APPENDIX B

SITE-SPECIFIC MAMMALIAN AND AVIAN WILDLIFE SCREENING LEVEL EXPOSURE EVALUATION

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B.1 INTRODUCTION

As requested by the EPA, the effects from the potential exposure of PAH and dioxins on higher trophic level organisms (avian and mammalian receptors) are being evaluated using the raccoon and Great Blue Heron as indicator species. These species occur at the site, are sensitive to changes in the ecosystem, and are sensitive to the constituents of concern (PAHs and dioxins). Both species are mobile and will use various portions of the Turkey Creek area; therefore, they are unlikely to be chronically exposed to the maximum detected concentrations. The maximum and average sediment, surface water and tissue concentrations are used to estimate the exposure to wildlife.

The following sections provide the process, assumptions and parameters used in the ecological risk calculations for mammalian and avian wildlife.

B.2 EXPOSURE PARAMETERS

The potential exposure pathways for avian and mammalian receptors at the site include ingestion of food, ingestion of surface water and incidental ingestion of sediment. The mostly piscivorous Great Blue Heron (*Ardea herodias)* diet includes fish, shellfish, and small animals. The omnivorous raccoon (*Procyon lotor*) feeds on plants and animals. Clams (*Rangia cuneata*) are included because a raccoon observed on-site appeared to be eating a clam. Fish species used in the evaluation include largemouth bass (*Micropterus salmoides*), pumpkinseed bream (*Lepomis gibbosus*), channel catfish (*Ictalurus punctatus*), hogchoker (*Trinectes maculatus*), pogie (*Brevoortia patronus*), striped mullet *(Mugil cephalus),* orangespotted sunfish (*Lepomis humilis*), and mosquitofish (*Gambusia affinis)*. Table B-1 summarizes parameters used in the evaluation risks to raccoons and the Great Blue Heron, as detailed in the following sections.

The daily intake of PAHs for potential receptors is estimated by the following equation (EPA, 1993):

$$\text{Daily Dose} = \frac{C \times IR}{BW} \times AUF$$

Where,

C = contaminant concentration in contacted media (mg/kg)

IR = ingestion rate of contacted media (kg/day of food or sediment; L/day water)
AUF = Area Use Factor
BW = body weight of species (kg)
Therefore, the total contaminant concentration is calculated as:

$$C = [(C_{food}) + (C_{sed} \text{ x } IR_{sed}) + (C_{water} \text{ x } IR_{water})].$$

Where,

$C_{food\ raccoon} = (C_{fish} \text{ x } IR_{fish}) + (C_{clams} \text{ x } IR_{clams})$
$C_{food\ heron} = C_{fish} \text{ x } IR_{fish}$

B.2.1 AREA USE FACTOR

The area use factor (AUF) is the percentage of the home range of a species that may include the area of concern. The minimum home range of the raccoon published in the *Wildlife Exposure Factors Handbook* is 39 plus or minus 16 hectares, so a conservative range of 23 hectares was used. The area of concern is approximately 14 hectares, which yields an AUF of about 60%. However, to add in a safety factor, it is assumed that the raccoon consumes its entire aquatic diet from Turkey Creek in the vicinity of the site.

The Great Blue Heron can have a feeding territory of about 0.5 to 13.8 hectares; therefore, the AUF is assumed to be 100% of the area of concern.

B.2.2 BODY WEIGHT

Values for wildlife body weights were derived from literature values from the *Wildlife Exposure Factors Handbook*, Volume I (EPA, 1993). The body weight value for the raccoon of 4 kg selected was the mean of the specimens found in Alabama. The body weight of 2.2 kg for the Great Blue Heron was the value from eastern North America.

B.2.3 FOOD INGESTION RATE

Food ingestion rates were derived using the following equations (*Field Metabolic Rate and Food Requirement Scaling in Mammals and Birds*, Nagy, 1987):

Mammals: $$\frac{IR_{food} = 0.0687 \text{ x } BW^{0.822}}{0.2}$$

Where,

IR_{food}	=	ingestion rate (kg/day, wet weight)
0.0687	=	mathematical constant (Nagy, 1987)
0.822	=	mathematical constant (Nagy, 1987)
BW	=	body weight of species (kg)
0.2	=	dry weight to wet weight conversion factor

Birds:

$$IR_{food} = \frac{0.0582 \times BW^{0.651}}{0.2}$$

Where,

IR_{food}	=	ingestion rate (kg/day, wet weight)
0.0582	=	mathematical constant (Nagy, 1987)
0.651	=	mathematical constant (Nagy, 1987)
BW	=	body weight of species (kg)
0.2	=	dry weight to wet weight conversion factor

The total food ingestion rate for the raccoon was calculated to be 1.1 kg/day. For the purposes of this evaluation food is assumed to be a mix of 10% fish, 50% clams and 40% plants, insects and other sources (EPA, 1993, *Wildlife Exposure Factors Handbook*). Thus, the ingestion rates for fish and clams are calculated to be 0.11 kg/day and 0.55 kg/day, respectively.

The Great Blue Heron diet includes fish, shellfish, and small animals. For the purposes of this evaluation, the food is assumed to be 100% fish at a rate of 0.49 kg/day.

B.2.4 INCIDENTAL SEDIMENT INGESTION RATE

Animals that feed near Turkey Creek, such as birds and mammals, may ingest sediment during prey capture and ingestion. Beyer et al. (1994, *Estimates of Soil Ingestion by Wildlife*) provided data for the incidental ingestion of soil/sediment by the raccoon as a percentage of food intake (9.4% dry weight). Data were not available for the incidental ingestion sediment/soil for the Great Blue Heron; however, herons fish in shallow waters (less than about 2 feet) with a firm substrate (EPA, 1993). They capture fish by thrusting the beak into the fish's side or back (Eckert and Karalus, 1983). Based on the Great Blue Heron fishing technique, a value of 2% (on a dry weight basis) was applied based on incidental ingestion during feeding and grooming.

The incidental ingestion rate for sediment was estimated using the following equation:

$$IR_{sed} = IR_{food} \times 0.2 \times I_{sed}$$

Where,

IR_{sed}	=	incidental ingestion rate of sediment
0.2	=	dry weight to wet weight conversion factor
I_{sed}	=	ingestion of sediment as a percentage of food intake

The incidental sediment ingestion rates for the raccoon and the Great Blue Heron were calculated to be 0.021 and 0.002 kg/day, respectively.

B.2.5 SURFACE WATER INGESTION RATE

Values for surface water ingestion rates were derived from literature values in the *Wildlife Exposure Factors Handbook*, Volume I (EPA, 1993).

IR_{water} = Water Intake (g/g-day) x body weight,

IR_{water} Rac	=	0.0825 g/g-day * 4 kg = 0.33 L/day
IR_{water} Heron	=	0.045 g/g-day * 2.2 kg = 0.1 L/day

B.3 WILDLIFE EXPOSURE EVALUATION - PAHS

To estimate the risks to wildlife receptors, hazard quotients were calculated for each species. The hazard quotient is the ratio of the exposure dose to a literature-based value and is expressed as follows:

$$\text{Hazard Quotient} = \frac{\text{Daily Dose}}{\text{Toxicological Benchmark}}$$

Where,

Daily Dose	=	As defined in Section 2.0 (mg/kg/day)
Toxicological Benchmark	=	Species specific (mg/kg/day)

In general, a hazard quotient value of less than 1 indicates that there is no risk.

The toxicological benchmarks used for each species are an estimate of the dose of a constituent at which no adverse effects (No Observed Adverse Effect Levels, NOAELs) are likely to occur. Toxicological data were available for benzo(a)pyrene and naphthalene. The derivation of the toxicological benchmarks and calculation of the hazard quotients used to estimate risk to the raccoon and Great Blue Heron is described in the following sections.

B.3.1 PAH EXPOSURE CONCENTRATIONS

The benzo(a)pyrene equivalent (BaP EQ) in sediment, surface water and aquatic wildlife tissue was calculated using the toxic equivalent approach, as summarized in Tables B-2 through B-5. The BaP EQ was calculated for each sample as the sum of the benzo(a)pyrene-like toxicity of each PAH, which yield a single concentration equivalent to the toxicity of a similar concentration of benzo(a)pyrene. Each PAH compound has been assigned a Toxic Equivalency Factor (TEF), which denotes a given PAH compound's toxicity relative to benzo(a)pyrene. The BAP EQ is calculated as follows:

BaP EQ = SUM($TEF_i[PAH]_i$)

PAH	TEF
1-Methylanthracene(1)	0.01
1-Methylphenanthrene(1)	0.001
2-Methylanthracene(1)	0.01
2-Methylphenanthrene(1)	0.001
3,6-Dimethylphenanthrene(1)	0.001
Acenaphthene(2)	0.001
Acenaphthylene(2)	0.001
Anthracene(2)	0.01
Benzo(a)anthracene(2)	0.1
Benzo(a)pyrene(2)	1
Benzo(b)fluoranthene(2)	0.1
Benzo(e)pyrene(1)	1
Benzo(g,h,i)perylene(2)	0.01
Benzo(k)fluoranthene(2)	0.01
C1-Anthracenes(1)	0.01
C1-Phenanthrenes(1)	0.001
C2-Phenanthrenes(1)	0.001
Chrysene(2)	0.001
Dibenz(a,h)anthracene(2)	5
Fluoranthene(2)	0.001
Fluorene(2)	0.001
Indeno(1,2,3-cd)pyrene(2)	0.1
Perylene(1)	1
Phenanthrene(2)	0.001
Pyrene(2)	0.001

(1) Estimated TEF
(2) TEF from EPA, 2000, Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, Volume 1 Fish Sampling and Analysis Third Edition, Table 5-6

Ten of the 25 PAH compounds did not have a published TEF and were therefore estimated. The TEF for benzo(e)pyrene and perylene were set at one due to their similarity to benzo(a)pyrene in molecular weight and Final Chronic Value (EPA, 2003). Although there is less toxicity information available for most of the alkyl PAHs than for their parent compounds, most alkyl PAHs appear to be at least as toxic or hazardous as the parent compound. Therefore, all alkyl homolog compounds such as methylanthracenes and methylphenanthrenes were assigned the same TEF as constituent parents anthracene and phenanthrene (NPS, 1997).

Naphthalene compound concentrations were summed and compared to the toxicological benchmark. The exposure concentrations for the various media for total naphthalenes include 1-methylnaphthalene, 2,3,5-trimethylnaphthalene, 2,6-dimethylnaphthalene, 2-methylnaphthalene, C1-naphthalenes, C2-naphthalenes, C3-naphthalenes, C4-naphthalenes, and naphthalene.

B.3.2 MAMMALIAN WILDLIFE SITE-SPECIFIC EVALUATION

Raccoons (*Procyon lotor*) were selected to represent omnivorous mammals. The raccoon has been reported to be the most abundant and widespread medium-sized omnivore in North America (EPA, 1993). Raccoons are also more closely associated with aquatic systems than other mammalian omnivores, although they feed opportunistically from both aquatic and terrestrial sources. Exposures to raccoons are enhanced by relatively small territory sizes, as well as their potential to ingest sediment that may be attached to invertebrate prey.

B.3.2.1 Toxicological Benchmarks

NOAEL data for the raccoon were available for benzo(a)pyrene and naphthalene.

The NOAEL value for benzo(a)pyrene was derived from a value published in a study by Mackenzie and Angeline (1981) for the mouse of 1 mg/kg of body weight per day. Sample and Arenal (1999) provide a means of converting a NOAEL value for one species to another:

$$NOAEL_{raccoon} = NOAEL_{mouse} \times (BW_{mouse}/BW_{raccoon})^{1-b}$$

Where,

$NOAEL_{mouse}$	=	1 mg/kg/day (Mackenzie and Angevine, 1981)
BW_{mouse}	=	body weight of mouse of 0.03 kg (Mackenzie and Angevine, 1981)
$BW_{raccoon}$	=	body weight of raccoon of 4 kg (EPA, 1993)
b	=	0.94 for generic mammals (Sample and Arenal, 1999)

The conversion yielded a NOAEL toxicological benchmark of 0.746 mg/kg/day for benzo(a)pyrene in the raccoon.

A NOAEL value of 50 mg/kg/day (NTP, 1991) for naphthalene was determined in a study using rats. This value required conversion for use with another species, as follows:

$NOAEL_{raccoon}$ = $NOAEL_{rat}$ x $(BW_{rat}/BW_{raccoon})^{1-b}$

Where,

$NOAEL_{rat}$ = 50 mg/kg/day (NTP, 1991)
BW_{rat} = body weight of rat of 0.35 kg (NTP, 1991)
$BW_{raccoon}$ = body weight of raccoon of 4 kg (EPA, 1993)
b = 0.94 for generic mammals (Sample and Arenal, 1999)

The conversion yielded a NOAEL toxicological benchmark of 43 mg/kg/day for naphthalene in the raccoon.

B.3.2.2 Hazard Index Results

Using the values derived for body weight, ingestion rates and toxicological benchmarks, the hazard index for the raccoon for PAHs was calculating using the maximum of each constituent detected and the average concentration of all samples. The results are as follows:

ANALYTE	WHOLE FISH		RANGIA TISSUE		SEDIMENT		SURFACE WATER	
	MAX	AVG	MAX	AVG	MAX	AVG	MAX	AVG
	mg/kg		mg/kg		mg/kg		mg/L	
Benzo(a)pyrene Equivalent	0.00594	0.00272	0.01759	0.01133	13.19	1.04	0.0000314	0.0000314
Total Naphthalenes	0.04334	0.01374	0.03742	0.01833	331.75	11.27	0.00102	0.00102

ANALYTE	FOOD EXPOSURE		TOTAL EXPOSURE		BENCHMARK	HAZARD QUOTIENT	
	MAX	AVG	MAX	AVG		MAX	AVG
	mg/day		mg/kg/day		mg/kg/day		
Benzo(a)pyrene Equivalent	0.0103	0.0065	0.0708	0.0070	0.746	0.0948	0.0094
Total Naphthalenes	0.0253	0.0116	1.7216	0.0612	43.2	0.0399	0.0014
					HAZARD INDEX	**0.1347**	**0.0108**

As shown above, the hazard indices using the maximum and average PAH concentrations are well below 1 indicating no significant risk from PAHs to raccoons from the ingestion of fish, clams, sediment and surface water in Turkey Creek.

B.3.3 AVIAN WILDLIFE SITE-SPECIFIC EVALUATION

Great Blue Herons (*Ardea herodias*) were evaluated as a representative of piscivorous birds. Because they ingest fish and invertebrates from the aquatic habitats at the site, they are exposed to the constituents of concern (COCs) through the food web.

B.3.3.1 Toxicological Benchmarks

A study by Patton and Dieter (1980) on mallard ducks using acenaphthene, acenaphthylene, phenanthrene and naphthalenes determined that 400 mg PAHs/kg food is considered to be a chronic NOAEL. However, EPA's 2000 *Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories* indicates that the benzo(a)pyrene Toxicity Equivalent Factor (TEF) of acenaphthene, acenaphthylene, phenanthrene is 0.001. So to account for the greater toxicity of benzo(a)pyrene a value of 0.4 mg PAHs/kg food will be used to evaluate PAHs in terms of the benzo(a)pyrene equivalent. The 400 mg PAHs/kg food value from the study will be used for naphthalene and methylnaphthalenes. Because the toxicological values require conversion to mg PAHs per kg body weight per day, the benchmarks were converted as follows:

$$\text{NOAEL (mg/kg/day)} = \frac{\text{0.4 mg benzo(a)pyrene}}{\text{kg food}} \times \frac{\text{0.117 kg food}}{\text{day}} / \text{1.17 kg body weight}$$

$$\text{NOAEL (mg/kg/day)} = \frac{\text{400 mg benzo(a)pyrene}}{\text{kg food}} \times \frac{\text{0.117 kg food}}{\text{day}} / \text{1.17 kg } BW_{duck}$$

Where,

$IR_{food,\ duck}$	=	0.117 kg food/day (Sample et al. 1996, Heinz et al.1989)
BW_{duck}	=	1.17 kg (EPA, 1993)

The conversions yielded NOAEL values of 0.04 and 40.0 mg/kg/day for the duck. These values are then converted for use with the Blue Heron as follows:

$$NOAEL_{heron} = NOAEL_{duck} \times (BW_{duck}/BW_{heron})^{1-b}$$

Where,

$NOAEL_{duck}$	=	0.04/40.0 mg/kg/day (Patton and Dieter, 1980)
BW_{duck}	=	body weight of duck of 1.17 kg (EPA, 1993)
BW_{heron}	=	body weight of heron of 2.2 kg (EPA, 1993)
b	=	1.2 for generic birds (Sample and Arenal, 1999)

The benzo(a)pyrene equivalent and naphthalene compound NOAELs for the Great Blue Heron were calculated to be 0.045 and 45.0 mg/kg/day, respectively.

B.3.3.2 Hazard Index Results

Using the values derived for body weight, ingestion rates and toxicological benchmarks, the total PAHs hazard index for the raccoon was calculated using the maximum concentration of each constituent detected and the average concentration of all samples. The results are as follows:

ANALYTE	WHOLE FISH		SEDIMENT		SURFACE WATER	
	MAX	AVG	MAX	AVG	MAX	AVG
	mg/kg		mg/kg		mg/L	
Benzo(a)pyrene Equivalent	0.00594	0.00272	13.19	1.04	0.0000314	0.0000314
Total Naphthalenes	0.04334	0.01374	331.75	11.27	0.00102	0.00102

ANALYTE	FOOD EXPOSURE		TOTAL EXPOSURE		BENCHMARK	HAZARD QUOTIENT	
	MAX	AVG	MAX	AVG		MAX	AVG
	mg/kg		mg/kg/day		mg/kg/day		
Benzo(a)pyrene Equivalent	0.0059	0.0027	0.0133	0.0006	0.045	0.2958	0.0135
Total Naphthalenes	0.0433	0.0137	0.3113	0.0031	45	0.0069	0.0001
					HAZARD INDEX	**0.3027**	**0.0135**

As shown above, the hazard indices calculated using both the maximum and average concentrations are well below 1 indicating no significant risk from PAHs to the Great Blue Heron from the ingestion of fish, sediment and surface water in Turkey Creek.

B.4 WILDLIFE EXPOSURE EVALUATION - DIOXINS

The sediment, pore water, surface water and aquatic wildlife tissue results were calculated using the toxic equivalent (TEQ) approach. A TEQ is developed for each sample as the sum of the dioxin-like toxicity of the dioxin/furan congeners to yield a single concentration equivalent to the toxicity of a similar concentration of 2,3,7,8-TCDD.

Within the TEQ method, each dioxin compound is assigned a Toxic Equivalency Factor, or TEF (see the table below). This factor denotes a given dioxin compound's toxicity relative to 2,3,7,8-TCDD, which is assigned the maximum toxicity designation of one. Other dioxin compounds are given equal or lower numbers, with each number roughly proportional to its toxicity relative to that of 2,3,7,8-TCDD. Developed by the World Health Organization, TEFs are used extensively by scientists and governments around the world. The dioxin TEQs were calculated as follows:

$TEQ = SUM(TEF_i[Congener]_i)$

The following World Health Organization Toxic Equivalency Values (WHO TEFs) were used:

ANALYTE	MAMMAL TEQ(1)	BIRDS TEQ(2)
2,3,7,8-TCDD	1	1
1,2,3,7,8-PeCDD	1	1
1,2,3,4,7,8-HxCDD	0.1	0.05
1,2,3,6,7,8-HxCDD	0.1	0.01
1,2,3,7,8,9-HxCDD	0.1	0.1
1,2,3,4,6,7,8-HpCDD	0.01	0.001
OCDD	0.0003	0.0001
2,3,7,8-TCDF	0.1	1
1,2,3,7,8-PeCDF	0.03	0.1
2,3,4,7,8-PeCDF	0.3	1
1,2,3,4,7,8-HxCDF	0.1	0.1
1,2,3,6,7,8-HxCDF	0.1	0.1
1,2,3,7,8,9-HxCDF	0.1	0.1
2,3,4,6,7,8-HxCDF	0.1	0.1
1,2,3,4,6,7,8-HpCDF	0.01	0.01
1,2,3,4,7,8,9-HpCDF	0.01	0.01
OCDF	0.0003	0.0001

(1) TEQ calculation based on World Health Organization's (WHO) 2005 TEF scheme (TEFWHO05), Van den Berg, M, L. Birnbaum, et al., The 2005 World Health Organization Re-evaluation of Human and Mammalian Toxic Equivalency Factors for Dioxins and Dioxin-like Compounds. Toxicological Sciences, October 2006; 93:223-241

(2) Toxic equivalency factors (TEFs) for PCBs, PCDDs, PCDFs for humans and wildlife. M Van den Berg, et al., 1998

B.4.1 WILDLIFE SCREENING EVALUATION

TEQ values were compared to screening levels presented in the EPA 1993 *Interim Report on Data and Methods for Assessment of 2,3,7,8-tetrachlorodibenzo-p-dioxin Risks to Aquatic Life and Associated Wildlife (EPA/600/R-93/055).* A review of EPA/600/R-93/055 reveals risk values associated with aquatic life and associated wildlife. Two of these pertinent to this study are reproduced below (see Table E-1 in that report):

Organism	Low Risk Sediment Concentration
Mammalian Wildlife	2.5 ng/kg dry weight
Avian Wildlife	21 ng/kg dry weight

B.4.1.1 Mammalian Wildlife

The following sections present the TEQ calculations using the 2005 WHO TEFs for the sediment and pore water samples collected in November 2009 and the surface water samples collected in June 2010.

Sediment

The following table presents the sediment TEQs using zero and ½ the detection limit for non-detects.

Sample Location	Half Detection Limit	Zero for Non-Detects
	ng/kg	
TC-SED-1	3.34	3.28
TC-SED-2	1.50	1.38
TC-SED-3	4.18	4.16
TC-SED-4	0.84	0.73
TC-SED-5	13.73	13.55
TC-SED-5 Dup	5.45	5.12
TC-SED-6	1.32	1.19
TC-SED-7	1.46	1.34
TC-SED-8	4.27	4.21
TC-SED-9	1.35	1.26
TC-SED-10	4.73	4.71
Mammal Screening	**2.5**	

As indicated on the preceding table, 6 of the 11 samples had dioxin TEQ values exceeding the 2.5 ng/kg screening value for mammalian wildlife. However, it should be noted that the upgradient sample TC-SED-1, also exceeds the screening standard and had a dioxin TEQ above 3, higher than samples collected in the vicinity of the site. The risk to mammalian wildlife from dioxin compounds is further evaluated in Section 4.2.

Creek Water

EPA Region 4 Ecological Screening Guidance (EPA 2001) provides a chronic screening value of 10 pg/L for 2,3,7,8-TCDD (dioxin) in surface water.

Pore Water

The following table presents the pore water TEQs using zero and ½ the detection limit for non-detects:

Sample Location	Half Detection Limit	Zero for Non-Detects
	ng/kg	
TC-PW-1	0.67	0.03
TC-PW-2	1.40	0.72

Sample Location	Half Detection Limit	Zero for Non-Detects
	ng/kg	
TC-PW-3	1.23	0.58
TC-PW-3 Dup	1.06	0.34
TC-PW-4	0.46	0.21
TC-PW-5	0.47	0.11
TC-PW-6A	1.80	1.09
TC-PW-6B	3.09	0.23
TC-PW-7	0.37	0.05
TC-PW-8	0.38	0.08
TC-PW-9	3.12	1.86
TC-PW-10	0.47	0.05

As shown on the preceding table, the maximum pore water TEQ of 3.09 pg/L is below the EPA screening value of 10 pg/L, indicating little risk to mammalian wildlife from dioxins in pore water.

Surface Water

The following table presents the surface water TEQs using zero and ½ the detection limit for non-detects:

Sample Location	Half Detection Limit	Zero for Non-Detects
	ng/kg	
TC-SW-11	1.43	0.50
TC-SW-12	1.24	0.46
TC-SW-13	1.68	0.41
TC-SW-14	3.02	2.21
TC-SW-15	1.35	0.42

As shown on the preceding table, the maximum surface water TEQ of 3.02 pg/L is below the EPA screening value of 10 pg/L, indicating no significant risk to mammalian wildlife from dioxins in surface water. It should be noted that the highest TEQ was derived from the upstream surface water sample collected at location TC-SW-14.

B.4.1.2 Avian Wildlife

The following sections present the TEQ calculations using the 1998 WHO bird TEFs for the sediment and pore water samples collected in November 2009 and the surface water samples collected in June 2010.

Sediment

The following table presents the sediment TEQs using zero and ½ the detection limit for non-detects:

Sample Location	Half Detection Limit	Zero for Non-Detects
	ng/kg	
TC-SED-1	1.52	1.39
TC-SED-2	0.75	0.56
TC-SED-3	2.34	2.27
TC-SED-4	0.50	0.31
TC-SED-5	7.19	6.89
TC-SED-5 Dup	2.61	2.02
TC-SED-6	0.70	0.50
TC-SED-7	0.81	0.54
TC-SED-8	2.20	2.07
TC-SED-9	0.72	0.55
TC-SED-10	2.91	2.90
Bird Screening	**21**	

As indicated on the table above, the recalculated TEQs (using half the detection limit) are all below the EPA screening level of 21 ng/kg, indicating no significant risk to birds from dioxins in sediment.

Creek Water

EPA Region 4 Ecological Screening Guidance (EPA 2001) provides a chronic screening value of 10 pg/L for 2,3,7,8-TCDD (dioxin) in surface water.

Pore Water

The following table presents the pore water TEQs using zero and ½ the detection limit for non-detects:

Sample Location	Half Detection Limit	Zero for Non-Detects
	ng/kg	
TC-PW-1	0.93	0.01
TC-PW-2	1.37	0.35
TC-PW-3	1.29	0.21
TC-PW-3 Dup	1.24	0.14
TC-PW-4	0.37	0.06
TC-PW-5	0.52	0.03
TC-PW-6A	1.49	0.44
TC-PW-6B	4.72	0.06
TC-PW-7	0.55	0.02
TC-PW-8	0.49	0.02
TC-PW-9	2.34	0.60
TC-PW-10	0.74	0.02

As shown on the preceding table, the maximum pore water TEQ of 4.72 pg/L is below the EPA screening value of 10 pg/L, indicating no significant risk to avian wildlife from dioxins in pore water.

Surface Water

The following table presents the surface water TEQs using zero and ½ the detection limit for non-detects:

Sample Location	Half Detection Limit	Zero for Non-Detects
	ng/kg	
TC-SW-11	1.42	0.12
TC-SW-12	1.19	0.11
TC-SW-13	1.76	0.10
TC-SW-14	2.90	1.54
TC-SW-15	1.45	0.11

As shown on the preceding table, the maximum pore water TEQ of 2.9 pg/L is below the EPA screening value of 10 pg/L, indicating no significant risk to avian wildlife from dioxins in surface water.

B.4.2 MAMMALIAN WILDLIFE SITE-SPECIFIC EVALUATION

B.4.2.1 Toxicological Benchmarks

The NOAEL value for dioxin (2,3,7,8-TCDD) TEQ was derived from a value published in a study by Murphy (1979) for the rat of 0.001 ug/kg of body weight per day. Sample and Arenal (1999) provide a means of converting a NOAEL value for one species to another:

$$NOAEL_{raccoon} = NOAEL_{rat} \times (BW_{rat}/BW_{raccoon})^{1-b}$$

Where,

$NOAEL_{rat}$ = 1 ng/kg/day (Murphy, 1979)
BW_{rat} = body weight of rat of 0.35 kg (Sample et al, 1996)
$BW_{raccoon}$ = body weight of raccoon of 4 kg (EPA, 1993)
b = 0.94 for generic mammals (Sample and Arenal, 1999)

The conversion yielded a NOAEL toxicological benchmark of 0.864 ng/kg/day for TCDD TEQ.

B.4.2.2 Hazard Index Results

Using the values derived for body weight, ingestion rates and toxicological benchmarks, the dioxin TEQ hazard index for the raccoon was calculated using the maximum of each constituent detected and the average concentration of all samples. The TEQs for sediment, surface water and biota samples used in the analysis are summarized on Table B-6. The results are as follows:

Parameter	Units	Average	Max
Sediment TEQ Half DL	ng/kg	3.83	13.87
Surface Water TEQ half DL	ng/L	0.00174	0.00330
Clam TEQ half DL	ng/kg	0.4044	0.934
Fish TEQ half DL	ng/kg	2.64	10.32
Body Weight	Kg	4	4
IRsed	kg/day	0.021	0.021
IRsw	L/day	0.33	0.33
IRfood total	kg/day	1.1	1.1
IRfish	kg/day	0.11	0.11
IRclams	kg/day	0.55	0.55
IRother	kg/day	0.44	0.44
AUF	Unitless	1	1
NOAEL*	ng/kg/day	0.864	0.864
Food Composition			
Fish	%	10	10
Clams	%	50	50
Other	%	40	40

Parameter	Units	Average	Max
Csed * IRsed	ng/day	0.08043	0.29127
Csw * IRsw	ng/day	0.00057552	0.001089
Cfood * IRfood	ng/day	0.51282	1.6489
Total Exposure	ng/kg/day	0.148	0.485
HAZARD INDEX		**0.17**	**0.56**

As indicated on the table above, the hazard indexes calculated using the maximum and average concentrations are below 1, indicating there is no significant risk to mammals from dioxins in sediment, surface water and aquatic organisms in Turkey Creek.

B.4.3 AVIAN WILDLIFE SITE-SPECIFIC EVALUATION

B.4.3.1 Toxicological Benchmarks

The NOAEL value for dioxin TEQ was derived from a value published in a study by Nosek (1992) for the ring-necked pheasant of 14,000 pg/kg of body weight per day. Sample and Arenal (1999) provide a means of converting a NOAEL value for one species to another:

$$NOAEL_{heron} = NOAEL_{pheasant} \times (BW_{pheasant}/BW_{heron})^{1-b}$$

Where,

$NOAEL_{pheasant}$ = 1.4 ng/kg/day (14 ng/kg/day from Nosek, 1992 divided by 10 subchronic to chronic adjustment factor)
$BW_{pheasant}$ = body weight of pheasant of 1 kg (Sample et al, 1996)
BW_{heron} = body weight of heron of 2.2 kg (EPA,1993)
b = 1.2 for generic birds (Sample and Arenal, 1999)

The conversion yielded a NOAEL toxicological benchmark of 1.64 ng/kg/day for TCDD TEQ.

B.4.3.2 Hazard Index Results

Using the values derived for body weight, ingestion rates and toxicological benchmarks, the TCDD TEQ hazard index for the Great Blue Heron was calculated using the maximum of each constituent detected and the average concentration of all samples. The results are as follows:

Parameter	Units	Average	Max
Sediment TEQ Half DL	ng/kg	3.83	13.87
Surface Water TEQ half DL	ng/L	0.00174	0.00330
Clam TEQ half DL	ng/kg	0.4044	0.934
Fish TEQ half DL	ng/kg	2.64	10.32

Parameter	Units	Average	Max
Body Weight	kg	2.2	2.2
IRsed	kg/day	0.00196	0.00196
IRsw	L/day	0.1	0.1
IRfood total	kg/day	0.49	0.49
IRfish	kg/day	0.49	0.49
IRclams	kg/day	0	0
IRother	kg/day	0	0
AUF	unitless	1	1
NOAEL	ng/kg/day	1.64	1.64
Food Composition			
Fish	%	100	100
Clams	%	0	0
Other	%	0	0
Csed * IRsed	ng/day	0.0075068	0.0271852
Csw * IRsw	ng/day	0.0001744	0.00033
Cfood * IRfood	ng/day	1.2936	5.0568
Total Exposure	ng/kg/day	0.591	2.311
HAZARD INDEX		**0.36**	**1.41**

As indicated on the table above, the hazard indexes calculated using the maximum and average concentrations are 1.41 and 0.36, respectively. Although the hazard index for the maximum concentrations exceeds 1, avian species are mobile and are unlikely to be chronically exposed to the maximum detected concentration.

The average concentrations, which are more representative of whole site conditions, yielded a hazard index less than 1, indicating there is no significant risk to birds from dioxins in sediment, surface water and aquatic organisms in Turkey Creek.

TABLES