in Table 7-2. Similar vegetative species occur in the woodlands surrounding the site and in the wooded island in the Sandbox. The areas are predominantly covered by pines, Live Oak, and Water Oak. The dominant vegetative species are also included in Table 7-2.

Table 7-2
Dominant Vegetation at the LARC 60 Site
Fort Story, Virginia

Common Name	Scientific Name
Vegetation at the Former UST Area	
Clover	*Trifolium sp.*
Grasses	*Poa sp.*
Aster	*Aster sp.*
Wild Onion	*Allium canadense*
Vegetation in the Adjacent Wooded Area	
Live Oak	*Quercus virginiana*
Loblolly Pine	*Pinus taeda*
Water Oak	*Quercus nigra*
Red Bay	*Persea borbonia*
Highbush Blueberry	*Vaccinium corymbosum*
Red Maple	*Acer ruburm*
American Holly	*Ilex opaca*
Inkberry	*Ilex glabra*
Common Greenbrier	*Smilax rotundifolia*
Broom Sedge	*Andropogon virginicus*
Virginia Pine	*Pinus virginiana*
Vegetation Associated with the Drainage Ditch in the Adjacent Wooded Area	
Soft Rush	*Juncus effusus*
Seed Box	*Ludwigia alternifolia*
Virginia Sweet Spires	*Itea virginica*
Highbush Blueberry	*Vaccinium corymbosum*
Broom Sedge	*Andropogon virginicus*
Wax Myrtle	*Myrica cerifera*

Indicators and observations of wildlife usage of the LARC 60 site, adjacent wooded area, and adjacent drainage ditch include the following: Bobwhite (*Colinus virginianus*), Green-backed Heron (*Butorides virescens*), Cardinal (*Richmondena cardinalis*), American Crow (*Corvus brachyrhynchos*), Mallard (*Anas platyrhynchos*), Rufous-sided Towhee (*Pipilo erythrophthalmus*), Common Grackle (*Quiscalus quiscula*), House Finch (*Carpodacus mexicanus*), and Brown-headed Nuthatch (*Sitta pusilla*).

Auto Craft Building Area

Site Description

The Auto Craft Site contains a small building and an asphalt parking lot completely enclosed by a chain link fence. A small weeded area now marks a former building, which was partially destroyed by fire, then dismantled. Downgradient of the site, between the site and Atlantic Avenue, lies a small grassy area. No wetlands or streams are located in the vicinity of the site.

Flora and Fauna

In April 1996, Malcolm Pirnie biologists conducted a vegetative inventory of the species occurring within the area. The few vegetative species occurring within the fenced area and the dominant grassy species occurring downgradient of the site are listed in Table 7-3. In addition, the species in the wooded area to the east of the site are listed. Because of the lack of vegetative species within the site itself, it is likely that wildlife will forage and nest within the adjacent wooded area.

Indicators and observations of wildlife within and adjacent to the site include the following: Common Grackle (*Quiscalus quiscula*), Mourning Dove (*Zenaidura macroura*), Killdeer (*Charadrius vociferus*), House Wren (*Troglodytes aedon*), Blue-grey Gnatcatcher (*Polioptila coerulea*), American Crow (*Corvus brachyrhynchos*), White-throated Sparrow (*Zonotrichia albicollis*), Rufous-sided Towhee (*Pipilo erythrophthalmus*), and Common Mole (*Condylura cristata*).

7.2.2 Threatened and Endangered Species

According to the Natural Heritage Listing, dated May 1995, three endangered species are known to occur in Virginia Beach (Horne Engineering Services, 1995). They are the Bald Eagle (*Haliaeetus leucocephalus*), Dismal Swamp Shrew (*Sorex longirostris fisheri*), and the Loggerhead Sea Turtle (*Caretta caretta*).

Table 7-3
Dominant Vegetation at the Auto Craft Site
Fort Story, Virginia

Common Name	Scientific Name
Vegetation in the Auto Craft Site	
Grasses	*Poa sp.*
Aster	*Aster sp.*
Wild Onion	*Allium canadense*
Vegetation in the Adjacent Grassy Area	
Grasses	*Poa sp.*
Aster	*Aster sp.*
Wild Onion	*Allium canadense*
Pixie	*Diapensia sp.*
Clover	*Trifolium sp.*
Vegetation in the Adjacent Wooded Area	
Live Oak	*Quercus virginiana*
Water Oak	*Quercus nigra*
Red Bay	*Persea borbonia*
American Holly	*Ilex opaca*
Common Greenbrier	*Smilax rotundifolia*
Wax Myrtle	*Myrica cerifera*

There is no suitable habitat or nesting area for these three species in or adjacent to the three sites. The Bald Eagle nests along inland waters and the Chesapeake Bay in relatively secluded areas. It requires large snags for perching and roosting, which do not occur within or near the sites. The Dismal Swamp Shrew is found in swampy forests near the interior waters of Virginia Beach and closer to the Dismal Swamp area of the City of Chesapeake, Virginia. The sandy coastal areas of the FTA site are not suitable habitat for the Dismal Swamp Shrew. The Loggerhead Turtle is known to nest along the beach areas of Virginia Beach. Each site is in developed areas, at least 1,200 feet from the Chesapeake Bay. Therefore, the turtle would not nest in any of the sites.

7.3 POTENTIAL STRESSORS, EXPOSURE PATHWAYS AND ECOLOGICAL EFFECTS

The next step in problem formulation involves the identification of the interrelationships between potential stressors, exposure pathways, and ecological effects for the identified ecosystems of concern. Chemical and/or physical stressors are identified, potential pathways for migration of contaminants from the site to the ecosystems of concern are discussed, and potential ecological effects are summarized.

Contaminants in surface soil samples were compared to USEPA Region III Biological Technical Assistance Group (BTAG) Screening Levels for Ecological Risks. Where no soil screening level was available, the screening level for sediment was used (Table 7-4). Contaminants detected in sediments were also compared to current Federal regional guidelines. USEPA Region III BTAG Screening Levels for Ecological Risks for sediment, or surface soils were utilized, where appropriate (Table 7-4). Contaminants detected in surface water were compared with available Federal and Virginia standards to determine which chemicals may be of concern with respect to target wildlife receptors. Virginia State Surface Water (Freshwater) Quality Standards, USEPA Region III BTAG Screening Levels for Aquatics in Surface Water (USEPA, 1995), and USEPA Ambient Water Quality Criteria for chronic effects in fresh water (USEPA, 1991) were utilized (Table 7-5).

The range, mean and maximum soil and sediment concentrations for the sites were compared with the 95th UCL background concentrations analyzed at Fort Story and the observed range and mean regional background concentrations. Background values are presented in Table 7-6 and in Appendix H. If criteria and background values were exceeded, the chemicals were chosen as chemicals of potential concern for this assessment. Sample results for the three sites and applicable screening criteria are presented in Tables 7-7 through 7-12.

TABLE 7-4
CHEMICAL-SPECIFIC ARARs AND TBC FOR SOIL AND SEDIMENT

	TBC Criteria			
	EPA Region III BTAG Screening Levels for Soil		EPA Region III BTAG Screening Levels for Sediment	
Parameters	Flora (mg/kg)	Fauna (mg/kg)	Flora (mg/kg)	Fauna (mg/kg)
VOCs				
Acetone	-	-	-	-
Chloroform	-	<0.30	-	-
Toluene	-	0.10	-	0.10
SOCs				
Acenaphthene	-	0.10	-	0.016
Anthracene	-	0.10	-	0.10
Benz(a)anthracene	-	0.10	-	0.261
Benzo(b)fluoranthene	-	0.10	-	0.43
Benzo(k)fluoranthene	-	0.10	-	3.2
Benzo(g,h,i)perylene	-	0.10	-	0.67
Benzo(a)pyrene	-	20	-	0.10
Bis(2-EH)phthalate	5.3 to 260	5.3 to 260	5.3 to 260	5.3 to 260
Butylbenzylphthalate	5.3 to 260	5.3 to 260	5.3 to 260	5.3 to 260
Carbazole	-	-	-	-
Chrysene	-	0.10	-	0.384
Dibenz(a,h)anthracene	-	0.10	-	0.0634
Dibenzofuran	-	0.54	-	0.54
Di-n-butylphthalate	5.3 to 260	5.3 to 260	5.3 to 260	5.3 to 260
Fluoranthene	-	0.10	-	0.60
Fluorene	-	0.10	-	0.019
Indeno(1,2,3-cd)pyrene	-	0.10	-	0.60
2-Methylnaphthalene	-	0.07	-	0.07
Naphthalene	-	0.10	-	0.16
Phenanthrene	-	0.10	-	0.24
Pyrene	-	0.10	-	0.665
Pesticides				
alpha-Chlordane	-	< 0.10	-	< 0.10
gamma-Chlordane	-	< 0.10	-	< 0.10
4,4'-DDD	-	< 0.10	-	< 0.10
4,4'-DDE	-	< 0.10	-	0.0022
4,4'-DDT	-	0.004	-	0.008
Endosulfan sulfate	-	-	-	-
Endrin ketone	-	< 0.10	-	< 0.10
Heptachlor	-	-	-	-
Methoxychlor	-	< 0.10	-	< 0.10
Inorganics				
Aluminum	-	-	-	-
Antimony	0.48	-	-	-
Arsenic	5	8.2	5	8.2
Barium	-	440	-	440
Beryllium	0.02	-	0.02	-
Cadmium	2.5	-	-	-
Chromium	0.02	0.0075	0.005	260,000
Cobalt	0.10	1,500	0.10	1,500
Copper	-	0.04	-	34
Cyanide	-	-	-	-
Iron	100	-	100	-
Lead	0.0125	0.01	0.0125	46.7
Manganese	-	330	-	330
Nickel	2.5	20.9	2.5	20.9
Selenium	-	0.26	-	0.26
Thallium	0.001	-	0.001	-
Vanadium	-	58	-	58
Zinc	-	4.8	-	150

Source:
EPA Region III BTAG Screening Levels for Ecological Risks (Jan 1995)

TABLE 7- 5
CHEMICAL-SPECIFIC ARARs AND TBC FOR SURFACE WATER

Parameters	ARARs				TBC Criteria	
	Virginia Surface Water (Freshwater) Quality Standards (1)		Federal Ambient Water (Freshwater) Quality Criteria (2)		EPA Region III BTAG Screening (Freshwater) (3)	
	Acute (ug/l)	Chronic (ug/l)	Acute (ug/l)	Chronic (ug/l)	Flora (ug/l)	Fauna (ug/l)
VOCs						
Chlorodifluoromethane	-	-	-	-	-	-
SOCs						
bis(2-EH)phthalate	-	-	-	-	-	30
2,4-Dimethylphenol	-	-	-	-	-	2,120
4-Methylphenol	-	-	-	-	-	-
Pesticides						
4,4-DDD	-	-	-	-	-	0.60
4,4-DDE	-	-	-	-	-	1,050
4,4-DDT	1.1	0.001	1.1	0.001	5,000	0.001
Total Metals						
Aluminum	-	-	-	-	460	200
Barium	-	-	-	-	-	10,000
Beryllium	-	-	-	-	100,000	5.3
Chromium	2,656	316	1,700	210	-	210
Cobalt	-	-	-	-	-	-
Copper	5	4	18	12	-	6.5
Iron	-	-	-	-	-	320
Lead	14	0.54	82	3.2	-	1
Magnesium	-	-	-	-	-	-
Manganese	-	-	-	-	-	-
Nickel	439	49	1,400	160	-	14.77
Thallium	-	-	-	-	-	40
Vanadium	-	-	-	-	-	10,000
Zinc	-	-	120	110	110	110

Notes:
(1) Virginia Surface Water Quality Standards (VR 680-21-01.14)
(2) Federal Ambient Water Quality Criteria (40 CFR 131)
(3) EPA Region III BTAG Screening Levels for Aquatics in Surface Water (Jan 1995)

TABLE 7-6
SITE SPECIFIC AND REGIONAL BACKGROUND CONCENTRATIONS
FORT STORY, VIRGINIA

Parameters	Fort Story Background 95th UCL [1]	USGS Regional Soils Data [2]	
		Observed Range	Mean
Aluminum	Not analyzed	7,000 ->100,000	33,000
Arsenic	2.1	<0.2 - 73	5.4
Barium	5	15 - 1,000	300
Calcium	Not analyzed	<100 - 160,000	3,200
Chromium	2.8	1 - 100	36
Cobalt	Not analyzed	<3 - 70	7
Copper	1.4	<1 - 150	14
Iron	Not analyzed	100 - >100,000	15,000
Lead	7.1	<7 - 300	14
Magnesium	Not analyzed	50 - 50,000	2,300
Manganese	Not analyzed	<2 - 7,000	290
Mercury	0.01	0.01 - 0.34	0.096
Nickel	2	<3 - 700	13
Potassium	Not analyzed	50 - 37,000	7,400
Sodium	Not analyzed	<200 - 15,000	2,600
Thallium	Not analyzed	~	~
Vanadium	Not analyzed	<5 - 300	46
Zinc	5.7	<5 - 400	36

Notes:

(1) James M. Montgomery, Inc. 1992.

(2) Comor et al, 1975.

TABLE 7-7
ECOLOGICAL ASSESSMENT FOR SURFACE SOILS
FORT STORY - FTA SITE

Parameter	Frequency of Detection	Range of Detection	TBC Criteria: EPA Region III BTAG Screening Levels (1)		Exceed or Lacking Criteria?
			Flora	Fauna	
VOCs (ug/kg)					
Acetone	3/28	140 - 220	-	-	Yes
Methylene Chloride	2/28	5.0 - 6.4	-	<300.0	
Methyl ethyl ketone	1/28	28.0	-	-	Yes
Styrene	1/28	3.0	-	100.0	
Toluene	25/28	8.3 - 140	-	100.0	Yes
Xylenes	1/28	7	-	-	Yes
SOCs (ug/kg)					
Benzo(b)fluoranthene	1/28	97	-	100.0	
Benzo(k)fluoranthene	1/28	86	-	100.0	
bis(2-EH)phthalate	1/28	110	5,300.0	5,300.0	
Chrysene	1/28	94	-	100.0	
Di-n-butylphthalate	1/28	150	260,000.0	260,000.0	
Fluoranthene	2/28	75 - 650	-	100.0	Yes
Pyrene	2/28	64 - 720	-	100.0	Yes
TPH (mg/kg)					
TPH as Heavy Oils	3/28	48 - 5300	-	-	
Inorganics (mg/kg)					
Aluminum	5/5	420 - 980	-	-	Yes
Arsenic	4/5	1.2 - 1.6	5.0	8.2	
Barium	5/5	3.9 - 12.0	-	440.0	
Calcium	4/5	71 - 370	-	-	Yes
Chromium	5/5	1.7 - 5.8	0.02	0.0075	Yes
Copper	5/5	3.2 - 13	-	0.04	Yes
Iron	5/5	1,200 - 5,400	100.0	-	Yes
Lead	5/5	7.0 - 33.0	0.0125	0.01	Yes
Magnesium	5/5	62 - 190	-	-	Yes
Manganese	5/5	10 - 34	-	330.0	
Potassium	1/5	160	-	-	Yes
Vanadium	5/5	1.8 - 3.7	-	58.0	
Zinc	5/5	14 - 22	-	4.8	Yes

Note:
(1) EPA Region III BTAG Screening Levels for Ecological risks (Jan 1995)

TABLE 7-8
ECOLOGICAL ASSESSMENT FOR SEDIMENTS
FORT STORY - FTA SITE

Parameter	Frequency of Detection	Range of Detection	TBC Criteria: EPA Region III BTAG Screening Levels (1)		Exceed or Lacking Criteria?
			Flora	Fauna	
VOCs (ug/kg)					
Toluene	4/4	23 - 180	-	100.0	**Yes**
SOCs (ug/kg)		BDL			
TPH (mg/kg)					
Total TPH	3/4	130 - 350	-	-	
Metals (mg/kg)					
Aluminum	4/4	160 - 7600	-	-	**Yes**
Arsenic	1/4	2.5	5.0	8.2	
Barium	4/4	2.4 - 110	-	440.0	
Calcium	4/4	64 - 120	-	-	**Yes**
Chromium	1/4	21	0.005	260,000.0	**Flora**
Cobalt	1/4	2.6	0.1	1,500.0	**Flora**
Copper	1/4	26	-	34.0	
Iron	4/4	230 - 17,000	100.0	-	**Flora**
Lead	4/4	4.3 - 210	0.0125	46.7	**Yes**
Magnesium	1/4	960	-	-	**Yes**
Manganese	3/4	1.7 - 42	-	330.0	
Mercury	2/4	0.017 - 0.051	-	0.2	
Potassium	1/4	260	-	-	**Yes**
Sodium	2/4	87 - 180	-	-	**Yes**
Thallium	1/4	1.4	0.001	-	**Flora**
Vanadium	2/4	2 - 18	-	58.0	
Zinc	2/4	6 - 76	-	150.0	

Note:
(1) EPA Region III BTAG Screening Levels for Ecological risks (Jan 1995)

TABLE 7-9
ECOLOGICAL ASSESSMENT FOR SURFACE SOIL
FT. STORY - LARC 60 SITE

Parameter	Frequency of Detection	Range of Detection	TBC Criteria: EPA Region III BTAG Screening Levels (1)		Exceed or Lacking Criteria?
			Flora	Fauna	
VOCs (ug/kg)					
Acetone	1/22	36	-	-	Yes
Methylene Chloride	7/22	5.2 - 160	-	<300.0	
Toluene	1/22	6.0	-	100.0	
Trichloroethene	2/22	5.9 - 6.4	-	<300.0	
SOCs (ug/kg)	0/22	BDL			
TPH (mg/kg)					
Total TPH	19/22	42 - 1500	-	-	
Metals (mg/kg)					
Aluminum	5/5	250 - 2,700	-	-	Yes
Arsenic	1/5	1.1	5.0	8.2	
Barium	5/5	1.8 - 19	-	440.0	
Calcuim	4/5	56 - 980	-	-	Yes
Chromium	5/5	1.7 - 4.3	0.02	0.0075	Yes
Cobalt	1/5	2.30	0.1	1,500.0	Flora
Copper	4/5	2.5 - 41	-	0.04	Yes
Iron	5/5	400 - 1,100	100.0	-	Yes
Lead	5/5	3.1 - 12	0.0125	0.01	Yes
Magnesium	4/5	77 - 1,400	-	-	Yes
Manganese	5/5	2.4 - 120	-	330.0	
Potassium	1/5	1,200	-	-	Yes
Vanadium	5/5	1.2 - 9.2	-	58.0	
Zinc	5/5	3.8 - 33	-	4.8	Yes

Notes:
(1) EPA Region III BTAG Screening Levels for Ecological risks (Jan 1995)

TABLE 7-10
ECOLOGICAL ASSESSMENT FOR SEDIMENT
FT. STORY - LARC 60 MAINTENANCE AREA

Parameter	Frequency of Detection	Range of Detection	TBC Criteria: EPA Region III BTAG Screening Levels (1)		Exceed or Lacking Criteria?
			Flora	Fauna	
VOCs (ug/kg)	0/2	BDL			
SOCs (ug/kg)	0/2	BDL			
TPH (mg/kg)					
Total TPH	2/2	530 - 2700	-	-	
Inorganics (mg/kg)					
Aluminum	2/2	310 - 650	-	-	**Yes**
Barium	2/2	1.4 - 2.7	-	440.0	
Calcium	2/2	53 - 210	-	-	**Yes**
Chromium	2/2	1.6 - 2.5	0.005	260,000	**Flora**
Copper	2/2	3.8 - 9.0	-	34	
Iron	2/2	310 - 940	100.0	-	**Flora**
Lead	2/2	8.2 - 14	0.0125	46.7	**Flora**
Magnesium	2/2	110 - 250	-	-	**Yes**
Manganese	2/2	3.4 - 6.9	-	330.0	
Sodium	1/2	70.00	-	-	**Yes**
Vanadium	2/2	1.3 - 2.7	-	58.0	
Zinc	2/2	11 - 30	-	150.0	

Notes:
(1) EPA Region III BTAG Screening Levels for Ecological risks (Jan 1995)

TABLE 7-11
ECOLOGICAL ASSESSMENT FOR SURFACE WATER
FT. STORY - LARC 60 MAINTENANCE AREA

Parameter	Frequency of Detection	Range of Detection	TBC Criteria		ARARs				Exceed or Lacking Criteria
			EPA Region III BTAG Screening (Freshwater) (1)		Virginia SW (Freshwater) Quality Standards(2)		Federal AWQC (Freshwater)(3)		
			Flora	Fauna	Acute	Chronic	Acute	Chronic	
VOCs (ug/l)									
Acetone	2/2	30 - 35	-	9,000,000	-	-	-	-	
SOCs (ug/l)	0/2	BDL							
TPH (mg/l)									
Total TPH	0/2	BDL							
Total Metals (ug/l)									
Aluminum	2/2	0.39 - 0.42	460	200	-	-	-	-	
Calcium	2/2	11 - 12	-	-	-	-	-	-	Yes
Iron	2/2	0.84 - 1.4	-	320	-	-	-	-	
Lead	2/2	0.0078 - 0.009	-	1	-	-	82	3.2	
Magnesium	2/2	15 - 17	-	-	-	-	-	-	Yes
Manganese	2/2	0.083 - 0.14	-	-	-	-	-	-	Yes
Potassium	2/2	9.1 - 9.4	-	-	-	-	-	-	Yes
Sodium	1/2	120.0	-	-	-	-	-	-	Yes
Zinc	2/2	0.04 - 0.062	110	110	-	-	120	110	

Notes:
(1) EPA Region III BTAG Screening Levels for Aquatics in Surface Water (Jan 1995)
(2) Virginia Surface Water Quality Standards (VR 680-21-01.14)
(3) Federal Ambient Water Quality Criteria (40 CFR 131)

TABLE 7-12
ECOLOGICAL ASSESSMENT FOR SURFACE SOIL
FT. STORY - AUTO CRAFT SITE

Parameter	Frequency of Detection	Range of Detection	TBC Criteria: EPA Region III BTAG Screening Levels (1)		Exceed or Lacking Criteria?
			Flora	Fauna	
VOCs (ug/kg)					
Methylene Chloride	1/6	41	-	<300.0	
Methyl ethyl ketone	1/6	55	-	-	**Yes**
Toluene	6/6	7.9 - 34	-	100.0	
Trichloroethene	1/6	33	-	<300.0	
SOCs (ug/kg)					
Acenaphthene	1/6	440.0	-	100.0	**Yes**
Benz(a)anthracene	1/6	2,500	-	100.0	**Yes**
Benzo(b)fluoranthene	1/6	4,100	-	100.0	**Yes**
Benzo(k)fluoranthene	1/6	490	-	100.0	**Yes**
Benzo(g,h,i)perylene	1/6	2,000	-	100.0	**Yes**
Benzo(a)pyrene	1/6	3,400	-	20,000.0	
Butylbenzylphthalate	1/6	550	5,300 - 260,000	5,300 - 260,000	
Chrysene	1/6	2,000	-	100.0	**Yes**
Fluoranthene	1/6	5,800	-	100.0	**Yes**
Indeno(1,2,3-cd)pyrene	1/6	1,500	-	100.0	**Yes**
Phenanthrene	1/6	1,300	-	100.0	**Yes**
Pyrene	1/6	11,000	-	100.0	**Yes**
TPH (mg/kg)					
Total TPH	3/6	220 - 390	-	-	
Metals (mg/kg)					
Aluminum	1/1	5,200	-	-	**Yes**
Arsenic	1/1	1.30	5.0	8.2	
Barium	1/1	82	-	440.0	
Calcuim	1/1	1,200	-	-	**Yes**
Chromium	1/1	9	0.02	0.0075	**Yes**
Cobalt	1/1	4.40	0.1	1,500.0	**Flora**
Copper	1/1	18	-	0.04	**Yes**
Iron	1/1	9,100	100.0	-	**Flora**
Lead	1/1	95	0.0125	0.01	**Yes**
Magnesium	1/1	2,400	-	-	**Yes**
Manganese	1/1	170	-	330.0	
Mercury	1/1	0.022	-	0.058	
Nickel	1/1	4.8	2.5	-	**Flora**
Potassium	1/1	2,700	-	-	**Yes**
Sodium	1/1	64	-	-	**Yes**
Vanadium	1/1	18	-	58.0	
Zinc	1/1	64	-	4.8	**Yes**

Note:
(1) EPA Region III BTAG Screening Levels for Ecological Risks (Jan 1995)

7.3.1 Potential Stressors

FTA Site

Both physical and chemical stressors do exist at the FTA site and in the surrounding wooded area. Physical stress is caused by the training activities in the area and former use of the site. These activities have prevented the revegetation of the northern end of the site and caused small burned areas in the woods. However, the physical disturbance occurs in a small area and chances of the physical stressor adversely effecting the surrounding areas and wildlife is minimal and is not considered long-term. Therefore, the physical stressors will not be addressed further in this assessment.

A detailed description of the extent of sampling conducted at the Site and full results are provided in Sections 2 and 4 of this report, respectively. Soil samples were taken in the northern area where stained soils were present, in the Former Fire Training Pit area, and in the Solvent Plume Area associated with the adjacent UST site. Sediment samples were taken within the drainage area in the woods located south of the site. No surface water was associated with the site.

Surface Soils

A total of 28 soil samples were analyzed for VOC, SOC and TPH contamination. Sampling locations are depicted in Figure 2-6. Toluene was detected in 25 of the 28 samples and was found to exceed the screening level in 1 of the samples. This sample was taken from the southeastern end of the site near the former UST area. Acetone, methyl ethyl ketone, and xylenes were also detected in the samples, and lacked screening criteria. However, these compounds were found at low frequency and at low levels, and were, therefore, not considered to be of concern. Of the SOCs detected in the samples, fluoranthene and pyrene values exceeded screening levels. Each was detected in 2 samples and exceeded criteria in 1. This sample was taken from the southeastern edge of the site, adjacent to the road. Total Petroleum Hydrocarbons (TPH) as heavy oils was detected in 3 samples, the highest being from the southeastern edge of the site, immediately north of the road. Polycyclic Aromatic Hydrocarbons (PAHs), more toxic components of TPH, were not detected at levels which exceeded regional criteria in samples which contained TPH. Therefore, due to the low frequency of detection and absence of detection of its components, TPH as heavy oils was not retained as a COPC.

A total of 5 soil samples were analyzed for contamination of metals. Several metals were detected with high frequency at levels that exceeded screening criteria. These metals included

chromium, copper, iron, lead, and zinc. In addition, aluminum, calcium, magnesium, and potassium lacked screening criteria. However, with the exception of lead, all concentrations detected are consistent with site-specific and regional background levels. Therefore, only lead was considered a COPC in surface soils.

The compounds chosen as chemicals of potential concern for surface soils for the FTA Ecological Risk Assessment are shown in Table 7-13.

Sediment

Sediment samples were taken from 4 locations in the adjacent woodland. All samples were analyzed for VOC, SOC, TPH, and metal concentrations. Toluene was detected in all 4 samples and exceeded screening criteria in 1 sample. This sample was taken closest to the former UST site. TPH as heavy oils was detected in 3 samples, but no PAHs were found above the detection limits. Metals were detected in several samples that exceeded the screening criteria for flora. Some metals detected lacked screening criteria. However, most of these concentrations were consistent with site-specific and regional background levels. Because no background levels were available for thallium and due to its toxicity, thallium was retained as a COPC for sediment even though it was detected in only 1 of the 4 samples. The level of lead detected in 1 sample exceeded screening criteria for flora and fauna and was higher than background concentrations. Therefore, lead was considered as a COPC for sediment.

The compounds chosen as chemicals of potential concern for sediment for the FTA Ecological Risk Assessment are shown in Table 7-14.

LARC 60 Site

Both physical and chemical stressors exist at the LARC 60 site and in the surrounding wooded area. Physical stress is caused by the training activities in the area which include driving the LARCs and other heavy equipment in the Sandbox. These activities prevent vegetation from becoming established in the Sandbox and have caused some stress on the vegetation in the small wooded island. However, the physical disturbance occurs in a small area and chances of the physical stressor adversely effecting the surrounding areas and wildlife is minimal and is not considered long-term. Therefore, the physical stressors will not be addressed further within the scope of this assessment.

TABLE 7-13
COPCs and EXPOSURE POINT CONCENTRATIONS - SURFACE SOILS
FORT STORY - FTA SITE

Parameter	Frequency of Detection	Range of Detection	Maximum Concentration	95th UCL Concentration
VOCs (mg/kg)				
Toluene	25/28	.0083 - 0.140	1.40E-01	4.81E-02
SOCs (mg/kg)				
Fluoranthene	2/28	0.075 - 0.650	6.50E-01	NA
Pyrene	2/28	0.064 - 0.720	7.20E-01	NA
Metals (mg/kg)				
Lead	5/5	7.0 - 33.0	3.30E+01	NA

Note: Shading indicates concentration selected for exposure calculations

TABLE 7-14
COPCs and EXPOSURE POINT CONCENTRATIONS - SEDIMENT
FORT STORY - FTA SITE

Parameter	Frequency of Detection	Range of Detection	Maximum Concentration	95th UCL Concentration
VOCs (mg/kg)				
Toluene	4/4	.023 - 0.180	1.80E-01	NA
METALS (mg/kg)				
Lead	4/4	4.3 - 210	2.10E+02	NA
Thallium	1/4	1.4	1.40E+00	NA

Note: Shading indicates concentration selected for exposure calculations

Soil samples were taken from the Sandbox, adjacent wooded area, the wash rack, the oil/water separator, and the former UST site. Sediment and surface water samples were taken within the drainage ditch in the woods north of the Sandbox.

Surface Soils

← table 7.6 need to include VOCs

A total of 22 soil samples were analyzed for VOCs, SOCs, and TPH concentrations. Five soil samples were also analyzed for metal concentrations. Sampling locations are depicted in Figure 2-9. Although VOCs were detected in some of the surface soil samples, none of the concentrations exceed regional criteria levels. Acetone was detected in 1 sample and lacked screening criteria. However, due to the low frequency and the low level at which it was detected, it was not considered to be of concern. Total TPH was detected in 19 of the 22 samples. These samples were taken from the former UST area, the wash rack, the Sandbox and the wooded area. PAHs were not detected at levels which exceeded regional criteria for any of the samples. Total TPH was not retained as a COPC, since the more toxic components of TPHs were infrequently detected and at low levels. Several metals were detected with high frequency at concentrations that exceeded regional screening criteria. Metals that exceeded criteria included chromium, cobalt, copper, iron, lead, and zinc. In addition, aluminum, calcium, magnesium, and potassium lacked screening criteria. However, these concentrations were consistent with site-specific and regional background levels for metals. Therefore, no compounds were selected as COPCs for surface soils.

These two statements contradict themselves

Sediment

A total of 2 sediment samples were taken from the drainage ditch adjacent to the site and analyzed for VOCs, SOCs, TPH and metal concentrations. VOC and SOCs were not detected in the samples. Total TPH was detected in both samples. Because PAHs were not detected in the samples, TPH was not considered to be of potential concern. Metals that exceeded or lacked criteria were detected in both samples. These levels are consistent with site-specific and regional background concentrations. Therefore, no COPCs for sediment were selected.

Surface Water

Two surface water samples were taken from the adjacent drainage ditch. Acetone was detected in both samples at levels below regional criteria. SOCs and TPHs were not detected in either sample. Metals were detected in some of the samples. Calcium, magnesium, manganese, potassium, and sodium do not have screening criteria. These constituents are naturally

occurring and were found at low levels in the samples taken. Therefore, they were not considered to be of concern. No COPCs were selected for surface water.

Auto Craft Site

Very little physical disturbance occurs at the site. Since the site is used as a vehicle impoundment lot, there is little human activity. Therefore, impacts from physical disturbance will not be considered for this site.

A total of 6 surface soil samples were taken from within the fenced area, downgradient of the site, and in the grassy areas to the west of the site. All samples were tested for VOC, SOC and TPH concentrations. One sample was further tested for metal concentrations. The VOCs detected were found to be at levels below screening criteria. Methyl ethyl ketone lacks screening criteria. However, it was detected in 1 sample at a low level and was not considered to be of concern. Several SOCs that were detected from the soil sample taken from within the fenced area were found to be above screening criteria. These were retained as COPCs. SOCs were not detected in any other sample. Total TPH was detected in three of the samples, all of which were sampled in the grassy area downgradient from the fenced auto craft area. Because several PAHs were considered of concern due to their detected level in the auto craft area and their lack of detection in the grassy areas, the less toxic TPH was not considered of potential concern. Several metals that were detected in the sample analyzed exceeded or lacked screening criteria. Again, the majority of these metals were detected at concentrations that fell within site-specific or regional background levels. These compounds included chromium, cobalt, magnesium, nickel, potassium, and sodium. Although the level of iron detected fell below regional background levels, it was retained as a COPC because its detection level far exceeded the levels detected at the two other sites investigated at Fort Story. In addition, the level of copper detected in 1 sample fell within regional background concentrations but far exceeded the Fort Story background concentrations. Therefore, copper was retained as a COPC. Lead and zinc were selected as COPCs because the levels detected exceeded screening criteria, site-specific background concentrations, and regional background concentrations. Neither sediment nor surface water existed at the site.

What was the level?

The compounds chosen as chemicals of potential concern for the Auto Craft Ecological Risk Assessment are shown in Table 7-15.

TABLE 7-15
COPCs and EXPOSURE POINT CONCENTRATIONS - SURFACE SOILS
FORT STORY - AUTO CRAFT SITE

Parameter	Frequency of Detection	Range of Detection	Maximum Concentration	95th UCL Concentration
SOCs (mg/kg)				
Acenaphthene	1/6	0.44	4.40E-01	3.11E-01
Benz(a)anthracene	1/6	2.50	2.50E+00	2.95E+00
Benzo(b)fluoranthene	1/6	4.10	4.10E+00	1.18E+01
Benzo(k)fluoranthene	1/6	0.49	4.90E-01	3.39E-01
Benzo(g,h,i)perylene	1/6	2.00	2.00E+00	2.00E+00
Chrysene	1/6	2.00	2.00E+00	2.00E+00
Fluoranthene	1/6	5.80	5.80E+00	1.76E+01
Indeno(1,2,3-cd)pyrene	1/6	1.50	1.50E+00	1.26E+00
Phenanthrene	1/6	1.30	1.30E+00	1.02E+00
Pyrene	1/6	11.00	1.10E+01	8.91E+01
Metals (mg/kg)				
Copper	1/1	18	1.80E+01	NA
Iron	1/1	9,100	9.10E+03	NA
Lead	1/1	95	9.50E+01	NA
Zinc	1/1	64	6.40E+01	NA

Note: Shading indicates concentration selected for exposure calculations

7.3.2 Exposure Pathways

Several ecologically relevant migration pathways for contaminants exist at the Site. Wildlife may have incidental contact with or ingestion of contaminants while foraging, nesting, or engaging in other activities in the site. Chemical contaminants can also adversely affect plants and animals in surrounding habitats via the food chain.

Upon their release, some site contaminants are persistent and may be transformed to more bioavailable forms and mobilized in the food chain. Mobilization of contaminants in the terrestrial food chain could occur through the following pathways:

- Root uptake from contaminated soil by herbaceous plants,
- Contact and absorption, incidental ingestion, and feeding on contaminated food by invertebrates,
- Drinking of contaminated surface water by wildlife, and
- Bioaccumulation from vegetation or animal prey at the base of the food chain by wildlife.

Based on these pathways, the following general classes of ecological receptors potentially might be exposed to contaminants at the Fort Story sites.

- Terrestrial plants growing within and adjacent to the sites,
- Terrestrial invertebrates likely to occur in surface soils and benthic invertebrates occurring within the sediments,
- Birds that forage or nest within the areas,
- Small mammals that reside and/or feed in the vicinity of the areas, and
- Other higher trophic level wildlife species (e.g., carnivores) that feed within the vicinity of the sites.

7.3.3 Ecological Effects

As discussed earlier, several site contaminants are present in soil, sediment, and surface water and exceed ecological concern levels and therefore, may have adverse effects on biota in the vicinity of the sites.

FTA Site

The COPCs for the FTA site include the following:

- **Surface Soil** - toluene, fluoranthene, pyrene, and lead
- **Sediment** - toluene, lead, and thallium

LARC 60 Site

The COPCs for the LARC 60 site include the following:

- **Surface Soil** - none
- **Sediment** - none
- **Surface Water** - none

Auto Craft Site

The COPCs for the Auto Craft site include the following:

- **Surface Soil** - acenaphthene, benz(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(g,h,i)perylene, chrysene, fluoranthene, indeno(1,2,3-cd)pyrene, phenanthrene, pyrene, copper, iron, lead, and zinc

Descriptions of the environmental fate and transport of these chemicals, as well as bioaccumulation potential and toxicity, with regard to various aquatic and terrestrial organisms, are included as Appendix K of this document.

7.4 ECOLOGICAL ENDPOINTS

Based on the potential pathways and receptors identified and described in Section 7.3, detrimental effects (i.e., reduced vigor or population decline) in vegetation, invertebrates, small mammals, birds, and carnivores were selected as the assessment endpoints for the Sites.

Endpoint species considered representative of the local wildlife populations that would use and frequent each Site are presented below. The species were selected based on their potential exposure (i.e., site usage, food habitats, home range size) and susceptibility to adverse effects of the site contaminants.

7.4.1 FTA Site

Following is a brief description of the habitat requirements and diet of the terrestrial endpoint species selected for the FTA Site. In addition, the reasons for selection of these species are discussed.

- **Herbaceous Vegetation.** Plants that occur in pine/oak woodland and disturbed areas of the northeastern United States are likely to occur at the Site. These plants include herbaceous species that serve as an important food source for songbirds, small mammals, and larger herbivores. The measurement endpoints for terrestrial vegetation are published phytotoxicity reference values for each contaminant.

- **Soil/Sediment Invertebrates.** Invertebrates that are common in sandy soils in Southeastern Virginia are likely to occur within and adjacent to the site. In addition, sediment invertebrates that favor intermittent streams or damp soils are likely to occur within the drainage area adjacent to the site. These invertebrates are an important food source for ground gleaning birds and small mammals. The measurement endpoints for soil/sediment invertebrates are published toxicity reference values for each contaminant.

- **Killdeer (*Charadrius vociferus*).** The Killdeer is common in Virginia, remaining in the area year-round. A typical density measured during the breeding season is 3.9 pairs per 100 acres, yielding an approximate home range of 25.6 acres per pair (10.36 hectares). Breeding Killdeer prefer open meadows, edges of pasture, and dry uplands. In all areas, sparse or closely cropped vegetation is required. Preferred food items include insects (especially beetles and grasshoppers), centipedes, spiders, worms, and seeds (Degraaf and Rudis, 1986).

The Killdeer has been selected to represent the ground-gleaning insectivorous bird community at the FTA site. Although the Killdeer is considered an insectivorous bird and may not represent other avian species that concentrate on seeds and worms, it represents avian food-chain exposure most likely at the site. The FTA site does not provide suitable forage habitat for avian species that prefer worms. Insectivorous birds such as the Killdeer are more likely to frequent the site.

Measurement endpoints for the Killdeer are derived from avian toxicity data taken from published dose-response studies that relate contaminant exposure or uptake to effects on individual organisms.

- **White-footed Mouse (*Peromyscus leucopus*).** This common small mammal occurs throughout Virginia and occupies home ranges from 0.054 to 0.072 hectares. It is found in a variety of habitats including interiors and edges of deciduous and coniferous forests, scrub areas, clearings, pastures, stream-side thickets, and buildings. The White-footed Mouse consumes arthropods, seeds, and other vegetation. It is active throughout the year and usually nests off the ground. (USEPA, 1993).

  The White-footed Mouse has been selected to represent the small mammal community at the FTA site. As a receptor with an omnivorous diet, the mouse is representative of herbivorous and insectivorous small mammals present within the boundaries of the site. Due to the scarcity of vegetation on the site itself, larger herbivores such as rabbits are unlikely to make significant use of the area.

  Measurement endpoints for the White-footed Mouse are derived from rodent toxicity data taken from published dose-response studies that relate contaminant exposure or uptake to effects on individual organisms.

- **Gray Fox (*Urocyon cinereoargenteus*).** Gray Foxes are present throughout the United States, except in the northwest and northern prairies. Foxes are secretive and nocturnal, and will often climb trees to evade predators. Gray foxes prey on small mammals but will also eat insects, fruits, acorns, birds, and eggs. The home range of this species varies from 57 and 855 hectares (USEPA, 1993). This species is similar in size and habits of the Red Fox (*Vulpes vulpes*).

  The Gray Fox has been selected to represent the terrestrial carnivore community at the Site. Although the Merlin and Red-tailed Hawk may also represent other potential endpoint species in the carnivore category, their home ranges are typically much larger than that of the fox, and their use of the FTA site is likely to be restricted.

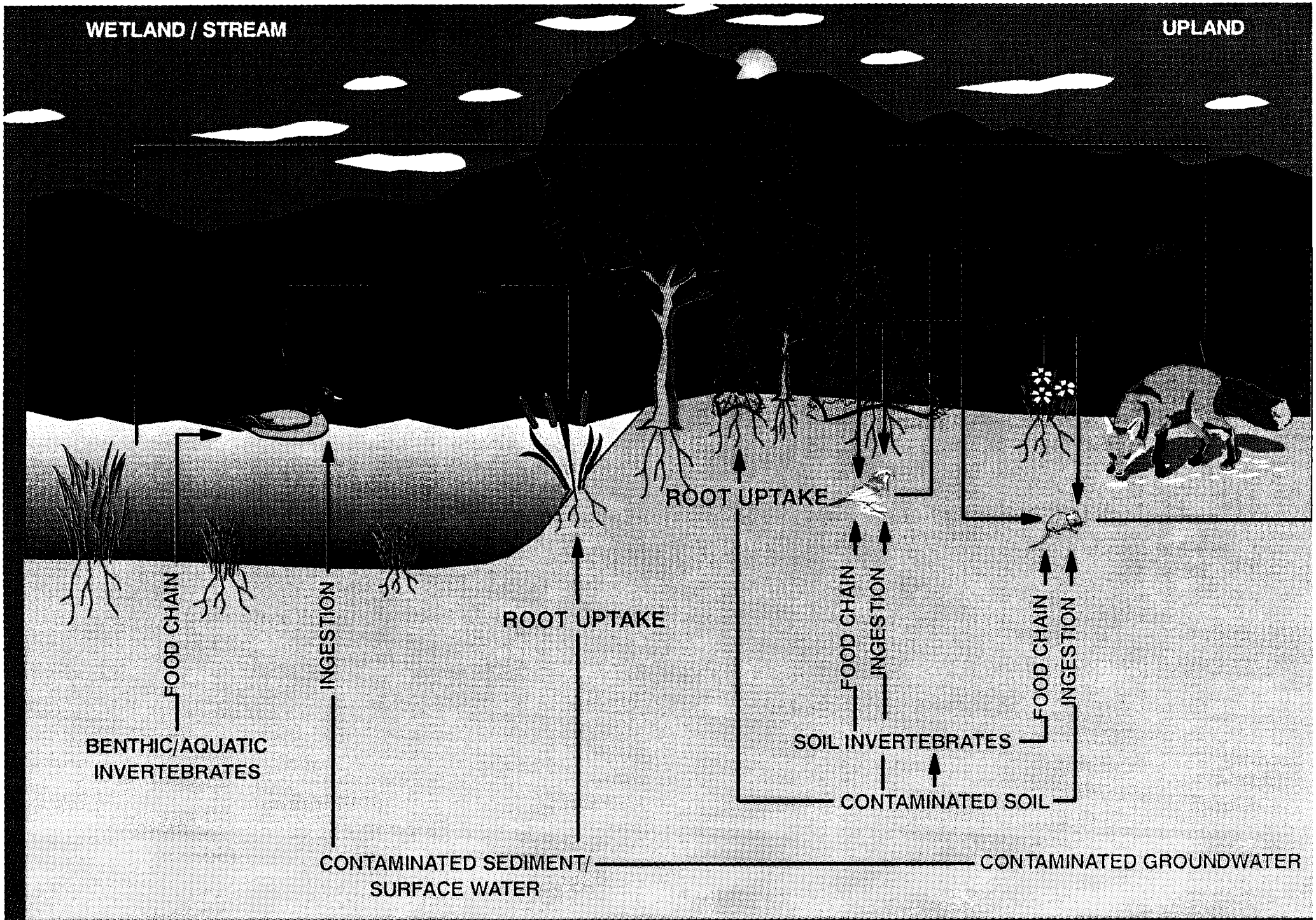

Figure 7-1 POTENTIAL EXPOSURE PATHWAYS FOR ECOLOGICAL RECEPTORS AT THE FORT STORY SITE

7.6 EXPOSURE ASSESSMENT AND RISK CHARACTERIZATION

This section includes site-specific information pertinent to the assessment of potential ecological exposures to contaminants at the Site. General discussions of ecosystems of concern, pathways and COPC are provided in Sections 7.2 and 7.3.

7.6.1 Exposure Point Concentrations

Exposure media of ecological concern at the sites include surface soils and sediment. Groundwater is not considered because the potential for exposure to groundwater is minimal. Surface water only exists at the LARC 60 site. The maximum exposure case is considered for terrestrial vegetation, because it is immobile. In this case, the maximum value best represents the most exposure received and therefore is a conservative estimate of the exposure experienced by the population. The average exposure case is considered for terrestrial wildlife receptors, since they are mobile and are not likely to be exposed to only the maximum concentrations of contaminants. Exposure point concentrations (EPCs) calculated for the average exposure case are the 95 percent upper-confidence limit (95% UCL) of the arithmetic mean of COPC concentrations in surface soil and sediment. When the 95% UCL concentrations of surface soil and sediment data could not be calculated due to the small sample size for each subsite (5 samples or fewer), the maximum concentrations of COPC in these media were used. When the same contaminant occurred in surface soil and sediment and wildlife receptors would be exposed to both media, the largest concentration was selected for exposure calculations. Exposure point concentrations for the COPC used in exposure calculations are highlighted in Tables 7-13 through 7-15.

7.6.2 Exposure Scenarios and Pathways

As explained previously, three wildlife scenarios were selected for the quantitative risk assessment: a small mammal, an insectivorous bird, and a terrestrial carnivore. The exposure parameters used to estimate exposure through incidental ingestion of soil and sediment, and exposure through food-chain receptors, are provided in Table 7-16.

The exposure parameters were derived or obtained from published sources (primarily the USEPA's Wildlife Exposure Factors Handbook, USEPA, 1993). The rate of incidental ingestion of sediment was assumed to be the same as the rate of ingestion of soil.

TABLE 7-16

EXPOSURE FACTORS FOR ECOLOGICAL RECEPTORS
FORT STORY - FTA SITE AND AUTO CRAFT SITE

Receptor	Exposure Factors [1]									
			Dietary Composition (% diet)							
	NIR_f (g/g-day)	IR (kg/day)(dw)	Vegetation	Invertebrates	Birds	Small Mammals	Soil/Sediment Ingestion	Body Weight (kg)	Home Range (hectares)	Exposure Duration[2]
Killdeer	0.134	0.0123	10%[3]	90%[3]	0%	0%	10%[4]	0.092 [5]	10.36 [6]	0.66
White-footed Mouse	0.20	0.003	42%	58%	0%	0%	<2%	0.0225	0.61	1
Gray Fox	0.09	0.24	7%	0%	46.50%	46.50%	2.80%	4.5	96	1

Notes:

NIR_w = Ingestion rate of water, normalized to body weight.

NIR_f = Ingestion rate of food, normalized to body weight.

IR = Daily ingestion rate of food.

[1] Reference: USEPA, 1993 (unless otherwise noted)

[2] = Fraction of year spent in region, 0-1 (unitless), Killdeer is migratory

[3] = Martin et. al., 1961.

[4] = Beyer et. al., 1992.

[5] = Dunning Jr., 1993.

[6] = DeGraaf and Rudis, 1986.

Area of Sites:

FTA	1.5 Ha
Auto Craft	.33 Ha

To estimate exposure through the terrestrial and wetland food chains, bioaccumulation factors (BAFs) for plants (plant uptake factors or PUFs) and soil/sediment invertebrates (IUFs) were derived from published sources. Using these BAFs, tissue levels in potential food items of the endpoint species were calculated. When soil and sediment invertebrate uptake values were not available, it was assumed that the uptake rate of contaminants was similar to that of earthworms. Where BAFs were not available, the plant and/or invertebrate tissue concentrations were assumed to be equal to the soil or sediment concentration. Concentrations in the prey of Gray Fox (small mammals) were assumed to be equal to the concentrations in their food source. Plant uptake factors and invertebrate uptake factors are provided in Table 7-17.

7.6.3 Exposure Estimates

The estimated exposures for terrestrial herbaceous vegetation and terrestrial invertebrates were derived from maximum surface soil and sediment concentrations of COPCs, as shown in Table 7-18.

Dietary exposure and exposure from ingestion of soil or sediment for each wildlife species were calculated using equations derived from USEPA's "Wildlife Exposure Factors Handbook" (USEPA, 1993), as described below.

Estimates of exposure to contaminants in soil/sediment via ingestion were made for the receptors by using equations adapted from USEPA's Wildlife Exposure Factors Handbook (USEPA, 1993), as follows:

$$EE_{soil/sediment} = (C \times FS \times IR_{total}(\text{dry weight}) \times FR) / BW$$

Where:

$EE_{soil/sediment}$	=	Estimated exposure through ingestion of soil\sediment (mg/kg BW-day)
C	=	Contaminant concentration in soil/sediment in the area of concern (mg/kg dry weight)
FS	=	Fraction of soil\sediment in diet (as percentage of diet on a dry-weight basis divided by 100; unitless)
IR_{total}	=	Food ingestion rate on a dry-weight basis (kg/day)
FR	=	Fraction of total food intake from the area of concern (unitless)
BW	=	Body weight (kg)

TABLE 7-17

PLANT AND INVERTEBRATE UPTAKE FACTORS
FORT STORY, VIRGINIA

Chemical	Plant Uptake Factor	Reference	Invertebrate (Earthworm) Uptake Factor	Reference
PAHs	0.0122(a)	(b)	0.7(a)	(c)
Toluene	0.94	(b)	1	(f)
Copper	0.4	(e)	2.4	(h)
Iron	0.004	(e)	1	(f)
Lead	0.045	(e)	0.95	(g)
Thallium	0.004	(e)	1	(f)
Zinc	1.5	(e)	5.7	(g)

Notes:

(a)Value is for benzo[a]pyrene.
(b) Calculated as $PUF = 38.9(Kow)^{-0.58}$, fromTravis and Hattemer-Frey, 1988.
(c)Beyer, 1990.
(d)Ma, 1982.
(e)Baes et al., 1984
(f)Assumed to equal soil concentration (EUF = 1) since earthworm uptake information was not found for this chemical.
(g)Gish and Christensen, 1973.
(H)Beyer et. al., 1982

TABLE 7-18

ESTIMATED TOXICITY TO TERRESTRIAL PLANTS AND SOIL/SEDIMENT INVERTEBRATES
FORT STORY, VIRGINIA

	FTA Site	Auto Craft Site	Phytotoxicity Value[1]	Invertebrate (Earthworm) Toxicity Value[2]	Exceeds Ecological Criteria?
Surface Soil (mg/kg)					
Toluene	1.40E-01	~	2.00E+02	NA	No
Acenaphthene	~	4.40E-01	2.00E+01	NA	No
Benzo(a)anthracene	~	2.50E+00	NA	NA	
Benzo(b)fluoranthene	~	4.10E+00	NA	NA	
Benzo(k)fluoranthene	~	4.90E-01	NA	NA	
Benzo(g,h,i)perylene	~	2.00E+00	NA	NA	
Chrysene	~	2.00E+00	NA	NA	
Fluoranthene	6.50E-01	5.80E+00	NA	NA	
Indeno(1,2,3-cd)pyrene	~	1.50E+00	NA	NA	
Phenanthrene	~	1.30E+00	NA	NA	
Pyrene	7.20E-01	1.10E+01	NA	NA	
Copper	~	1.80E+01	1.00E+02	5.00E+01	No
Iron	~	9.10E+03	NA	NA	
Lead	3.30E+01	9.50E+01	5.00E+01	5.00E+02	Yes (veg. - AC Site)
Zinc	~	6.40E+01	5.00E+01	2.00E+02	Yes (vegetation)
Sediment (mg/kg)					
Toluene	1.80E-01	~	2.00E+02	NA	No
Lead	2.10E+02	~	5.00E+01	9.00E+02	Yes (vegetation)
Thallium	1.40E+00	~	1.00E+00	NA	Yes (vegetation)

Notes:

~ = Not a COPC or was not tested at the site

NA = Not Available

References:

(1) Will and Suter, 1995b

(2) Will and Suter, 1995a

The food ingestion rate on a dry-weight basis was estimated based on body weight (USEPA, 1993):

Birds: IR_{total} (kg/day) = 0.0582 $BW^{0.651}$ (kg)
Mammals: IR_{total} (kg/day) = 0.0687 $BW^{0.822}$ (kg)

Estimates of exposure to contaminants via dietary sources were made for the receptors by using equations adapted from USEPA's Wildlife Exposure Factors Handbook (USEPA, 1993), as follows:

$$EE_{diet} = \sum_{k=1}^{m} (C_k \times FR_k \times NIR_k)$$

Where:

EE_{diet}	=	Estimated exposure through diet (e.g., in mg/kg BW-day)
C_k	=	Average contaminant concentration in the kth type of food (e.g., in mg/kg wet weight).
FR_k	=	Fraction of intake of the kth food type that is contaminated (unitless).
NIR	=	Normalized ingestion rate of the kth food type on a wet weight basis (e.g., in g/g-day).
m	=	Number of contaminated food types

The estimated exposure through ingestion of soil/sediment and food for each of the wildlife receptors is given in Tables 7-19 through 7-24. Full exposure calculations are presented in Appendix M.

TABLE 7-19
ESTIMATED EXPOSURE TO KILLDEER - FTA SITE
FORT STORY, VIRGINIA

Chemical (mg/kg)	Estimated Exposure from Soil/Sediment (mg/kg BW-day)	Estimated Exposure from Invertebrates (mg/kg BW-day)	Estimated Exposure from Vegetation (mg/kg BW-day)	Total Estimated Exposure (mg/kg BW-day)
Toluene	2.31E-04	2.09E-03	2.18E-04	2.54E-03
Fluoranthene	8.34E-04	5.29E-03	1.02E-05	6.13E-03
Pyrene	9.24E-04	5.85E-03	1.13E-05	6.79E-03
Lead	2.70E-01	2.32E+00	1.22E-02	2.60E+00
Thallium	1.80E-03	1.63E-02	7.20E-06	1.81E-02

Notes:
BW = Body Weight
NA = Not Available

TABLE 7-20
EXTIMATED EXPOSURE TO
WHITE-FOOTED MOUSE - FTA SITE
FORT STORY, VIRGINIA

Chemical	Estimated Exposure from Soil/Sediment (mg/kg BW-day)	Estimated Exposure from Invertebrates (mg/kg BW-day)	Estimated Exposure from Vegetation (mg/kg BW-day)	Total Estimated Exposure (mg/kg BW-day)
Toluene	4.80E-04	2.09E-02	1.42E-02	3.56E-02
Fluoranthene	1.73E-03	5.28E-02	6.66E-04	5.52E-02
Pyrene	1.92E-03	5.85E-02	7.38E-04	6.11E-02
Lead	5.60E-01	2.31E+01	7.94E-01	2.45E+01
Thallium	3.73E-03	1.62E-01	4.70E-04	1.67E-01

Notes:
BW = Body Weight
NA = Not Available

TABLE 7-21
ESTIMATED EXPOSURE TO
GRAY FOX - FTA SITE
FORT STORY, VIRGINIA

Chemical	Estimated Exposure from Surface Soil (mg/kg BW-day)	Estimated Exposure from Prey (mg/kg BW-day)	Estimated Exposure from Vegetation (mg/kg BW-day)	Estimated Exposure from Diet (mg/kg BW-day)	Total Estimated Exposure (mg/kg BW-day)
Toluene	4.30E-06	2.34E-04	1.71E-05	2.51E-04	2.55E-04
Fluoranthene	1.55E-05	3.10E-04	7.99E-07	3.11E-04	3.26E-04
Pyrene	1.72E-05	3.43E-04	8.85E-07	3.44E-04	3.61E-04
Lead	5.02E-03	1.40E-01	9.53E-04	1.41E-01	1.46E-01
Thallium	3.35E-05	9.41E-04	5.64E-07	9.42E-04	9.75E-04

Notes:
BW = Body Weight
NA = Not Available

TABLE 7-22
ESTIMATED EXPOSURE TO
KILLDEER - AUTO CRAFT SITE
FORT STORY, VIRGINIA

Chemical (mg/kg)	Estimated Exposure from Soil (mg/kg BW-day)	Estimated Exposure from Invertebrates (mg/kg BW-day)	Estimated Exposure from Vegetation (mg/kg BW-day)	Total Estimated Exposure (mg/kg BW-day)
Acenaphthene	8.73E-05	5.53E-04	1.07E-06	6.42E-04
Benz(a)anthracene	7.02E-04	4.45E-03	8.58E-06	5.16E-03
Benzo(b)fluoranthene	1.15E-03	7.29E-03	1.41E-05	8.46E-03
Benzo(k)fluoranthene	9.52E-05	6.03E-04	1.16E-06	6.99E-04
Benzo(g,h,i)perylene	5.62E-04	3.56E-03	6.87E-06	4.13E-03
Chrysene	5.62E-04	3.56E-03	6.87E-06	4.13E-03
Fluoranthene	1.63E-03	1.03E-02	1.99E-05	1.20E-02
Indeno(1,2,3-cd)pyrene	3.54E-04	2.24E-03	4.33E-06	2.60E-03
Phenanthrene	2.86E-04	1.81E-03	3.50E-06	2.10E-03
Pyrene	3.09E-03	1.96E-02	3.78E-05	2.27E-02
Copper	5.05E-03	1.10E-01	2.03E-03	1.17E-01
Iron	2.55E+00	2.31E+01	1.02E-02	2.57E+01
Lead	2.67E-02	2.29E-01	1.20E-03	2.57E-01
Zinc	1.80E-02	1.32E+02	2.70E-02	1.32E+02

Notes:
BW = Body Weight
NA = Not Available

TABLE 7-23
ESTIMATED EXPOSURE TO
WHITE-FOOTED MOUSE - AUTO CRAFT SITE
FORT STORY, VIRGINIA

Chemical	Estimated Exposure from Soil (mg/kg BW-day)	Estimated Exposure from Invertebrates (mg/kg BW-day)	Estimated Exposure from Vegetation (mg/kg BW-day)	Total Estimated Exposure (mg/kg BW-day)
Acenaphthene	4.48E-04	1.36E-02	1.72E-04	1.43E-02
Benz(a)anthracene	3.60E-03	1.10E-01	1.38E-03	1.15E-01
Benzo(b)fluoranthene	5.90E-03	1.80E-01	2.27E-03	1.88E-01
Benzo(k)fluoranthene	4.88E-04	1.49E-02	1.88E-04	1.55E-02
Benzo(g,h,i)perylene	2.88E-03	8.77E-02	1.11E-03	9.17E-02
Chrysene	2.88E-03	8.77E-02	1.11E-03	9.17E-02
Fluoranthene	9.36E-04	2.85E-02	3.60E-04	2.98E-02
Indeno(1,2,3-cd)pyrene	1.81E-03	5.52E-02	6.97E-04	5.78E-02
Phenanthrene	1.47E-03	4.47E-02	5.64E-04	4.68E-02
Pyrene	1.04E-03	3.16E-02	3.98E-04	3.30E-02
Copper	2.59E-02	2.71E+00	3.27E-01	3.06E+00
Iron	1.31E+01	5.70E+02	1.65E+00	5.85E+02
Lead	1.37E-01	5.65E+00	1.94E-01	5.98E+00
Zinc	9.22E-02	3.25E+03	4.35E+00	3.25E+03

Notes:
BW = Body Weight
NA = Not Available

TABLE 7-24
ESTIMATED EXPOSURE TO
GRAY FOX - AUTO CRAFT SITE
FORT STORY, VIRGINIA

Chemical	Estimated Exposure from Surface Soil (mg/kg BW-day)	Estimated Exposure from Prey (mg/kg BW-day)	Estimated Exposure from Vegetation (mg/kg BW-day)	Estimated Exposure from Diet (mg/kg BW-day)	Total Estimated Exposure (mg/kg BW-day)
Acenaphthene	1.39E-06	2.78E-05	7.17E-08	2.79E-05	2.93E-05
Benz(a)anthracene	1.12E-05	2.24E-04	5.76E-07	2.24E-04	2.35E-04
Benzo(b)fluoranthene	1.84E-05	3.67E-04	9.45E-07	3.68E-04	3.86E-04
Benzo(k)fluoranthene	1.52E-06	3.03E-05	7.82E-08	3.04E-05	3.19E-05
Benzo(g,h,i)perylene	8.96E-06	1.79E-04	4.61E-07	1.79E-04	1.88E-04
Chrysene	8.96E-06	1.79E-04	4.61E-07	1.79E-04	1.88E-04
Fluoranthene	2.91E-06	5.81E-05	1.50E-07	5.83E-05	6.12E-05
Indeno(1,2,3-cd)pyrene	5.64E-06	1.13E-04	2.91E-07	1.13E-04	1.19E-04
Phenanthrene	4.57E-06	9.12E-05	2.35E-07	9.14E-05	9.60E-05
Pyrene	3.23E-06	6.44E-05	1.66E-07	6.45E-05	6.78E-05
Copper	8.06E-05	6.33E-03	1.36E-04	6.46E-03	6.54E-03
Iron	4.08E-02	8.14E-01	2.10E-03	8.16E-01	8.57E-01
Lead	4.26E-04	8.49E-03	2.19E-05	8.52E-03	8.94E-03
Zinc	2.87E-04	5.72E-03	1.48E-05	5.74E-03	6.02E-03

Notes:
BW = Body Weight
NA = Not Available

The test species and receptor species NOAELs are provided for each of the COPC in Table 7-25.

7.8 RISK CHARACTERIZATION

In this section, the ecological risks posed by COPC at the sites are identified and summarized. Risk characterization involves two major steps: risk estimation and risk description (USEPA, 1992). The risks are estimated in Section 7.8.1 using general comparisons and hazard quotients (HQs) calculated with estimated exposure and toxicity reference values for each endpoint species. The ratios are summarized, and the principal uncertainties of the assessment are discussed in Section 7.8.2. The ecological significance of the findings and recommendations for further study are discussed in Section 7.9.

7.8.1 Hazard Quotients

FTA Site

The levels of lead and thallium in sediment were found to exceed phytotoxicity values. Phytotoxicity and invertebrate toxicity values were not available for flouranthene or pyrene.

The hazard quotients (HQs) for the maximum exposure case are summarized in Table 7-26. The wildlife HQs were all less than 1, with the exception of an exceedence of 1 for lead and thallium for the White-footed Mouse. These results indicate that the maximum concentrations of these COPCs are unlikely to pose a risk to the Killdeer, White-footed Mouse, or Gray Fox at the FTA site. Avian toxicity values were not available for toluene, fluoranthene, pyrene or thallium. Therefore, the potential risks of these COPCs to the Killdeer were not evaluated.

Auto Craft Site

The levels of lead and zinc were found to exceed the phytotoxicity values. Phytotoxicity or invertebrate toxicity values were not available for most PAHs or iron.

The HQs for the average exposure case are summarized in Table 7-27. The levels of zinc were found to exceed both Killdeer and White-footed Mouse toxicity values (HQ>1). The wildlife HQs were less than 1 for all other compounds where TRVs were available. These results indicate that the mean concentrations of the SOCs and the maximum concentrations of metals are

TABLE 7-25

NOAELS FOR BIRDS AND MAMMALS: ENVIRONMENTAL ASSESSMENT
FORT STORY, VIRGINIA

COPC	NOAELs[1] (mg/kg BW-day)				
	Test Species (Avian)	Killdeer	Test Species (Mammal)	White-footed Mouse	Gray Fox
Toluene	NA	NA	25.98 (rat)	28.78	4.97
PAHs	NA	NA	1(mus)[2]	1.11	0.19
Copper	33.21(ck)	50.73	11.71 (mk)	41.26	7.13
Iron	NA	NA	NA	NA	NA
Lead	3.85 (ak)	4.21	8 (rat)	19.94	3.44
Thallium	NA	NA	0.0074 (rat)	0.019	0.003
Zinc	3 (ma)	6.12	160 (rat)	398.72	68.88

Notes:

NA = Not Available

[1] NOAELs for laboratory species converted to receptor species NOAELs as follows (Opresko et al., 1994):

$$NOAEL_r = NOAEL_t\ (bw_t/bw_r)^{1/3}$$

Where: $NOAEL_r$ = receptor NOAEL
$NOAEL_t$ = test species NOAEL
bw_r = receptor body weight
bw_t = test species body weight

Body weights of test species (kg):

Mallard (ma) = 1.3
Chicken (ck) = 0.0328 (chick)
American Kestrel (ak) = 0.12
Rat = 0.35
Mouse (mus) = 0.03
Mink (mk) = 1.0

[2] Value is for Benzo(a)pyrene

Reference:

Opresko et al., 1994.

TABLE 7-26
SUMMARY OF EXPOSURE ESTIMATES AND HAZARD QUOTIENTS
FTA SITE, FORT STORY, VIRGINIA

Chemical	Killdeer			White-footed Mouse			Gray Fox		
	EE_{total}	NOAEL	HQ	EE_{total}	NOAEL	HQ	EE_{total}	NOAEL	HQ
	mg/kg BW-day			mg/kg BW-day			mg/kg BW-day		
Toluene	2.54E-03	NA	NA	3.56E-02	2.88E+01	1.24E-03	2.56E-04	4.97E+00	5.16E-05
Fluoranthene	6.13E-03	NA	NA	5.52E-02	1.11E+00	4.98E-02	3.26E-04	1.91E-01	1.71E-03
Pyrene	6.79E-03	NA	NA	6.11E-02	1.11E+00	5.52E-02	3.61E-04	1.91E-01	1.89E-03
Lead	2.60E+00	4.21E+00	6.17E-01	2.45E+01	1.99E+01	1.23E+00	1.46E-01	3.44E+00	4.24E-02
Thallium	1.81E-02	NA	NA	1.67E-01	1.90E-02	8.77E+00	9.75E-04	3.00E-03	3.25E-01

Notes:
BW = Body Weight
NA = Not Available
~ = Not a COPC at the site
EE_{total} =Total Estimated Exposure from Soil + Food
TRV = Toxicity Reference Value
HQ = Hazard Quotient

TABLE 7-27
SUMMARY OF EXPOSURE ESTIMATES AND HAZARD QUOTIENTS
AUTO CRAFT SITE, FORT STORY, VIRGINIA

Chemical	Killdeer			White-footed Mouse			Gray Fox		
	EE_{total}	NOAEL	HQ	EE_{total}	NOAEL	HQ	EE_{total}	NOAEL	HQ
	mg/kg BW-day			mg/kg BW-day			mg/kg BW-day		
Acenaphthene	6.42E-04	NA	NA	1.43E-02	1.11E+00	1.29E-02	2.93E-05	1.91E-01	1.53E-04
Benz(a)anthracene	5.16E-03	NA	NA	1.15E-01	1.11E+00	1.03E-01	2.35E-04	1.91E-01	1.23E-03
Benzo(b)fluoranthene	8.46E-03	NA	NA	1.88E-01	1.11E+00	1.70E-01	3.86E-04	1.91E-01	2.02E-03
Benzo(k)fluoranthene	6.99E-04	NA	NA	1.55E-02	1.11E+00	1.40E-02	3.19E-05	1.91E-01	1.67E-04
Benzo(g,h,i)perylene	4.13E-03	NA	NA	9.17E-02	1.11E+00	8.27E-02	1.88E-04	1.91E-01	9.86E-04
Chrysene	4.13E-03	NA	NA	9.17E-02	1.11E+00	8.27E-02	1.88E-04	1.91E-01	9.86E-04
Fluoranthene	1.20E-02	NA	NA	2.98E-02	1.11E+00	2.69E-02	6.12E-05	1.91E-01	3.20E-04
Indeno(1,2,3-cd)pyrene	2.60E-03	NA	NA	5.78E-02	1.11E+00	5.21E-02	1.19E-04	1.91E-01	6.21E-04
Phenanthrene	2.10E-03	NA	NA	4.68E-02	1.11E+00	4.22E-02	9.60E-05	1.91E-01	5.03E-04
Pyrene	2.27E-02	NA	NA	3.30E-02	1.11E+00	2.98E-02	6.78E-05	1.91E-01	3.55E-04
Copper	1.17E-01	5.07E+01	2.30E-03	3.06E+00	4.13E+01	7.41E-02	6.54E-03	7.13E+00	9.18E-04
Iron	2.57E+01	NA	NA	5.85E+02	NA	NA	8.57E-01	NA	NA
Lead	2.57E-01	4.21E+00	6.11E-02	5.98E+00	1.99E+01	3.00E-01	8.94E-03	3.44E+00	2.60E-03
Zinc	1.32E+02	6.12E+00	2.15E+01	3.25E+03	3.99E+02	8.16E+00	6.02E-03	6.89E+01	8.75E-05

Notes:
BW = Body Weight
NA = Not Available
~ = Not a COPC at the site
EE_{total} =Total Estimated Exposure from Soil + Food
TRV = Toxicity Reference Value
HQ = Hazard Quotient

unlikely to pose a risk to the Killdeer, White-footed Mouse, or Gray Fox at the Auto Craft Site. Avian toxicity values were not available for PAHs or iron. Mammalian toxicity values were not available for iron. Therefore, the potential risks of these COPCs were not evaluated.

7.8.2 Summary of Risks and Uncertainties

FTA Site

At the FTA site, potential risks of exposure to lead and thallium in sediment was identified for small mammals. In addition, potential risk of exposure to lead and thallium was identified for plants growing in the drainage area adjacent to the site. These risks of adverse effects were identified for the maximum exposure scenario.

LARC 60 Site

At the LARC 60 site, no potential risks of exposure for plants, invertebrates, or wildlife was identified in surface soil, sediment, or surface water. Of the compounds detected in these media, none were identified at levels of concern.

Auto Craft Site

At the Auto Craft site, potential risks of exposure to zinc were identified for ground-gleaning birds and small mammals. Potential risks of exposure to lead and zinc were identified for plants growing in the area. These risks of adverse effects were identified for the maximum exposure scenario.

Summary of Uncertainties

Uncertainty in the risk estimates may arise during any stage in the ecological risk assessment process. Incorrect assumptions may be made regarding the potential effects of a stressor, the ecosystems of concern, or the species residing within those ecosystems. Generally, care was taken to fully assess and incorporate field observations into the decision process during problem formulation to minimize these uncertainties.

Uncertainty associated with environmental sampling is generally related to the limitations of the sampling program in terms of the number and distribution of samples, while uncertainty associated with the analysis of the samples is generally related to systematic or random errors. The limited number of samples collected at the sites, and the limited testing of those samples,

particularly for the metals at these sites add uncertainty to the contaminant values used for the exposure assessment.

The principal uncertainties in the exposure assessment have to do with quantitative estimates of exposure parameters such as BAFs. These parameters typically are chemical, species, and site specific. Exposure parameters for COPCs were taken from the literature or calculated from literature data. Data on contaminants in wild animals, as opposed to domestic or laboratory animals, were used when available. Generally, the reasonable worst case was assumed to provide a conservative estimate.

Another point of uncertainty lies in the assumption that each of the wildlife receptor species feeds only upon food items found in the study areas. For species with very small home ranges, this assumption is likely to be close to actuality. However, several of the receptors may consume food sources other than those considered in the assessment, the exclusion which could either over-or underestimate the potential risk. It is also possible, particularly due to the lack of forage within the sites, that the receptors may not feed entirely within the study areas. In addition, the average weights and daily intakes used for the receptor species do not take into account smaller and larger individuals, and young of the species, which may be more or less sensitive to contaminants than average-sized adults.

The assumption that soil and sediment invertebrate uptake of compounds would be equal to published Earthworm Uptake Factors may also result in an over- or underestimation of potential risk. The amount of a contaminant which is taken up by earthworms from soil or sediment depends, in part, on site-specific soil and sediment conditions such as organic content, contaminant concentration, and presence of other chemicals in the soil or sediment. Uptake of contaminants by soil and sediment invertebrates may occur at different rates or under different conditions than earthworms. Similarly, uptake of chemicals by vegetation is very dependent on the type of chemical, soil type, plant species, and other environmental factors.

Uncertainty arises when using any published toxicity results as TRVs. These uncertainties include extrapolating from acute or subchronic exposures to chronic exposure durations and extrapolating across different species, genera, orders, and families. The lack of published toxicity data adds uncertainty to the assessment.

In general, the risk assessment is likely to overestimate rather than underestimate the risks of adverse ecological effects at the sites, because of the conservative nature of the assumptions used. Overall, a generally conservative approach was taken in the evaluation to minimize the possibility of actual risk being greater than that predicted. Conservative steps taken include:

- The use of maximum chemical concentrations, where appropriate.
- The comparison of maximum chemical concentrations in site media with maximum background concentrations
- The selection of COPC based on exceedence of criteria or guideline values.

7.8.3 Ecological Significance

The FTA and Auto Craft sites are potential sources of environmental contamination in soil and sediments. These potential effects are considered to have minimal ecological significance for the following reasons:

- In many cases, wildlife risks were not identified for the average exposure case. The average concentrations are more representative of exposure for mobile species of wildlife, such as the Killdeer.
- The sites are currently disturbed by military activities occurring on the base, particularly the FTA and LARC 60 sites. In addition, the Auto Craft site is paved and fenced. Therefore, the sites can support only a few individuals, and the potential impacts to plant or animal populations as a whole are minimal.
- The ecosystems in the general vicinity of the site do not appear to be impacted or stressed due to chemical contamination.
- Apex predators and wildlife with large home ranges are not likely to be adversely affected due to the comparatively limited extent of contamination.

7.9 CONCLUSIONS AND RECOMMENDATIONS

No further investigation is recommended for any of the sites examined at Fort Story. Very few chemicals were selected as COPCs and the environmental evaluation is likely to have overestimated the potential risk.

Results show that under certain scenarios, potential does exist for risk to terrestrial vegetation and small mammals in the drainage ditch adjacent to the FTA site. Because of the size of the

drainage ditch compared to the home range of a small mammal and the lack of current visible impacts on vegetation, this risk is considered very low.

Although contaminants were detected at the LARC 60 site, none were detected at levels which were considered to be of concern. Ecologically, much of the site provides little value to wildlife for foraging or nesting habitat. Much of the wildlife activity would occur in the adjacent woodland area, or possibly at the former UST area. Therefore, the risks to wildlife associated with the ongoing activities at the LARC 60 site are considered low.

Assessment results at the Auto Craft site show that potential risk of exposure to metals does exist for terrestrial vegetation, invertebrates, ground-gleaning birds, and small mammals. One sample downgradient of the site was tested for metals. This small sample size adds uncertainty to the analysis through the possibility of under- or overestimation of risk. Because of the size of the site and the lack of current visible impacts on vegetation, the risk of exposure to metals is considered low.

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APPENDIX K

TOXICITY PROFILES: ECOLOGICAL RISK ASSESSMENT

COPPER

Fate and Transport

Copper has two oxidation states, +1 (cuprous) and +2 (cupric). Cuprous copper is unstable in aerated water over the pH range of most natural waters (6 to 8) and oxidizes to the cupric state. Several processes determine the fate of copper in the aquatic environment: formation of complexes, especially with humic substances; sorption to hydrous metal oxides, clays, and organic materials; and bioaccumulation. Copper has a strong affinity for hydrous iron and manganese oxides, clays, carbonate minerals, and organic matter. Sorption to these materials, both suspended in the water column and in the sediment, results in relative enrichment of the solid phase and reduction in dissolved levels (Clement Associates 1985).

Because many copper compounds and complexes are readily soluble, copper is among the more mobile heavy metals in soil and other surface environments. The major process that limits the environmental mobility of copper is adsorption to organic matter, clays and other materials (Clement Associates 1985).

The bioconcentration factor (BCF) of copper in fish obtained in various field studies is 10-100 indicating a low potential for bioconcentration. The BCF is higher in molluscs, such as oysters, where it may reach 30,000. However, abundant evidence has shown that there is no biomagnification in the food chain. Studies have been performed on bottom-feeding fish such as suckers and bullheads, as well as on herbivorous, omnivorous and carnivorous animals.

Toxicity

Acute toxicity data are available for species in 41 genera of freshwater animals. At a hardness of 50 mg/l, the genera range in sensitivity from 16.74 μg/l for the squawfish, *Ptychocheilus*, to 10,240 μg/l for the stonefly, *Acroneuria*. Data for eight aquatic species indicate that acute toxicity decreases as hardness increases. Additional data for several species indicate that toxicity also decreases with increases in alkalinity and total organic carbon (USEPA 1986).

Chronic values are available for 15 freshwater species and range from 3.873 μg/l for brook trout to 60.36 μg/l for northern pike. Fish and invertebrate species seem to be about equally sensitive to the chronic toxicity of copper. Toxicity tests have been conducted on copper with a wide range of freshwater plants and the sensitivities are similar to those of animals. Copper does not appear to bioconcentrate very much in the edible portion of freshwater aquatic species (USEPA 1986).

Sheep are very susceptible to copper toxicosis, and poisoning may be acute or chronic. The toxic dose is about 200 mg/kg. Copper intake of 1.5 g/day for 30 days is known to be fatal for many breeds of sheep. Swine develop copper poisoning at levels of 250 mg/kg in the diet unless zinc and iron levels are increased. Cattle are much more resistant to copper than sheep or swine (Clement Associates 1985).

IRON

Fate and Transport

Iron is an essential element required by both plants and animals. The ferrous, or bivalent (Fe^{++}), and the ferric, or trivalent (Fe^{+++}) irons are the primary forms of concern in the aquatic environment, although other forms may be in organic and inorganic wastewater streams. Prime pollution sources are industrial wastes, mine drainage waters, and iron-bearing groundwaters. In the presence of dissolved oxygen, iron in water is precipitated as a hydroxide, $Fe(OH)_3$ or occasionally as ferric oxide (Fe_2O_3). Both of these precipitates form as gels or flocs that may be detrimental, when suspended in water, to fishes and other aquatic life. They can settle to form flocculent materials that cover stream bottoms thereby destroying bottom-dwelling invertebrates, plants or incubating fish eggs.

Toxicity

A 96-hour LC_{50} value of 0.32 mg/l (320 μg/l) was obtained for mayflies, stoneflies, and caddisflies (USEPA 1979). Iron was found to be toxic to carp at concentrations of 0.9 mg/l (900 μg/l) when the pH of the water was 5.5, and both pike and trout died at iron concentrations of 1 to 2 mg/l (1,000 to 2,000 μg/l) (USEPA 1976). The USEPA (1986) has established a criterion of 1,000 μg/l for fresh water, based upon laboratory tests. Data obtained under laboratory conditions suggest a greater toxicity for iron than that obtained in natural ecosystems, due to variations in alkalinity, pH, hardness, temperature and the presence of ligands which change the valence state and solubility, and therefore the toxicity of the metal.

LEAD

Fate and Transport

Natural compounds of lead are not usually mobile in normal surface or groundwater because the lead leached from ores is adsorbed by ferric hydroxide or combines with carbonate or sulfate ions to form insoluble compounds. The transport of lead in the aquatic environment is influenced by the speciation of the ion. Lead exists mainly as the divalent cation in most unpolluted waters and becomes adsorbed into particulate phases. Volatilization of lead compounds probably is not important in most aquatic environments (Clement Associates 1985).

Sorption processes appear to exert a dominant effect on the distribution of lead in the environment. Adsorption to inorganic solids, organic materials, and hydrous iron and manganese oxides usually controls the mobility of lead and results in a strong partitioning of lead to the bed sediments in aquatic systems. The sorption mechanism most important in a particular system varies with geological setting, pH, Eh, availability of ligands, dissolved and particulate ion concentrations, salinity, and chemical composition (Clement Associates 1985).

Lead does not seem to be biomagnified in food chains, yet it may accumulate in plants such as fungi, as well as earthworms, millipedes, terrestrial birds and mammals, freshwater invertebrates and fish. In aquatic environments, lead concentrations are usually highest in benthic organisms and algae, and lowest in upper-trophic-level predators like carnivorous fish. High BCFs were determined in studies using

oysters, freshwater algae and marine algae. Bioconcentration factors are available for four freshwater invertebrate and two fish species and range from 42 to 1,700. Available bioconcentration factors for saltwater species range from 17.5 to 2,570.

Toxicity

The acute and chronic toxicity of lead to several species of freshwater animals has been shown to decrease as the hardness of water increases. At a hardness of 50 mg/l the acute sensitivities of 10 species range from 142.5 μ/l for an amphipod to 235,900 μg/l for a midge. Freshwater algae are affected by concentrations of lead above 500 μg/l. Data on the chronic effects of lead freshwater animals are available for two fish and two invertebrate species. The lowest and highest available chronic values (12.26 and 128.1 μg/l) are both for a cladoceran, but in soft and hard water, respectively (USEPA 1986).

Among sensitive species of birds, survival was reduced at doses of 50 to 75 mg Pb^{2+}/kg body weight or 28 mg organolead/kg body weight, reproduction was impaired at dietary levels of 50 mg Pb^{2+}/kg, and signs of poisoning were evident at doses as low as 2.8 mg organolead/kg body weight. In general, forms of lead other than shot (or ingestible lead object), or routes of administration other than ingestion, are unlikely to cause clinical signs of lead poisoning in birds. Data for toxic and sublethal effects of lead on mammalian wildlife are missing. For sensitive species of domestic and laboratory animals, survival was reduced at acute oral lead doses of 4 mg/kg body weight (rat), at chronic oral doses of 5 mg/kg body weight (dog), and at dietary levels of 1.7 mg/kg body weight (horse). Sublethal effects were documented in monkeys exposed to doses as low as 0.1 mg Pb/kg body weight daily or fed diets containing 0.5 mg Pb/kg. In general, organolead compounds were more toxic than inorganic lead compounds, food chain biomagnification of lead was negligible, and younger organisms were most susceptible (Eisler 1988).

TOTAL PAHs

Fate and Transport

Polynuclear Aromatic Hydrocarbons (PAHs) occur as a result of natural processes, such as forest fires and volcanic activity, and anthropogenic activities, such as catalytic cracking, manufacturing of asphalt and coal tar pitch, heating and power generation, and internal combustion engines. PAHs released to the atmosphere are subject to short- and long-term transport. Atmospheric residence time and transport distance depend on the size of the particles to which PAHs are sorbed and the molecular weight of the PAH.

Much of the PAHs released into the atmosphere eventually reaches the soil by direct deposition of by deposition on vegetation. In sediments, PAHs can biodegrade, biotransform, or accumulate in aquatic organisms, specifically bottom-dwelling vertebrates. PAHs in soil can biodegrade or accumulate in terrestrial plants, through roots or foliage. Specific transport and partitioning are determined by: water solubility; vapor pressure; concentration; and molecular weight of the PAH. The half-life for PAHs differs according to physical properties. For example, the half-life in soil for Benz(a)anthracene ranges from 102 days to 1.86 years while the half life for Benzo(b)fluoranthene ranges from 360 days to 1.67 years. (Howard, 1990). PAHs may accumulate in terrestrial animals through the food chain or by ingestion of soil. PAHs can also enter groundwater and be transported within an aquifer. In surface water, these

compounds can volatilize, photodegrade, oxidize, biodegrade, bind to particles, or accumulate in aquatic organisms. Because of their low solubility, PAHs in aquatic systems are usually found sorbed to particles that either have settled to the bottom or are suspended in the water column. PAHs tend to be removed from the water column by volatilization to the atmosphere, binding to sediments or by being accumulated or sorbed onto aquatic biota.

Bioconcentration factors (BCFs) of PAHs in fish and crustaceans have frequently been reported to be in the range of 100-2000 (ATSDR 1989b), and exposure to PAHs has been linked to the development of tumors in fish. The ability of fish to metabolize PAHs may explain why benzo(a) pyrene is frequently not detected or found at only low levels in fish from environments heavily contaminated with PAHs. According to the Draft Toxicological Profile for PAHs (ATSDR 1989b), one study ranked the amount of benzo(a)pyrene metabolism by aquatic organisms as follows: fish > shrimp > crustaceans > clams. Half lives for elimination of PAHs in fish ranged from 1.5 days to 9 days.

Toxicity

Numerous PAH compounds are distinct in their ability to produce tumors in skin and most epithelial tissues of practically all animal species tested. Certain carcinogenic PAHs are capable of passage across skin, lungs, and intestine, and can enter the rat fetus, for example, following intragastric or intravenous administration to pregnant dams. Acute and chronic exposure to various carcinogenic PAHs have resulted in destruction of hematopoietic and lymphoid tissues, ovotoxicity, anitspermatogonic effects, adrenal necrosis, changes in intestinal and respiratory epithelia, and other effects. For the most part, however, tissue damage occurs at dose levels that would also be expected to induce carcinomas. Laboratory studies with mice have shown that many carcinogenic PAHs adversely affect the immune system, thus directly impacting an organism's general health; in general, the more carcinogenic the PAH, the greater (Eisler, 1987).

No studies were located regarding either deaths in animals following dermal exposure or neurological effects to PAHs in animals, although the skin is susceptible to PAH induced toxicity in animals. The developmental toxicity data in animals for PAHs are limited. Available animal studies exclusively discuss the reproductive effects of benzo(a)pyrene, adverse effects such as decreased fertility and total sterility in mice (F1 progeny of CD-1). Effects of hepatic injury have also been observed in animals. In one study, a simple injection of pyrene resulted in minimal swelling of the liver. Longer administration of PAHs has been reported to result in adverse hepatic effects in animals. Adverse hematological effects have also been observed in animals following exposure to PAHs. PAHs tend to exert their adverse effects on rapidly proliferating tissues, such as the bone marrow forming elements and the lymphatic system.

For avian wildlife, data are missing on PAH background concentrations and on acute and chronic toxicity. Studies with mallard embryos and PAHs applied to the egg surface showed toxic and adverse sublethal effects at concentrations between 0.036 and 0.18 μg PAH/kg whole egg (Eisler, 1987).

A growing literature exists on uptake, retention, and translocation of PAHs by aquatic plants and animals. Authorities generally agree that: most species of aquatic organisms studied to date rapidly accumulate PAHs from low concentrations in the ambient medium; uptake of PAHs is highly species specific, being higher in algae, molluscs, and other species which are incapable of metabolizing PAHs; bioconcentration factors tend to increase as the molecular weight of the PAH increases, with increasing

octanol/water partition coefficient values, with time until approaching an apparent equilibrium level (sometimes within 24 hours), and with increases in dissolved organic matter in the medium, lipid content of the organism, and a variety of endogenous and exogenous factors (Eisler 1987).

TOLUENE

Fate and Transport

Toluene released to the soil will be lost by evaporation from near-surface soil and by leaching to the ground water. Toluene is expected to exhibit very high to moderate mobility in soil, depending on site specific characteristics of soil type, load, flow rate and other loss factors such as evaporation and biodegradation. Biodegradation occurs both in soil and ground water , but is apt to be slow, especially at high concentrations, which may be toxic to microorganisms. The presence of acclimated microbial populations may allow rapid biodegradation. It will not significantly hydrolyze in soil or water under normal environmental conditions. Toluene released to water will be lost by both volatilization to the atmosphere and biodegradation. The predominant process will depend on water temperature, mixing conditions, and the existence of acclimated microorganisms at the site. It will not significantly hydrolyze, directly photolyze, absorb to sediment, or bioconcentrate in aquatic organisms. Toluene released to the atmosphere will degrade by reaction with photochemically produced hydroxyl radicals or be washed out in rain. It will not be subject to direct photolysis. The half-life of toluene in soil ranges from 4 days to 22 days (Howard, 1990). Limited data indicate that toluene has a moderate tendency to bioaccumulate in the food chain. Toluene does have some tendency to accumulate in fatty tissues. (ATSDR, 1989a)

There are limited animal data on the effects of oral exposure to toluene. The available oral exposure data focus on acute oral lethality studies. Reported acute oral LD_{50}s ranged from 5,580 mg/kg to 7,300 mg/kg for the adult rat. Age may play a role in the acute lethality of toluene. No studies were located regarding immunological, reproductive, genetic, or carcinogenic effects following acute oral exposure to toluene. Subchronic oral exposure effects included increased relative heart weights in rats exposed to toluene at 1250 mg/kg/day for 13 weeks and myocardial degeneration in mice exposed to 5000 mg/kg/day for 13 weeks. Various other subchronic studies (oral exposure for 13 weeks) reported increased liver and kidney weights in mice and rats, hemorrhages in the urinary bladder of rats, and increased relative brain weight in mice and brain necrosis in rats.(ATSDR, 1989a)

ZINC

Fate and Transport

Zinc can occur in both suspended and dissolved forms. Dissolved zinc may occur as the free (hydrated) zinc ion or as dissolved complexes and compounds with varying degrees of stability and toxicity. Suspended zinc may be dissolved following minor changes in water chemistry or may be sorbed to suspended matter. The predominant fate of zinc in aerobic aquatic systems is sorption of the divalent cation by hydrous iron and manganese oxides, clay minerals and organic material. Concentrations of zinc in suspended and bed sediments always exceed concentrations in ambient water. Zinc tends to be more readily sorbed at higher pH than lower pH and tends to be desorbed from sediments as salinity increases (Clement Associates 1985).

Microcosm studies generally indicate that zinc is not biomagnified. Although biota seem to be a minor sink compared to sediments, this compound is actively bioaccumulated in aquatic systems. Zinc has been found to accumulate in freshwater animal tissues from 51 to 1,130 times the concentration present in the water. A 1981 study reported zinc BCF values of 1000 for both aquatic plants and fish. Steady-state bioconcentration factors for twelve saltwater species range from 3,692 to 23,820.

Toxicity

Acute toxicity values are available for 43 species of freshwater animals and data for eight species indicate that acute toxicity decreases as hardness increases. Additional data indicate that toxicity increases as temperature increases. Chronic values for two invertebrates ranges from 46.73 μg/l for *Daphnia magna* to $>$5,243 μg/l for the caddisfly, *Clistoronia magnificia*. Chronic values for seven fish species ranged from 36.41 μg/l for the flagfish, *Jordanella floridae*, to 854.7 μg/l for the brook trout, *Salvelinus fontinalis* (USEPA 1986).

The sensitivity range of freshwater plants to zinc is greater than that for animals. Growth of the alga, *Selenastrum capricornutum*, was inhibited by 30 μg/l. On the other hand, with several other species of green algae, 4-day EC_{50}s exceeded 200,000 μg/l. Zinc was found to bioaccumulate in freshwater animal tissues from 51 to 1,130 times the concentration present in the water (USEPA 1986).

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APPENDIX L

WILDLIFE SPECIES OF THE FORT STORY/CAPE HENRY REGION

SELECTED LIST OF WILDLIFE OF THE FORT STORY/CAPE HENRY REGION
(excluding fish and marine life)

Common Name	Scientific Name	Common Name	Scientific Name
Mammals			
Bobcat	*Lynx rufus*	Meadow-jumping Mouse	*Zapus hudsonius*
Common Mole*	*Condylura cristata*	Mink	*Mustela vison*
Cotton Mouse	*Peromyscus gossypinus*	Muskrat	*Ondata zibethicus*
E. Cottontail Rabbit*	*Sylvilagus floridanus*	Otter	*Lutra canadensis*
Evening Bat	*Nycticelus humeralis*	Raccoon*	*Procyon lotor*
Golden Mouse	*Peromyscus nuttalli*	Red Bat	*Lasiurus borealis*
Gray Fox	*Urocyon cinereoargenteus*	Red Fox	*Vulpes fluva*
Gray Squirrel*	*Sciurus carolinensis*	Red Squirrel	*Tamiasciurus hudsonicus*
Least Shrew	*Cayptositis parva*	Rice Rat	*Oryxomys palustris*
Lemming Mouse	*Synaptomys cooperi*	Short-tailed Shrew	*Blarina brevicauda*
Little Brown Bat	*Myotis lucifungus*	Silver-haired Bat	*Lasionycteris noctivagens*
Long-tailed Weasel	*Mustela frenata*	Southern Flying Squirrel	*Glaucomys volanus*
Marsh Rabbit	*Sylvilagus palustris*	Virginia Opossum	*Didelphis marsupialis*
Meadow Mouse	*Microtus pennsylvanicus*	White-footed Mouse*	*Peromyscus leucopus*
Birds			
Acadian Flycatcher	*Empidonax flaviventris*	Belted Kingfisher	*Megaceryle alcyon alcyon*
American Bittern	*Botaurus lentiginosus*	Black and White Warbler	*Mniotilta varia*
American Coot	*Fulica americana*	Black Duck	*Anas rubripes*
American Crow*	*Corvus brachyrhynchos*	Black Vulture	*Coragyps atratus*
American Kestrel	*Falco sparverius*	Black-bellied Plover	*Squatorola squatarola*
American Redstart	*Setophaga ruticilla*	Black-billed Cuckoo	*Coccyzus erythrophthalmus*
American Widgeon	*Mareca americana*	Black-crowned Night Heron	*Nycticorax nycticorax hoactile*
Baltimore Oriole	*Icterus galbula*	Black-throated Blue Warbler	*Dendroica caerulescens*
Barn Owl	*Tyto alba*	Black-throated Green Warbler*	*Dendroica virens*
Barn Swallow	*Hirundo rustica erythrogaster*	Blue Jay	*Cyanocitta cristata*
Bay-breasted Warbler	*Dendroica castanea*	Blue-gray Gnatcatcher*	*Polioptila caerulea caerulea*

Birds (continued)

Bobwhite*	*Colinus virginianus*
Boat-tailed Grackle*	*Cassidix mexicanus*
Bobolink	*Dolichonyx oryzivorus*
Broad-winged Hawk	*Buteo platypterus platypterus*
Brown Creeper	*Certhia familiaris*
Brown Thrasher	*Toxostoma rufum*
Brown-headed Nuthatch*	*Sitta pusilla*
Cape Warbler	*Dendroica tigrina*
Cardinal*	*Richmondena cardinalis*
Carolina Chickadee	*Parus carolinensis*
Carolina Wren*	*Thryothorus ludoviclianus*
Catbird*	*Dumetella carolinensis*
Cedar Waxwing	*Bombycilla cedrorum*
Chimney Swift	*Dhoetura pelagica*
Chipping Sparrow	*Spizella passerina*
Chuck-wills-widow	*Caprimulgus caroliniensis*
Common Grackle*	*Quiscalus quiscula*
Common Loon	*Gavia immer*
Common Merganser	*Mergus merganser*
Common Nighthawk	*Chordeiles minor*
Common Tern	*Sterma hirundo hirundo*
Common Yellowthroat	*Geothlypis trichas*
Cooper's Hawk	*Accipiter cooperii*
Cowbird	*Molothrus ater ater*
Downy Woodpecker	*Dendrocopus pubenscens*
Eastern Bluebird*	*Sialis sialis*
Eastern Kingbird	*Tyrannus tyrannus*
Eastern Meadowlark	*Sturnella magna*
Eastern Phoebe	*Sayomis phoebe*
Eastern Wood Pewee	*Contopus virens*
Glouse Sparrow	*Passer domesticus*
European Starling*	*Sturnus vulgaris*
Fish Crow*	*Corvus ossifragus*
Flicker	*Colaptes auratus*
Gannet	*Morus bassanus*
Golden-crowned Kinglet*	*Regulus satrapa satrapa*
Goldfinch	*Spinus tristis*
Great Blue Heron	*Ardea herodias*
Great-crested Flycatcher*	*Myiarchus crinitus*
Great Egret	*Casmerodinus albus*
Great Horned Owl	*Bubo virginianus*
Greater Scaup	*Aythya valisineria*
Greater Yellowlegs*	*Tringa melanoleuca*
Green-backed Heron	*Butorides virescens virescens*
Hairy Woodpecker	*Dendrocopus villosus*
Hermit Thrush	*Hylocichla guttata faxoni*
Herring Gull*	*Larus argentatus*
Hooded Merganser	*Lophodytes cucullatus*
Hooded Warbler	*Wilsonia citrina*
House Finch*	*Carpodacus mexicanus*
House Wren*	*Troglodytes aedon*
Indigo Bunting	*Passerina cyanea*
Kentucky Warbler	*Oporonis formosus*
Killdeer*	*Charadrius vociferus*
King rail	*Rallus elagans elegans*
Laughing Gull*	*Larus atricilla*
Least Tern	*Sterna albifrons*
Little Blue Heron	*Florida caerulea caerulea*
Loggerhead Shrike	*Lanius ludovicianus*
Louisiana Waterthrush	*Seiurus motacilla*
Magnolia Warbler	*Dendroica magnolia*
Mallard*	*Anas platyrhynchos*
Marsh Hawk	*Circus cyaneus*
Marsh Wren	*Troglodytes aedon*
Mourning Dove*	*Zenaidia macroura*
Myrtle Warbler	*Dendroica coronata*

Birds (continued)

Orchard Oriole	*Icterus spurius*
Osprey*	*Pandion haliaetus carolinensis*
Ovenbird	*Seiurus aurocapillus*
Parula Warbler	*Parula americana*
Pied-billed Grebe	*Podilymbus podiceps podiceps*
Pileated Woodpecker*	*Hylatomus pileatus*
Pine Warbler	*Dendroica pinus*
Piping Plover	*Charadius melodus*
Prairie Warbler*	*Dendroica discolor*
Prothonotary Warbler*	*Protonotaria citrea*
Purple Finch	*Carpodacus purpureus*
Purple Martin	*Progne subis subis*
Red-winged Blackbird	*Agelaius phoeniceus*
Red-bellied Woodpecker	*Centurus carolinus*
Red-breasted Merganser	*Mergus serrator*
Red-breasted Nuthatch	*Sitta canadensis*
Red-eyed Vireo	*Vireo olivaceus*
Red-shouldered Hawk	*Buteo lineatus*
Red-tailed Hawk	*Buteo jamaicensis*
Redhead	*Aythya americana*
Ring-billed Gull*	*Larus delawarensis*
Robin*	*Turdus migratorius*
Ruby-crowned Kinglet	*Regulus calendula*
Ruby-throated Hummingbird	*Archilochus colubris*
Rufous-sided Towhee*	*Pipilo erythrophthalmus*
Scarlet Tanager	*Piranga olivacea*
Screech Owl	*Otus asio*
Sedge Wren	*Cistothorus platensis*
Semi-palmated Sandpiper	*Piranga oilvacea*
Sharp-shinned Hawk	*Accipiter striatus*
Slate-colored Junco	*Junco hyemalis*
Snowy Egret	*Leucophoyx thula*
Song Sparrow	*Melospiza melodia*
Spotted Sandpiper	*Actitis macularia*
Summer Tanager	*Piranga rubra*
Swamp Sparrow	*Melospiza georgia*
Tree Sparrow	*Spizella arborea*
Tree Swallow	*Iridoprocne bicolor*
Tufted Titmouse*	*Parus bicolor*
Turkey Vulture	*Cathartes aura*
White-breasted Nuthatch	*Sitta carolinensis*
White-eyed Vireo	*Vireo griseus*
White-throated Sparrow*	*Zonotrichia albicollis*
Wilson's Snipe	*Capella gallinago delicata*
Winter Wren	*Troglodytes troglodytes*
Wood Duck	*Axis sponsa*
Wood Thrush	*Hylocichla mustelina*
Yellow Warbler	*Dendroica petechia*
Yellow-bellied Sapsucker	*Sphyrapicus varius*
Yellow-billed Cuckoo	*Coccyzus americanus*
Yellow-breasted Chat	*Icteria virens*
Yellow-crowned Night Heron	*Nyctanassa violacea*
Yellow-throated Vireo	*Vireo Flavifrons*
Yellow-throated Warbler	*Dendroica dominica*

Reptiles and Amphibians

Bronze Frog	*Rana clamitans clamitans*
Carpenter Frog	*Rana virgatipes*
Common Snapping Turtle	*Chelydra serpertina*
Eastern Box Turtle	*Terrapene carolina carolina*
Eastern Cottonmouth	*Agkistrodon piscivorous*
Eastern Garter Snake	*Thamnophis sirtalis*

Reptiles and Amphibians (continued)

Eastern Gray Tree Frog	*Hyla chrysoscelis*
Eastern Kingsnake	*Lampropetis getulus*
Eastern Mud Salamander	*Pseudotriton montanus*
Eastern Mud Snake	*Farancia abacura*
Eastern Painted Turtle	*Chrysemys picta*
Eastern Ribbon Snake	*Thamnophis sauritus*
Green Treefrog	*Hyla cinerea*
Marbled Salamander	*Ambystoma opacum*
Northern Diamondback Terrapin	*Malaclemys terrapin*
Red-bellied Turtle*	*Chrysemys scripta rubriventer*
Red-bellied Water Snake	*Natrix erythrogaster*
Scarlet Snake	*Cemophora coccinea*
Slimy Salamander	*Plethodon glutinosus*
Southern Copperhead	*Agkistrodon contorix*
Southern Cricket Frog	*Acris gryllus*
Southern Dusty Salamander	*Desmognathus auriculatus*
Southern Water Snake	*Nerodia fascinata*
Yellow Spotted Turtle	*Clemmys guttata*

Note: * = Observed by Malcolm Pirnie during April 1996 field visits.

Sources: Horne Engineering and Environmental Services. *Draft Fort Story Integrated Natural Resources Management Plan*, June 28, 1995.
Field Surveys by Malcolm Pirnie, April 1996

APPENDIX M

ECOLOGICAL RISK ASSESSMENT EXPOSURE CALCULATIONS

KILLDEER EXPOSURE CALCULATIONS - FTA SITE
FORT STORY, VIRGINIA

Chemical (mg/kg)	Concentration in Sediment/ Surface Soil (mg/kg)	Concentration in Terrestrial Invertebrates (mg/kg)	Concentration in Vegetation (mg/kg)	Estimated Exposure from Soil/Sediment (mg/kg BW-day)	Estimated Exposure from Invertebrates (mg/kg BW-day)	Estimated Exposure from Vegetation (mg/kg BW-day)	Total Estimated Exposure (mg/kg BW-day)	Killdeer NOAEL (mg/kg BW-day)	Hazard Quotents (unitless)
Toluene	1.80E-01	1.80E-01	1.69E-01	2.31E-04	2.09E-03	2.18E-04	2.54E-03	NA	NA
Fluoranthene	6.50E-01	4.55E-01	7.93E-03	8.34E-04	5.29E-03	1.02E-05	6.13E-03	NA	NA
Pyrene	7.20E-01	5.04E-01	8.78E-03	9.24E-04	5.85E-03	1.13E-05	6.79E-03	NA	NA
Lead	2.10E+02	2.00E+02	9.45E+00	2.70E-01	2.32E+00	1.22E-02	2.60E+00	4.21E+00	6.17E-01
Thallium	1.40E+00	1.40E+00	5.60E-03	1.80E-03	1.63E-02	7.20E-06	1.81E-02	NA	NA
	Cs	Ci = Cs x EUF	Cv = Cs X PUF	EEs=(CsxFSxIRxFR)/BW	EEi=CixFRxNIRi	EEv = CvxFRvxNIRv	EEt = EEs + EEi + EEv		HQ = EEt/NOAELr
				Cs = Conc. in sediment	Ci = Conc. in invertebrates	Cv = Conc. in vegetation			
				FS = 10%	FR = 0.096	FR = 0.096			
				IR = 0.0123 kg/day	NIRi = NIRf x 90%	NIRv = NIRf X 10%			
				FR = 0.145 x 0.66	NIRf = 0.134 g/g-day	NIRf = 0.134 g/g-day			
				FR = 0.096					
				BW = 0.092 kg					

WHITE FOOTED MOUSE EXPOSURE CALCULATIONS
FTA SITE
FORT STORY, VIRGINIA

Chemical	Concentration in Sediment/ Surface Soil (mg/kg)	Concentration in Terrestrial Invertebrates (mg/kg)	Concentration in Vegetation (mg/kg)	Estimated Exposure from Soil/Sediment (mg/kg BW-day)	Estimated Exposure from Invertebrates (mg/kg BW-day)	Estimated Exposure from Vegetation (mg/kg BW-day)	Total Estimated Exposure (mg/kg BW-day)	White-Footed Mouse NOAEL (mg/kg BW-day)	Hazard Quotents (unitless)
Toluene	1.80E-01	1.80E-01	1.69E-01	4.80E-04	2.09E-02	1.42E-02	3.56E-02	2.88E+01	1.24E-03
Fluoranthene	6.50E-01	4.55E-01	7.93E-03	1.73E-03	5.28E-02	6.66E-04	5.52E-02	1.11E+00	4.98E-02
Pyrene	7.20E-01	5.04E-01	8.78E-03	1.92E-03	5.85E-02	7.38E-04	6.11E-02	1.11E+00	5.52E-02
Lead	2.10E+02	2.00E+02	9.45E+00	5.60E-01	2.31E+01	7.94E-01	2.45E+01	1.99E+01	1.23E+00
Thallium	1.40E+00	1.40E+00	5.60E-03	3.73E-03	1.62E-01	4.70E-04	1.67E-01	1.90E-02	8.77E+00
	Cs	Ci = Cs x EUF	Cv = Cs x PUF	EEs=(CsxFSxIRxFR)/BW	EEi=CixFRxNIRi	EEv=CvxFRxNIRv	EEt = EEs + EEi + EEv		HQ = EEt/NOAELr
				Cs = Conc. in sediment	Ci = Conc. in invertebrates	Cv = Conc. in vege.			
				FS = 2%	FR = 1	FR = 1			
				IR = 0.003 kg/day	NIRi = NIRf x 58%	NIRv = NIRf x 42%			
				FR = 1	NIRf = 0.20 g/g-day	NIRf = 0.20 g/g-day			
				BW = 0.0225 kg					

GRAY FOX EXPOSURE CALCULATIONS - FTA SITE
FORT STORY, VIRGINIA

Chemical	Concentration in Sediment/ Surface Soil (mg/kg)	Concentration in Vegetation Consumed by Prey (mg/kg)	Concentration in Invertebrates Consumed by Prey (mg/kg)	Concentration in Prey (mg/kg)	Concentration in Vegetation Consumed by Fox (mg/kg)	Estimated Exposure from Surface Soil (mg/kg BW-day)	Estimated Exposure from Prey (mg/kg BW-day)
Toluene	1.80E-01	1.69E-01	1.80E-01	1.75E-01	1.69E-01	4.30E-06	2.34E-04
Fluoranthene	6.50E-01	7.93E-03	4.55E-01	2.31E-01	7.93E-03	1.55E-05	3.10E-04
Pyrene	7.20E-01	8.78E-03	5.04E-01	2.56E-01	8.78E-03	1.72E-05	3.43E-04
Lead	2.10E+02	9.45E+00	2.00E+02	1.04E+02	9.45E+00	5.02E-03	1.40E-01
Thallium	1.40E+00	5.60E-03	1.40E+00	7.03E-01	5.60E-03	3.35E-05	9.41E-04
	Cs	Cv = Cs x PUF	Ci = Cs x EUF	Cp = Cv/2 + Ci/2		EEs=(CsxFSxIRxFR)/BW	EEp = Cp x FR x NIRp
						Cs = Conc. in sediment	Cp = Conc. in prey
						FS = 2.8%	FR = 0.016
						IR = 0.24 kg/day	(NIRp = NIRf x 93%)
						FR = area/HR	NIRp = 0.0837
						FR = 0.016	
						BW = 4.5 kg	

GRAY FOX EXPOSURE CALCULATIONS - FTA SITE
FORT STORY, VIRGINIA

Chemical	Estimated Exposure from Vegetation (mg/kg BW-day)	Estimated Exposure from Diet (mg/kg BW-day)	Total Estimated Exposure (mg/kg BW-day)	Gray Fox NOAEL (mg/kg BW-day)	Hazard Quotents (unitless)
Toluene	1.71E-05	2.51E-04	2.55E-04	4.97E+00	5.13E-05
Fluoranthene	7.99E-07	3.11E-04	3.26E-04	1.91E-01	1.71E-03
Pyrene	8.85E-07	3.44E-04	3.61E-04	1.91E-01	1.89E-03
Lead	9.53E-04	1.41E-01	1.46E-01	3.44E+00	4.24E-02
Thallium	5.64E-07	9.42E-04	9.75E-04	3.00E-03	3.25E-01

EEv=CvxFRxNIRv EEd = EEv + EEp EEt = EEs+EEd HQ = EEt/NOAELr

Cv = Conc. in vege.
FR = 0.016
(NIRv = NIRf x 7%)
NIRv = 0.0063 g/g-day

KILLDEER EXPOSURE CALCULATIONS - AUTO CRAFT SITE
FORT STORY, VIRGINIA

Chemical (mg/kg)	Concentration in Surface Soil (mg/kg)	Concentration in Terrestrial Invertebrates (mg/kg)	Concentration in Vegetation (mg/kg)	Estimated Exposure from Soil (mg/kg BW-day)	Estimated Exposure from Invertebrates (mg/kg BW-day)	Estimated Exposure from Vegetation (mg/kg BW-day)	Total Estimated Exposure (mg/kg BW-day)	Killdeer NOAEL (mg/kg BW-day)	Hazard Quotents (unitless)
Acenaphthene	3.11E-01	2.18E-01	3.79E-03	8.73E-05	5.53E-04	1.07E-06	6.42E-04	NA	NA
Benz(a)anthracene	2.50E+00	1.75E+00	3.05E-02	7.02E-04	4.45E-03	8.58E-06	5.16E-03	NA	NA
Benzo(b)fluoranthene	4.10E+00	2.87E+00	5.00E-02	1.15E-03	7.29E-03	1.41E-05	8.46E-03	NA	NA
Benzo(k)fluoranthene	3.39E-01	2.37E-01	4.14E-03	9.52E-05	6.03E-04	1.16E-06	6.99E-04	NA	NA
Benzo(g,h,i)perylene	2.00E+00	1.40E+00	2.44E-02	5.62E-04	3.56E-03	6.87E-06	4.13E-03	NA	NA
Chrysene	2.00E+00	1.40E+00	2.44E-02	5.62E-04	3.56E-03	6.87E-06	4.13E-03	NA	NA
Fluoranthene	5.80E+00	4.06E+00	7.08E-02	1.63E-03	1.03E-02	1.99E-05	1.20E-02	NA	NA
Indeno(1,2,3-cd)pyrene	1.26E+00	8.82E-01	1.54E-02	3.54E-04	2.24E-03	4.33E-06	2.60E-03	NA	NA
Phenanthrene	1.02E+00	7.14E-01	1.24E-02	2.86E-04	1.81E-03	3.50E-06	2.10E-03	NA	NA
Pyrene	1.10E+01	7.70E+00	1.34E-01	3.09E-03	1.96E-02	3.78E-05	2.27E-02	NA	NA
Copper	1.80E+01	4.32E+01	7.20E+00	5.05E-03	1.10E-01	2.03E-03	1.17E-01	5.07E+01	2.30E-03
Iron	9.10E+03	9.10E+03	3.64E+01	2.55E+00	2.31E+01	1.02E-02	2.57E+01	NA	NA
Lead	9.50E+01	9.03E+01	4.28E+00	2.67E-02	2.29E-01	1.20E-03	2.57E-01	4.21E+00	6.11E-02
Zinc	6.40E+01	5.19E+04	9.60E+01	1.80E-02	1.32E+02	2.70E-02	1.32E+02	6.12E+00	2.15E+01

Cs	Ci = Cs x EUF	Cv = Cs X PUF	EEs=(CsxFSxIRxFR)/BW	EEi=CixFRxNIRi	EEv = CvxFRvxNIRv	EEt = EEs + EEi + EEv	HQ = EEt/NOAELr
			Cs = Conc. in sediment	Ci = Conc. in invertebrates	Cv = Conc. in vegetation		
			FS = 10%	FR = 0.021	FR = 0.021		
			IR = 0.0123 kg/day	NIRi = NIRf x 90%	NIRv = NIRf X 10%		
			FR = 0.032 x 0.66	NIRf = 0.134 g/g-day	NIRf = 0.134 g/g-day		
			FR = 0.021				
			BW = 0.092 kg				

WHITE FOOTED MOUSE EXPOSURE CALCULATIONS
AUTO CRAFT SITE
FORT STORY, VIRGINIA

Chemical	Concentration in Surface Soil (mg/kg)	Concentration in Terrestrial Invertebrates (mg/kg)	Concentration in Vegetation (mg/kg)	Estimated Exposure from Soil (mg/kg BW-day)	Estimated Exposure from Invertebrates (mg/kg BW-day)	Estimated Exposure from Vegetation (mg/kg BW-day)	Total Estimated Exposure (mg/kg BW-day)	White-Footed Mouse NOAEL (mg/kg BW-day)	Hazard Quotents (unitless)
Acenaphthene	3.11E-01	2.18E-01	3.79E-03	4.48E-04	1.36E-02	1.72E-04	1.43E-02	1.108	1.29E-02
Benz(a)anthracene	2.50E+00	1.75E+00	3.05E-02	3.60E-03	1.10E-01	1.38E-03	1.15E-01	1.108	1.03E-01
Benzo(b)fluoranthene	4.10E+00	2.87E+00	5.00E-02	5.90E-03	1.80E-01	2.27E-03	1.88E-01	1.108	1.70E-01
Benzo(k)fluoranthene	3.39E-01	2.37E-01	4.14E-03	4.88E-04	1.49E-02	1.88E-04	1.55E-02	1.108	1.40E-02
Benzo(g,h,i)perylene	2.00E+00	1.40E+00	2.44E-02	2.88E-03	8.77E-02	1.11E-03	9.17E-02	1.108	8.27E-02
Chrysene	2.00E+00	1.40E+00	2.44E-02	2.88E-03	8.77E-02	1.11E-03	9.17E-02	1.108	8.27E-02
Fluoranthene	6.50E-01	4.55E-01	7.93E-03	9.36E-04	2.85E-02	3.60E-04	2.98E-02	1.108	2.69E-02
Indeno(1,2,3-cd)pyrene	1.26E+00	8.82E-01	1.54E-02	1.81E-03	5.52E-02	6.97E-04	5.78E-02	1.108	5.21E-02
Phenanthrene	1.02E+00	7.14E-01	1.24E-02	1.47E-03	4.47E-02	5.64E-04	4.68E-02	1.108	4.22E-02
Pyrene	7.20E-01	5.04E-01	8.78E-03	1.04E-03	3.16E-02	3.98E-04	3.30E-02	1.108	2.98E-02
Copper	1.80E+01	4.32E+01	7.20E+00	2.59E-02	2.71E+00	3.27E-01	3.06E+00	4.13E+01	7.41E-02
Iron	9.10E+03	9.10E+03	3.64E+01	1.31E+01	5.70E+02	1.65E+00	5.85E+02	NA	NA
Lead	9.50E+01	9.03E+01	4.28E+00	1.37E-01	5.65E+00	1.94E-01	5.98E+00	1.99E+01	3.00E-01
Zinc	6.40E+01	5.19E+04	9.60E+01	9.22E-02	3.25E+03	4.35E+00	3.25E+03	3.99E+02	8.16E+00

Cs	Ci = Cs x EUF	Cv = Cs x PUF	EEs=(CsxFSxIRxFR)/BW	EEi=CixFRxNIRi	EEv=CvxFRxNIRv
			Cs = Conc. in sediment	Ci = Conc. in invertebrates	Cv = Conc. in vege.
			FS = 2%	FR = 0.54	FR = 0.54
			IR = 0.003 kg/day	NIRi = NIRf x 58%	NIRv = NIRf x 42%
			FR = 0.54	NIRf = 0.20 g/g-day	NIRf = 0.20 g/g-day
			BW = 0.0225 kg		

EEt = EEs + EEi + EEv

HQ = EEt/NOAELr

GRAY FOX EXPOSURE CALCULATIONS - AUTO CRAFT SITE
FORT STORY, VIRGINIA

Chemical	Concentration in Surface Soil (mg/kg)	Concentration in Vegetation Consumed by Prey (mg/kg)	Concentration in Invertebrates Consumed by Prey (mg/kg)	Concentration in Prey (mg/kg)	Concentration in Vegetation Consumed by Fox (mg/kg)	Estimated Exposure from Surface Soil (mg/kg BW-day)	Estimated Exposure from Prey (mg/kg BW-day)
Acenaphthene	3.11E-01	3.79E-03	2.18E-01	1.11E-01	3.79E-03	1.39E-06	2.78E-05
Benz(a)anthracene	2.50E+00	3.05E-02	1.75E+00	8.90E-01	3.05E-02	1.12E-05	2.24E-04
Benzo(b)fluoranthene	4.10E+00	5.00E-02	2.87E+00	1.46E+00	5.00E-02	1.84E-05	3.67E-04
Benzo(k)fluoranthene	3.39E-01	4.14E-03	2.37E-01	1.21E-01	4.14E-03	1.52E-06	3.03E-05
Benzo(g,h,i)perylene	2.00E+00	2.44E-02	1.40E+00	7.12E-01	2.44E-02	8.96E-06	1.79E-04
Chrysene	2.00E+00	2.44E-02	1.40E+00	7.12E-01	2.44E-02	8.96E-06	1.79E-04
Fluoranthene	6.50E-01	7.93E-03	4.55E-01	2.31E-01	7.93E-03	2.91E-06	5.81E-05
Indeno(1,2,3-cd)pyrene	1.26E+00	1.54E-02	8.82E-01	4.49E-01	1.54E-02	5.64E-06	1.13E-04
Phenanthrene	1.02E+00	1.24E-02	7.14E-01	3.63E-01	1.24E-02	4.57E-06	9.12E-05
Pyrene	7.20E-01	8.78E-03	5.04E-01	2.56E-01	8.78E-03	3.23E-06	6.44E-05
Copper	1.80E+01	7.20E+00	4.32E+01	2.52E+01	7.20E+00	8.06E-05	6.33E-03
Iron	9.10E+03	1.11E+02	6.37E+03	3.24E+03	1.11E+02	4.08E-02	8.14E-01
Lead	9.50E+01	1.16E+00	6.65E+01	3.38E+01	1.16E+00	4.26E-04	8.49E-03
Zinc	6.40E+01	7.81E-01	4.48E+01	2.28E+01	7.81E-01	2.87E-04	5.72E-03
	Cs	Cv = Cs x PUF	Ci = Cs x EUF	Cp = Cv/2 + Ci/2		EEs=(CsxFSxIRxFR)/BW	EEp = Cp x FR x NIRp
						Cs = Conc. in sediment	Cp = Conc. in prey
						FS = 2.8%	FR = 0.003
						IR = 0.24 kg/day	(NIRp = NIRf x 93%)
						FR = area/HR	NIRp = 0.0837
						FR = 0.003	
						BW = 4.5 kg	

GRAY FOX EXPOSURE CALCULATIONS - AUTO CRAFT SITE
FORT STORY, VIRGINIA

Chemical	Estimated Exposure from Vegetation (mg/kg BW-day)	Estimated Exposure from Diet (mg/kg BW-day)	Total Estimated Exposure (mg/kg BW-day)	Gray Fox NOAEL (mg/kg BW-day)	Hazard Quotents (unitless)
Acenaphthene	7.17E-08	2.79E-05	2.93E-05	1.91E-01	1.53E-04
Benz(a)anthracene	5.76E-07	2.24E-04	2.35E-04	1.91E-01	1.23E-03
Benzo(b)fluoranthene	9.45E-07	3.68E-04	3.86E-04	1.91E-01	2.02E-03
Benzo(k)fluoranthene	7.82E-08	3.04E-05	3.19E-05	1.91E-01	1.67E-04
Benzo(g,h,i)perylene	4.61E-07	1.79E-04	1.88E-04	1.91E-01	9.86E-04
Chrysene	4.61E-07	1.79E-04	1.88E-04	1.91E-01	9.86E-04
Fluoranthene	1.50E-07	5.83E-05	6.12E-05	1.91E-01	3.20E-04
Indeno(1,2,3-cd)pyrene	2.91E-07	1.13E-04	1.19E-04	1.91E-01	6.21E-04
Phenanthrene	2.35E-07	9.14E-05	9.60E-05	1.91E-01	5.03E-04
Pyrene	1.66E-07	6.45E-05	6.78E-05	1.91E-01	3.55E-04
Copper	1.36E-04	6.46E-03	6.54E-03	7.13E+00	9.18E-04
Iron	2.10E-03	8.16E-01	8.57E-01	NA	NA
Lead	2.19E-05	8.52E-03	8.94E-03	3.44E+00	2.60E-03
Zinc	1.48E-05	5.74E-03	6.02E-03	6.89E+01	8.75E-05

EEv=CvxFRxNIRv EEd = EEv + EEp EEt = EEs+EEw+EEd HQ = EEt/NOAELr

Cv = Conc. in vege.
FR = 0.003
(NIRv = NIRf x 7%)
NIRv = 0.0063 g/g-day