MEMO

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Victor DiGiacomo, Jr., Niagara County Soil & Water Conservation District

From: Karl Gustavson, Ph.D., and Sara Hendrix, US Army Engineer Research and Development Center
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Subject: Eighteenmile Creek Area of Concern Food Web Modeling: Final Data Gaps Memorandum

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BACKGROUND

Eighteenmile Creek is one of forty-three areas of concern (AOCs) established within the Great Lakes due to loss of "beneficial uses" from degraded water quality. The AOC encompasses Eighteenmile Creek from its entry into Lake Ontario, upstream to the Burt Dam (approximately 2 miles). The AOC has three identified use impairments linked to sediment contamination: (1) restrictions on fish and wildlife consumption; (2) degradation of benthos; and (3) restrictions on dredging activities.

Previous studies indicate elevated levels of polychlorinated biphenyls (PCBs), chlorinated pesticides, and metals in surficial sediments throughout most of the AOC. Invertebrate bioaccumulation testing also suggests that organic contaminants moving through the food chain are creating environmental risks (Karn et al., 2004). Contamination sources to the river have not been fully delineated. However, recent investigations by New York State Department of Environmental Conservation (NYSDEC) have focused on a contamination source in Lockport, NY, near the upper reach at the Erie Canal (approximately 12 miles upstream of Burt Dam). During investigations in the 1980s and early-1990s, elevated levels of PCBs were detected in sediments near this facility and fish tissue contaminant levels are also elevated (samples above 2 mg/kg total PCBs wet weight) in the river reach above the Burt Dam (NYSDEC 1997a).

To date, there have been several data collection efforts in and upstream of the AOC to define contaminant levels in sediments, surface water, and biota. However, they have been limited in scope and have not focused on understanding contaminant bioaccumulation, movement in the food chain, and consequent environmental risks. Developing such an understanding will assist site managers as they move toward greater resolution on the nature of impairments at the site, develop remedial actions, and ultimately delist the area.

The US Army Engineer Research and Development Center is conducting a bioaccumulation modeling effort at the AOC in response to a request from the US Army Corps of Engineers (USACE) Buffalo District (See Appendix A, Statement of Work). This interim memo provides a description of the food chain bioaccumulation modeling to be performed and an associated review of existing contaminant data for Eighteenmile Creek to identify data gaps with respect to spatial resolution, contaminants, or types of organisms that will inform the bioaccumulation modeling effort. For a model to adequately represent a system, sufficient data must exist to populate essential parameters, calibrate model results, and verify/validate model output. The objective of this paper is to evaluate whether existing data meet modeling needs and to identify and recommend targeted analyses to fill data gaps, if necessary.

Modeling Area

This evaluation will focus on two areas: the lower reach of Eighteenmile Creek from Lake Ontario to Burt Dam and an upper reach from Burt Dam to the Newfane Dam (Figure 1). The definition of the two areas assumes that the dams act as physical barriers and that fish populations will not interact and only be exposed to conditions in those areas.

Above Burt Dam, a substantial reservoir extends approximately 2 miles before more typical stream morphology continues for another mile to the Newfane Dam. The Newfane Dam is not currently in use, and is essentially submerged; however, that structure along with the relatively swift shallower bedrock and gravel channel below the Newfane dam are hydraulically significant features and serve as impediments to fish movement, so Newfane Dam will represent the upstream extent of the project boundary.

Since the AOC and the Burt Dam backwater area are the closest in environmental conditions, habitat, and fishery, they are appropriate conditions to fulfill the SOW objective "to evaluate organic contaminant bioaccumulation, trophic transfer and consequent risks in river sections above and below Burt Dam of the Eighteenmile Creek." Upstream from Newfane Dam, the conditions are more complex with more typical stream reach/run morphology; these areas will support a different fishery and exhibit a different dynamic of contaminant exposure between modeled organisms, sediments, dietary constituents, and water. Contamination source areas and impacted receptors extend further upstream of the modeled sections to the city of Lockport at the Erie Canal. Site characterization data from upstream as far as the confluence of the Main Stem of Eighteenmile Creek (which runs through Lockport) and the East Branch (a more pristine subwatershed) will be included in this project's database, and may be used to provide context and input to the modeling project as appropriate. See the "Database Development" section for further information.

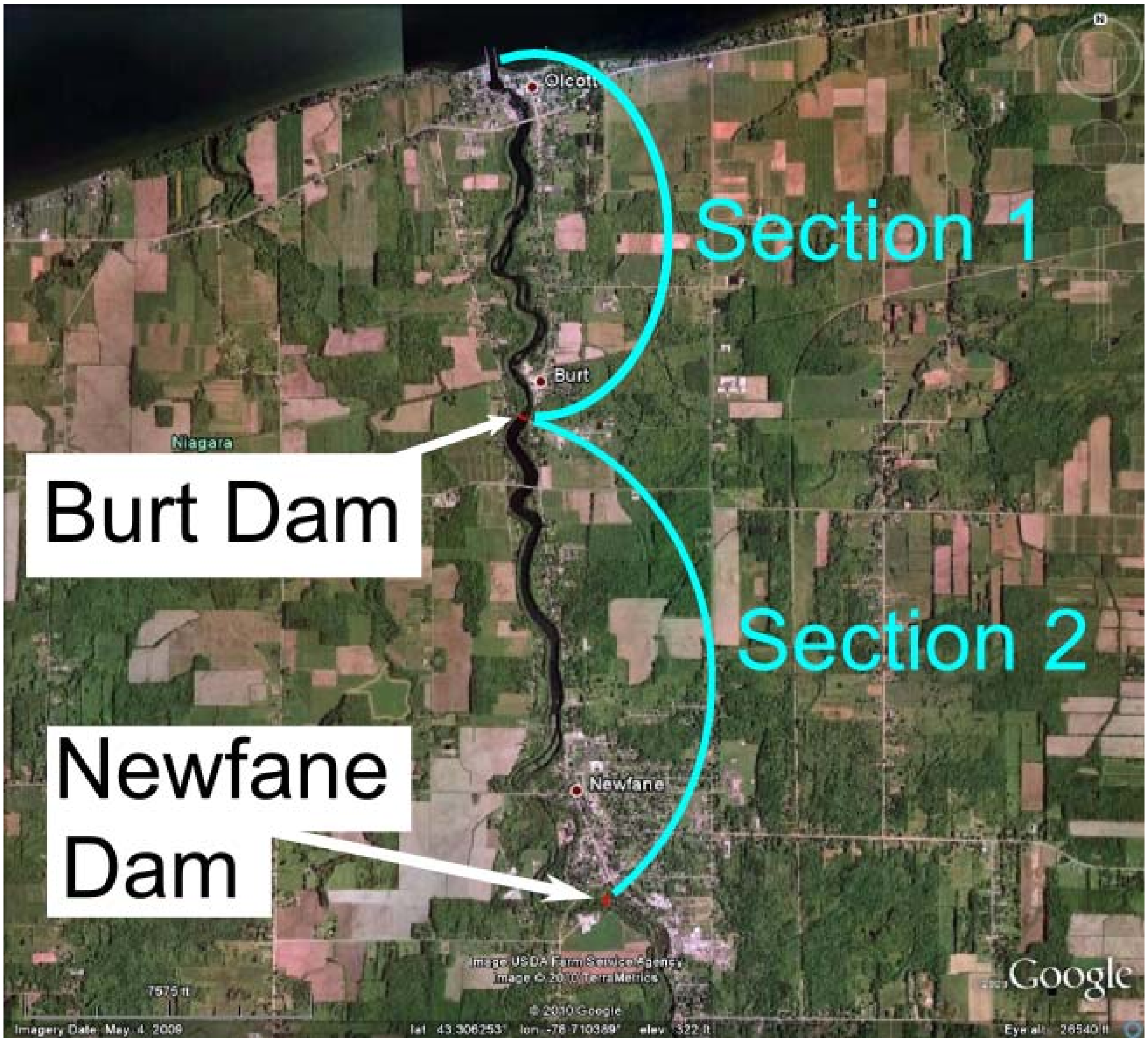

Figure 1. Map of the sections of Eighteenmile creek to be modeled in this study. Section 1 is defined as downstream of Burt Dam to Olcott Harbor at Lake Ontario, and Section 2 is defined as downstream of Newfane Dam and upstream of Burt Dam.

Evaluation of Risk to Human and Ecological Receptors

Several studies have been conducted in the AOC to document potential risk to human, aquatic organism, and terrestrial wildlife receptors. New York State Department of Health has designated Eighteenmile Creek with its most stringent "Do Not Eat" fish advisory on the basis of PCB contamination. Lake Ontario is subject to other less stringent, species-specific fish advisories related to the presence of PCBs, Mirex, and dioxin (NYSDOH, 2009). USACE Buffalo District conducted an evaluation of the toxicity and bioaccumulation of persistent organics in samples from the lower reach collected in 2003 (USACE Buffalo District, 2008); this study indicated that DDE likely presented a chronic toxicity risk relative to selected freshwater toxicity threshold values and was bioaccumulating at higher than anticipated levels. PCBs were also found to be bioaccumulating. Dioxins were detected in sediment samples and predicted to cause potential wildlife bioaccumulation risks based on an equilibrium partitioning approach used by New York State.

In 2008, a study on the Beneficial Use Impairments of Eighteenmile Creek (Ecology and Environment, 2008) concluded that the impairment was largely due to PCB contamination. This study evaluated contaminant levels in brown bullhead collected below the dam and at a reference station (Oak Orchard Creek). It showed elevated levels in Eighteenmile Creek compared to Oak Orchard Creek, with PCBs exceeding literature-based critical tissue concentrations for PCBs, but dioxins did not exceed critical levels (Ecology and Environment, 2008). That report concluded, "Overall, these results suggest that bullhead from Eighteenmile Creek may be at risk from elevated tissue residues of PCBs but not from dioxins/furans" (p. 3-29). A risk evaluation for fish-eating wildlife from PCBs and dioxins/furans was conducted as part of the investigation. The results indicate small excess risk from dioxins to mink with much greater risk from PCBs. Slightly elevated risk to fish-eating birds was indicated for PCBs, but not dioxins (p. 3-36). Risks from chlorinated pesticides were not evaluated in this study.

DATA COMPILATION AND DATABASE DEVELOPMENT

Aquatic food web bioaccumulation models are designed to predict the transfer and accumulation of organic contaminants; they are best suited to chemicals that undergo minimal metabolism and breakdown when taken up by organisms. As such, polychlorinated biphenyls, dioxins/furans, and some chlorinated pesticides are good candidates for modeling. These models also require that environmental data (i.e., sediment and water data) be available to characterize exposure concentrations. Model calibration and validation also requires measured contaminant concentrations in organisms to compare against model output. The following table provides a general breakdown of the available contaminant data, media, and location for dichlorodiphenyltrichloroethane (DDT) and its metabolites ("DDTs"), chlorinated dibenzodioxins/furans ("dioxins"), and polychlorinated biphenyls ("PCBs"). The robustness of those data sets, as reviewed in the "Data Compilation" section below will provide a basis for recommendations regarding whether a class of compounds will be modeled and/or recommended for additional sampling.

Table 1. Summary of chemical sampling in various media above and below Burt Dam.

	Section 1: Below Burt Dam			***Section 2: Above Burt Dam***		
	Water	**Sediment**	**Biota**	**Water**	**Sediment**	**Biota**
Pre-1990		PCBs, DDTs				
1990s	Dioxins, ***PCBs***, DDTs	Dioxins, PCBs, DDTs			Dioxins, PCBs, DDTs	Dioxins
2000-2010	Dioxins, ***PCBs***	***Dioxins, PCBs, DDTs***	Dioxins, PCBs		***PCBs***, DDTs	

Bold italics indicate that more than 10 samples are available.

Data Compilation

Contaminant data from surface water, sediments, and biota in the AOC and upstream areas were requested from USACE Buffalo District, U.S. Environmental Protection Agency (USEPA) Great Lakes National Program Office (GLNPO), the New York State Department of Environmental Conservation (NYSDEC), and the Niagara County Soil and Water Conservation District. The primary source of historical studies was an online repository of documents on Eighteenmile Creek contamination compiled by the Eighteenmile Creek Remedial Action Plan (RAP) Coordinator, available at URL http://www.eighteenmilerap.com/data.htm. This website and follow-up document requests from the RAP coordinator were used to compile all existing relevant datasets on Eighteenmile Creek. The most recent sampling effort was conducted by USEPA (CH2MHill, 2009) for sediment contaminant and geotechnical property analysis from Burt Dam up to Lockport, NY near the Erie Canal. At the time of writing, data from sampling in the fall of 2009 were available; additional sampling in the reservoir directly upstream of Burt Dam was planned for May 2010.

Documents were evaluated for potential inclusion in the database based on: a) whether they contained data; b) type of data collected; and c) spatial location of the data collected. Sampling locations within Lake Ontario, or upstream of the confluence of the Main Stem and East Branch of Eighteenmile Creek (e.g., samples in Lockport), were not included in the database. The database includes all data available on PCBs (congeners or Aroclors), DDTs, and dioxins/furans in sediment, water, or biota, as well as sediment properties and water quality parameters. Additionally, information such as habitat analyses, wildlife surveys, and laboratory bioaccumulation or toxicity studies were included as auxiliary datasets. If data were semi-quantitative or no specific location information beyond “Eighteenmile Creek” was indicated, they were not included. Some datasets appeared multiple times in different documents. In those cases, the new source was assessed for new information. If new information was provided (e.g., more detailed sampling dates), as was often the case, the database was updated with the new information. The document was listed as “included” in the database whether or not it contained new information.

All documents that contained datasets suitable for inclusion in the database are listed in Table 2a; documents that were evaluated but found unsuitable for inclusion in the database are listed in Table 2b. The most important sources were the 1997 Eighteenmile Creek RAP (NYSDEC, 1997a), which compiled most of the contamination data available at that time; the 2004 Army Engineer Research and Development Center (ERDC) sediment study (Karn et al., 2004), which took 15 surface sediment samples throughout the AOC and performed chemical analyses as well as laboratory bioaccumulation studies; very recent (late 2009) samples provided directly in spreadsheet form by Ecology and Environment, Inc., which focused on PCBs in upstream areas but contained 35 sampling locations within the scope of the data compilation effort (for field sampling plan, see CH2MHILL, 2009); and the 2008 Beneficial Use Impairment Investigation (Ecology and Environment, 2008), which analyzed biota (brown bullhead) for contaminants, and provided useful auxiliary data. Three NYSDEC reports (Estabrooks et al., 1994; Litten, 1996; NYSDEC, 1997b) had partial or complete data overlap with the 1997 RAP. Other sources of datasets included the Biological Stream Assessment (Bode et al., NYSDEC, 1990), a NYSDEC report on 1998 sediment sampling (Garabedian et al., 2001), three EPA field data reports (USEPA, 2006, 2008a, 2008b), a university study on sediment transport in the creek (Makarewicz et al., SUNY College at Brockport, 2006), and USGS online electronic data (USGS, 1971-2008). Three documents (Ecology and Environment, 1978, 2004; and a spreadsheet of unknown origin [probably NYSDEC] documenting collected fish species over time) were used solely for auxiliary data and not for the main database.

Database Development

The source datasets were harmonized into a common database structure to facilitate comprehensive comparison and evaluation of data gaps. For each relevant sample, the sampling date, the agency or organization performing the sampling, the sampling location, and the source document and page number for the information was recorded along with standard data (i.e., the name of the parameter or analyte, units, value, and any quality control comments). Locations were geocoded using the Google Earth mapping service to determine latitude/longitude coordinates in decimal degrees when not provided in the original document. In the case of the 2009 samples collected by Ecology and Environment for the USEPA, coordinates were converted from UTM Zone 17 to latitude/longitude using the NOAA National Geodetic Survey's UTMS utility for PC. The complete database is available in the form of three Microsoft Excel files for sediment, water, and biota. Additional spreadsheets compile information on ecology and habitat (primarily species lists and land cover types), results of laboratory bioaccumulation studies, and other data of interest that were not possible to harmonize into the common database structure.

Data were stratified by media (sediment, water, or biota), contaminant (PCB congeners or aroclors, DDTs, and dioxins/furans), sampling date (pre-1990, 1990-2000, and post-2000), and sampling location (downstream of Burt Dam, between Burt Dam and Newfane Dam, and between Newfane Dam and the confluence with the East Branch). For spatial categorization, three creek sections were defined, from Section 1 (below Burt Dam) to Section 3 (above Newfane Dam). See Table 3 for a summary of data availability by section, contaminant, and timeframe (1990s or 2000s). For data coverage visualization, Google Earth files for PCBs, dioxins, DDTs, and media properties sampling locations were created using the Google Earth Outreach Spreadsheet Mapper v.2.0 tool. When loaded into Google Earth, the files display the sampling locations for all available data, organized by contaminant, time period, and media such that subsets of interest can be selected interactively. When one of the points is clicked, a pop-up provides information on dates, Agency collecting the sample, and any additional information (e.g., core or surface sample; PCB congeners or aroclors). See Figures 2-7 for static map images showing the spatial extent of the existing PCBs and DDTs data within the area of interest for bioaccumulation modeling.

Overall, despite a large number of total data points with roughly 10,000 records in the database, many of the datasets are old – collected in the 1990's or earlier. Most efforts were focused on a specific contaminant, media, and/or location, so synoptic data are lacking. The recent (2009) sampling effort focused primarily upstream of the Newfane Dam and is beyond this study's boundaries; moreover, most sediment concentrations from that study come from cores at least one foot deep, which are not representative of the surface sediments, and therefore not useful for depicting exposure concentrations in food web bioaccumulation modeling.

EVALUATION OF SITE DATA FOR USE IN *TROPHICTRACE* MODELING

The TrophicTrace food web bioaccumulation model will be applied at the site to evaluate contaminant bioaccumulation across trophic levels. TrophicTrace and its underlying mathematical structure (Gobas 1993) are well-accepted and have been used in a number of regulatory applications. See Appendix B, The *TrophicTrace* Bioaccumulation Model, for further information on the model.

Data needs for modeling are dictated by model structure and requisite inputs. Food web bioaccumulation models require input of multiple parameters on environmental conditions, contaminant exposure concentrations, contaminant characteristics, food web structure, and biological parameters. Input parameters are drawn from empirical data collected from the site, literature values from similar sites or conditions, or model default parameters. For example, site data to establish exposure concentrations include contaminant concentrations in sediment and water, and sediment total organic carbon content. Additional site-specific data (such as organism weight and lipid content of food web organisms and environmental parameters such as temperature and dissolved oxygen) are also needed to support a site-specific application of the model.

Below, an overview of the proposed modeling setup is provided and datasets are briefly summarized and described with regard to sampling and analysis issues known to affect contaminant concentrations, data comparability, and data quality.

Area

As described above, The *TrophicTrace* model will be applied to two general locations: Olcott Harbor to Burt Dam (Section 1) and Burt Dam to Newfane Dam (Section 2). Table 4 presents an overview of the available data from these Sections for use in the modeling.

Contaminants

This modeling effort will focus on PCBs. This decision was made for a variety of reasons: Based on the risk evaluations described above, PCBs are the primary risk drivers. The database compilation and assessment indicate that PCBs have the most robust recent data set, including sampling during the 2009 and 2010 sediment sampling effort performed by USEPA (See Table 4). That sampling effort did not evaluate dioxins and chlorinated pesticides were not particularly elevated or prevalent. Finally, a focus on a single class of contaminants will permit more intensive sampling to support the modeling compared to the amount that could be conducted if three contaminant classes were monitored.

Timeframe

The most recent data are most useful for representing current system conditions, so data collected prior to 1990 will not be used in modeling, and data collected prior to 2000 will be used only if necessary.

Sediment and Water Analyses

Sediment sampling depth: For sediments, those samples that represent the sediment surface are most relevant for modeling exposure to organisms. Surface sediments are those sediments in the biologically active zone (BAZ) of benthic organisms. This study will use data with sampling depths of 6 inches or less, which typically represents the BAZ (NRC, 2001). Further, for the data sets available, there are no samples less than 6 inches. Those samples with depths greater than 6 inches contain sediments that are below the BAZ and cannot reasonably be expected to represent sediment contaminant exposures to benthos, surface water, or fish.

Contaminant analyses. For PCBs, some of the data are available as congeners and some as Aroclors. Aroclors (or sum of Aroclors) and sum of congener data sets are not interchangeable as representations of total PCB; they are measured using very different analytic approaches. The same approach must be also used in all media modeled, i.e., biota, water, and sediment. In Section 1 (Post-2000), there are 21 congener and one Aroclor data points from the Corps' 2003 and EPA's 2008 sediment sampling efforts. In Section 2 (post-2000), only 4 sediment samples were analyzed for Aroclors; in 1998, NYDEC analyzed congeners on 4 sediment samples (3 discrete and 1 composite). USEPA's 2010 sediment sampling in Section 2 will include congener analyses of surface sediments. For biota, only Aroclor measurements in brown bullhead downstream of the dam (Section 1) are available. EPA has routinely sampled contaminants in surface water in Eighteenmile Creek and several other tributaries to Lake Ontario. PCBs levels (measured as congeners) in Eighteenmile Creek are significantly elevated compared to other tributaries, "up to 20 times higher than levels observed in any other tributary to Lake Ontario from the American side of the Lake" (USEPA 2008b). Dioxins were generally not detected in water; DDTs samples had low concentrations and their analysis in water was discontinued (USEPA 2008a).

Total organic carbon: The organic carbon phase of sediment has a well-known modifying effect on the bioavailability and bioaccumulation of contaminants from sediments. Organic carbon analyses were taken in conjunction with the 2009 sampling round and the USACE sediment sampling that took place in 2003.

Biological Analyses

Biota contaminant concentrations, particularly at higher trophic levels, are necessary for model calibration and validation. Few usable fish tissue contaminant concentrations exist for the site (one species, brown bullhead, over one sampling period). Additional fish tissue concentration data exist from several studies in the 1990s (as presented in Table 4-6 of the RAP [NYSDEC, 1997a]), but the collection location of these samples is not known nor are individual sample concentrations. The relevance of these older data to present conditions is also uncertain. Optimally, there is close temporal overlap of exposure conditions (sediment and water contaminants) and fish tissue contaminants. Fish and sediment sampling should also be conducted so that exposure areas of the organisms and the sampled sediment areas correspond closely. A more detailed examination of issues surrounding the fish collection for use in modeling can be found in EPA (2008c).

Collection Date: Fish contaminant levels can vary seasonally. In temperate climates, fish tissue contaminant concentrations tend to be at their lowest following winter and highest following summer. As a result, it is important that fish sampled across years be collected at similar times so that this known source of variation can be addressed. The one sample set of fish data that are available were collected in August 2007.

Lipid: Lipid concentrations in collected fish are an essential component for modeling because of the preferential partitioning of hydrophobic contaminants into lipid components. Lipid concentrations were collected for the brown bullheads sampled in 2007; however, estimates of lipid concentrations in benthic organisms are not available. Those estimates can be obtained from the literature or by modeling but will introduce uncertainty into the modeling results.

Site-specific Bioaccumulation Data

We will use the bioaccumulation test results analyzed in 2008 (USACE, Buffalo District, 2008) to evaluate model assumptions at the base of the food web. The *TrophicTrace* model typically assumes equilibrium partitioning from sediment to benthic invertebrates based on a lipid content in invertebrates and a measured percent organic carbon and contaminant concentration in sediment. This is equivalent to a biota:sediment accumulation factor (BSAF) of one. However, the results of the bioaccumulation testing (USACE, Buffalo District, 2008) suggest that higher BSAFs may be warranted. In this study, bioaccumulation testing on Eighteenmile Creek sediments was conducted using *Lumbriculus variegates*, a sediment-dwelling oligochaete. From these analyses we will use the BSAF data values directly or as a line of evidence to support the bioaccumulation parameters.

DATA GAPS ANALYSIS AND RECOMMENDATIONS

Sediment

Approximately 20 surficial sediment samples from Section 1 were analyzed for PCBs (congener basis) in 2003 (15 locations and 5 composites of 3 locations each). This is a reasonable number and spatial coverage of the sampling is appropriate to represent fish exposure areas in bioaccumulation modeling. However, because of the age of that data, it is questionable whether those data can adequately represent current conditions. To supplement and verify data from Section 1, we recommend collecting an additional 5 surface sediment (top 6 inches) samples consisting of a composite of 3 locations each, similar to the 2003 USACE composite sampling plan. If there are no statistically significant differences in contaminant concentrations between the averages of the two years, then the combined data set can be used.

In the spring of 2010, USEPA will be sampling surface sediments (top 6 inches) at several locations in Section 2 in the Burt Dam reservoir. These samples will be analyzed for PCBs (dioxins or DDTs will not be analyzed) and will be used to represent that area’s surface sediment contaminant concentration in the modeling.

Water

USEPA conducted water sampling for PCBs on a congener basis over several different seasons (USEPA, 2006, 2008a). These data will be used to represent contaminant exposures from water and we do not recommend collecting any additional water samples at this time.

Biota

We recommend collecting fish samples from both Sections 1 and 2. Species will be chosen to represent different trophic levels in the food web so that bioaccumulation in the foodweb can be assessed. Preferably, a forage fish (e.g., a resident minnow or shiner species), a piscivorous fish (e.g., bass), and a demersal species (e.g, brown bullhead) will be included. Approximately 5-10 fish per species per Section would be appropriate.

ASSOCIATED DATABASE AND VISUALIZATION FILES

Google Earth map files:
- 18miCk DDTs.kmz
- 18miCk DioxinsFurans.kmz
- 18miCk Media Properties.kmz
- 18miCk PCBs.kmz

Main database files:
- 18miCk_biota.xlsx
- 18miCk_sediment.xlsx
- 18miCk_water.xlsx

Additional database files:
- 18miCk_ecology.xlsx
- 18miCk_LabBioacc.xlsx
- 18miCk_OtherData.xlsx

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http://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=04219765

Table 2a. Documents and sources for datasets included in the database.

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Table 3. Overview of data compiled for Eighteenmile Creek.

Section 1
Burt Dam -> Olcott Harbor

Dioxins/furans

Year	Who Collected	Media
1994	NYSDEC	sediment
1998	NYSDEC	water
2002	EPA	water
2003	EPA; COE	water; sediment
2007	Ecology & Environ.	biota

PCBs (Aroclors)

Year	Who Collected	Media
1977	COE	sediment
1981	EPA; COE	sediment
1987	COE	sediment
1994	NYSDEC	water; sediment
2003	COE	sediment
2007	Ecology & Environ.	biota

PCBs (congeners)

Year	Who Collected	Media
1998	NYSDEC	water
2002	EPA	water
2003	EPA; COE	water; sediment
2004	EPA	water
2005	EPA	water
2006	EPA	water
2007	EPA	water
2008	EPA	sediment

DDTs

Year	Who Collected	Media
1977	COE	sediment
1981	COE; EPA	sediment
1987	COE	sediment
1994	NYSDEC	water; sediment
2003	COE	sediment
2008	EPA	sediment

Section 2

Newfane Dam -> Burt Dam

Dioxins/furans

Year	Who Collected	Media
1990	NYSDEC	biota
1994	NYSDEC	sediment
1998	NYSDEC	sediment

PCBs (Aroclors)

Year	Who Collected	Media
1994	NYSDEC	sediment
2009	Ecology & Environ.	sediment

PCBs (congeners)

Year	Who Collected	Media
1998	NYSDEC	sediment
2009	Ecology & Environ.	sediment

DDTs

Year	Who Collected	Media
1994	NYSDEC	sediment
1998	NYSDEC	sediment
2009	Ecology & Environ.	sediment

Section 3

Main Stem/East Branch confluence -> Newfane Dam

Dioxins/furans

Year	Who Collected	Media
1989	NYSDEC	water
1990	NYSDEC	biota; sediment
1994	NYSDEC	sediment
1998	NYSDEC	sediment

PCBs (Aroclors)

Year	Who Collected	Media
1972	USGS	water
1973	USGS	water
1974	USGS	water
1989	USGS	sediment
1990	NYSDEC; USGS	biota; sediment
2009	EPA	sediment

PCBs (congeners)

Year	Who Collected	Media
1998	NYSDEC	sediment
2009	EPA	sediment

DDTs

Year	Who Collected	Media
1971	USGS	water
1972	USGS	water
1973	USGS	water
1974	USGS	water
1989	USGS	sediment
1990	NYSDEC; USGS	biota; sediment
1994	NYSDEC	sediment
1998	NYSDEC	sediment
2009	EPA	sediment

Table 4. Synopsis of Eighteenmile Creek data for food web modeling.

Section 1			----------------*90s*-------------						----------------*00s*-------------					
Contaminant	*Media*	*Units*	*# samples*	*% detects*	*Mean*	*Min*	*Max*	*Max Location*	*# samples*	*% detects*	*Mean*	*Min*	*Max*	*Max Location*
DDTs	Sediment	µg/kg	6	100%	9.0	3.6	16	S94-4	20	85%	18.9	3.2	51	EMC 12
	Water	ng/L	5	80%	0.09	0.08	0.11	DEC-Q1	no data					
	Biota	mg/kg lipid	no data						no data					
PCBs (sum of congeners)	Sediment	µg/kg	no data						21	86%	190.5	26.8	454.6	EMC 12
	Water	ng/L	1	100%	84.1	84.1	84.1	DEC-6A	13	100%	39.1	21.5	52.2	EPA-W1
	Biota	mg/kg lipid	no data						no data					
Aroclor 1248	Sediment	µg/kg	4	100%	262.7	0.39	630	S94-4	1	100%	718	718	718	EMC 4 QA
	Water	ng/L	no data						no data					
	Biota	mg/kg lipid	no data						8	100%	64.1	46	87	EMC-18-BB-LP
Aroclor 1254	Sediment	µg/kg	4	100%	110.1	0.14	230	S94-4	1	100%	<20.4 *	<20.4 *	<20.4 *	EMC 4 QA
	Water	ng/L	no data						no data					
	Biota	mg/kg lipid	no data						8	100%	30.3	17	53	EMC-18-BB-LP
Aroclor 1260	Sediment	µg/kg	2	0%	n/a	n/a	n/a		1	100%	<20.4 *	<20.4 *	<20.4 *	EMC 4 QA
	Water	ng/L	no data						no data					
	Biota	mg/kg lipid	no data						8	100%	8.01	4.4	14	EMC-18-BB-LP
PCBs (sum of Aroclors)	Sediment	µg/kg	4	50%	745	630	860	S94-4	no data					
	Water	ng/L	13	100%	9.8	5	27.7	DEC-Q1	no data					
	Biota	mg/kg lipid	no data						8	100%	96.5	69	140	EMC-18-BB-LP

Section 2			90s						00s					
Contaminant	*Media*	*Units*	*# samples*	*% detects*	*Mean*	*Min*	*Max*	*Max Location*	*# samples*	*% detects*	*Mean*	*Min*	*Max*	*Max Location*
DDTs	Sediment	µg/kg	2	100%	20.1	10.2	30	S94-6	2	50%	6.4	6.4	6.4	R4-119-T
	Water	ng/L	no data						no data					
	Biota	mg/kg lipid	no data						no data					
PCBs (sum of congeners)	Sediment	µg/kg	4	100%	0.82	0.42	1.12	DEC-6F	no data					
	Water	ng/L	no data						no data					
	Biota	mg/kg lipid	no data						no data					
Aroclor 1248	Sediment	µg/kg	1	100%	1900	1900	1900	S94-6	4	0%	n/a	n/a	n/a	
	Water	ng/L	no data						no data					
	Biota	mg/kg lipid	no data						no data					
Aroclor 1254	Sediment	µg/kg	1	100%	590	590	590	S94-6	4	75%	152.3	67	290	R4-038-C
	Water	ng/L	no data						no data					
	Biota	mg/kg lipid	no data						no data					
Aroclor 1260	Sediment	µg/kg	1	0%	n/a	n/a	n/a		4	0%	n/a	n/a	n/a	
	Water	ng/L	no data						no data					
	Biota	mg/kg lipid	no data						no data					
PCBs (sum of Aroclors)	Sediment	µg/kg	1	100%	2490	2490	2490	S94-6	4	75%	152.3	67	290	R4-038-C
	Water	ng/L	no data						no data					
	Biota	mg/kg lipid	no data						no data					

Notes:

* = analyte detected at concentration below reporting limit
Surface sediment or cores of depth 6 inches or less only; composites included. Water is suspended solids phase only (pressure filtration), except for PCBs (sum of congeners), which is whole or unfiltered water. Biota is brown bullhead whole body.

Figure 2. All sampling locations for PCBs in the database. Note that locations upstream of Newfane Dam will not be used directly in food web modeling.

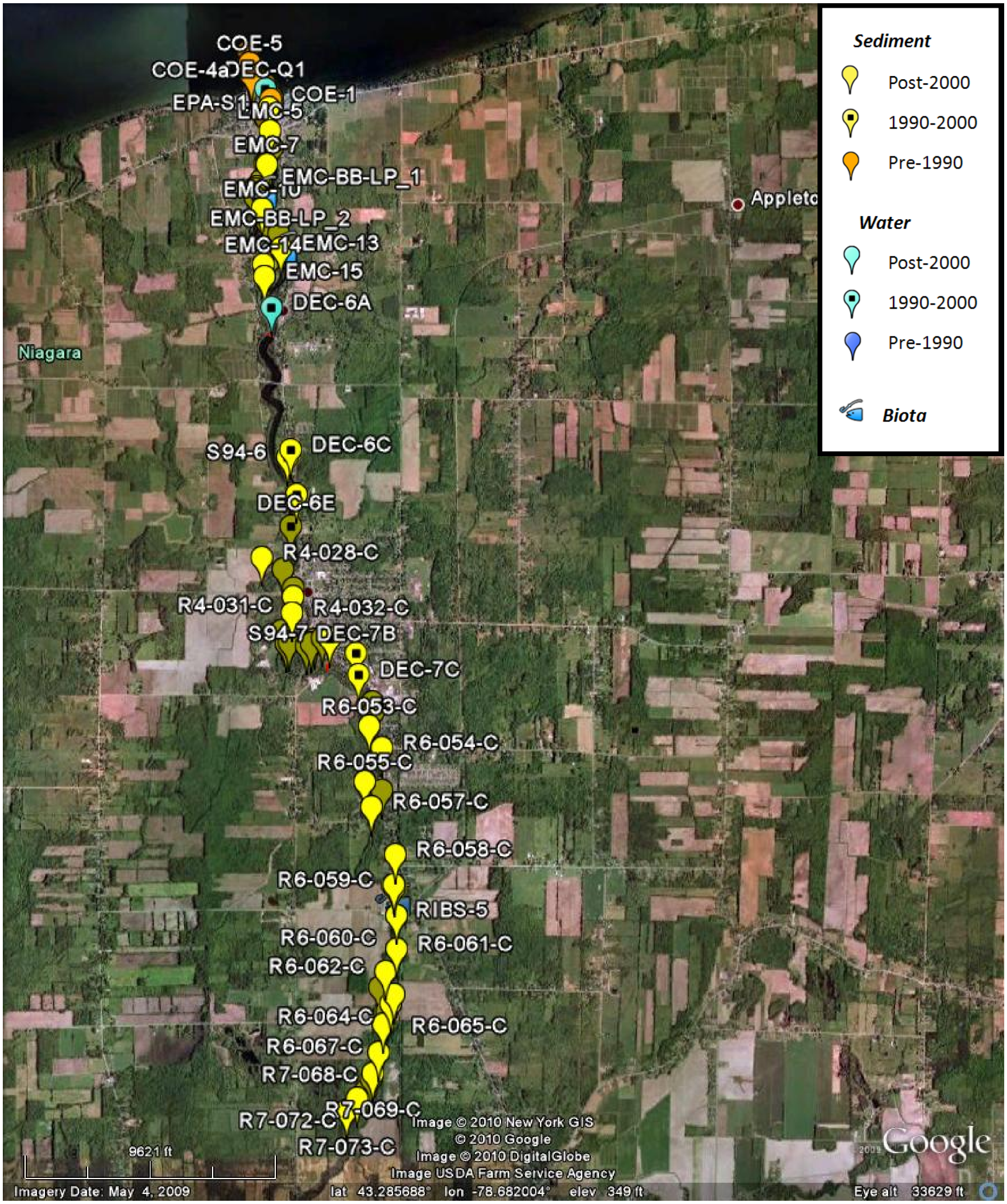


Figure 3. All sampling locations for DDTs in the database. Note that locations upstream of Newfane Dam will not be directly used in food web modeling.

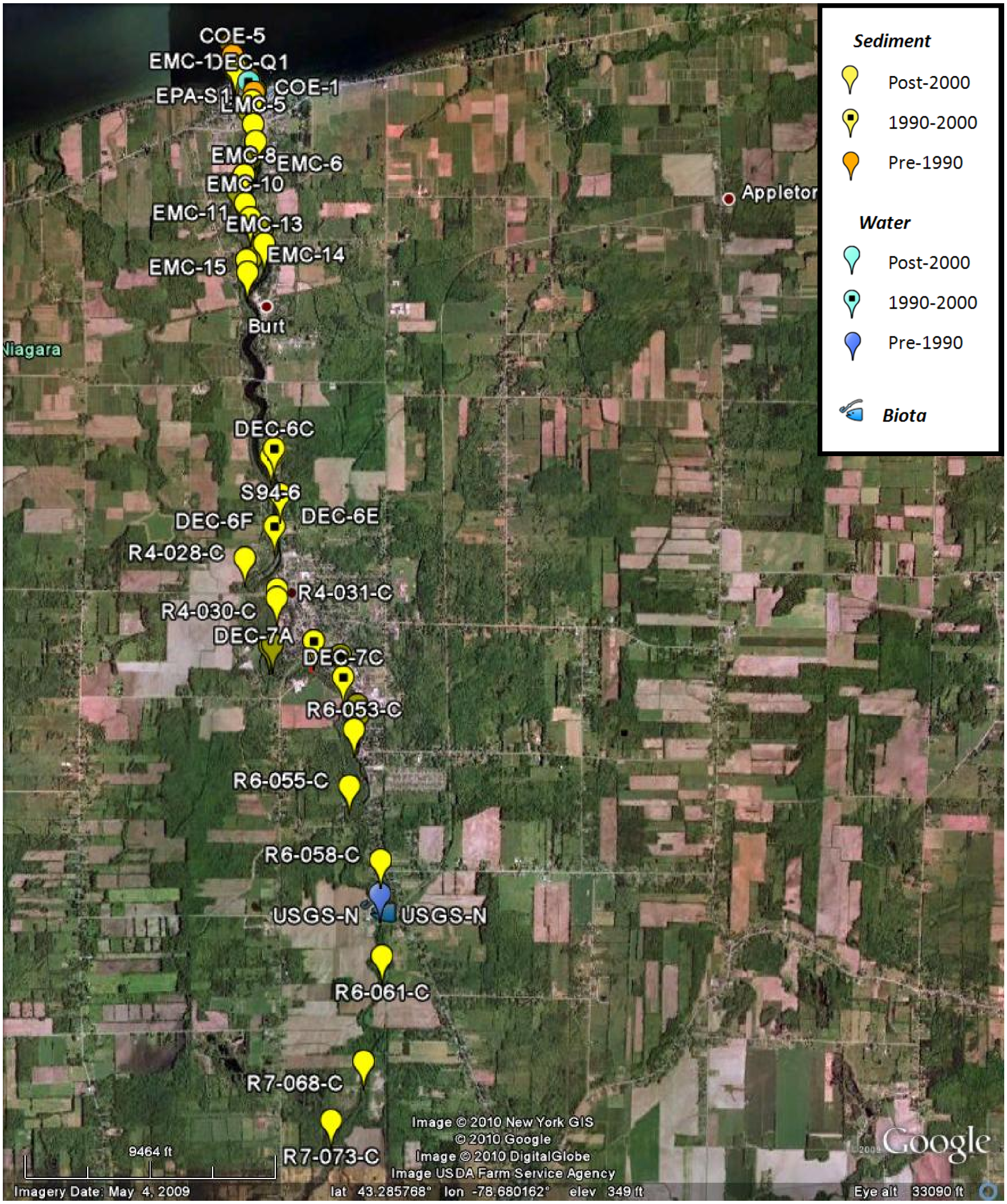


Figure 4. Sampling locations for PCBs in Section 1, between Burt Dam (in red) and Olcott Harbor.

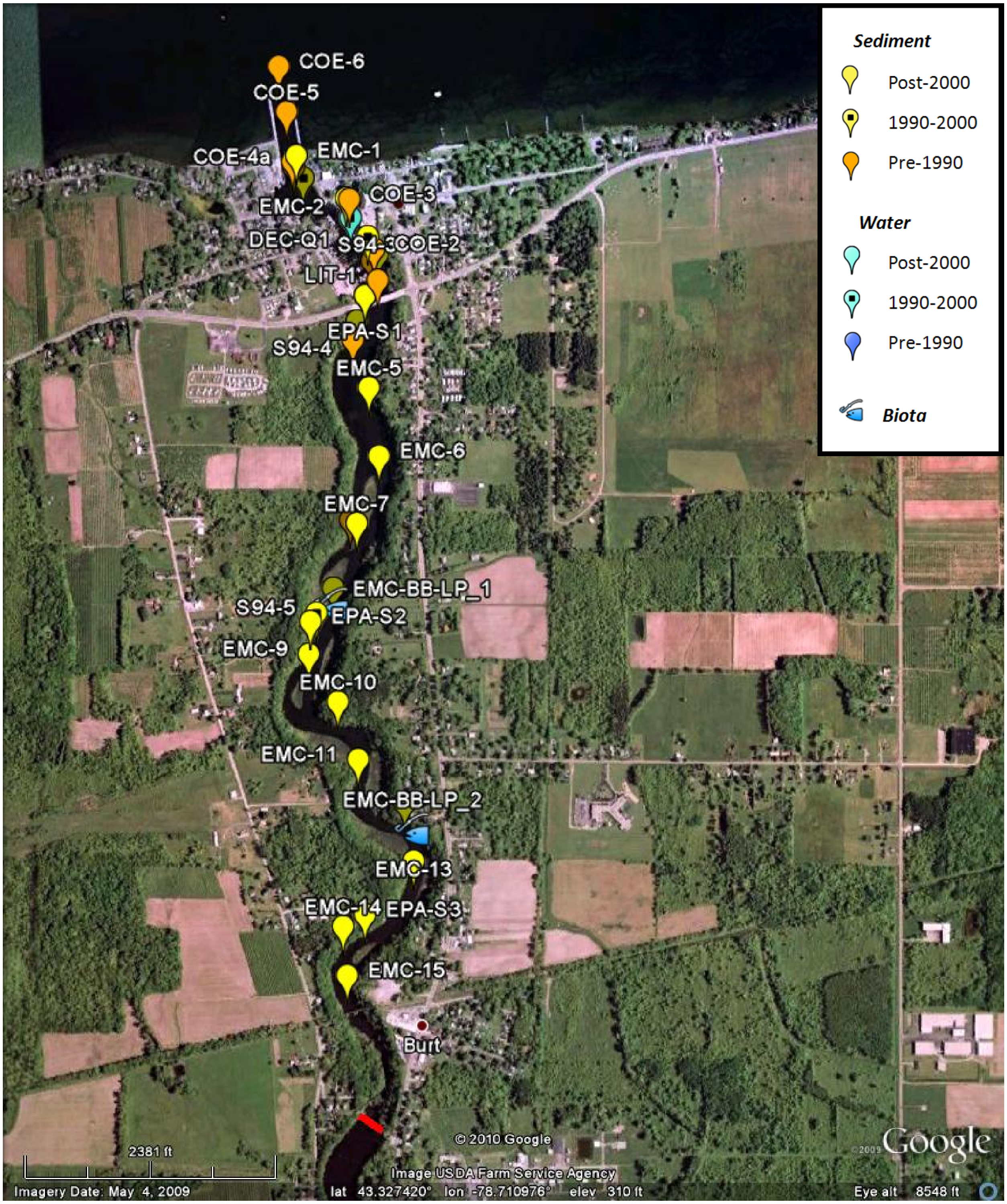


Figure 5. Sampling locations for DDTs in Section 1, between Burt Dam (in red) and Olcott Harbor.

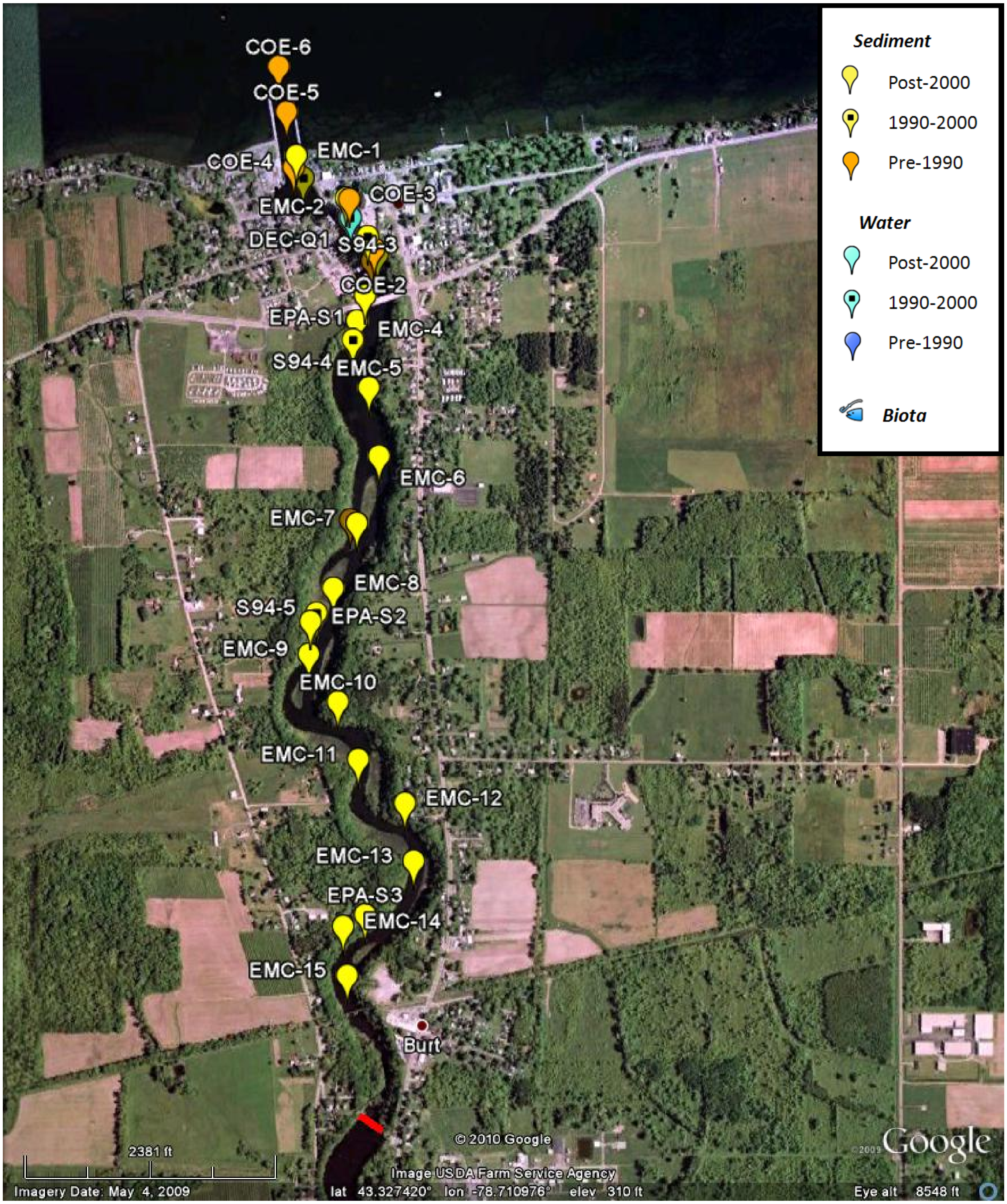


Figure 6. Sampling locations for PCBs in Section 2, between Newfane Dam and Burt Dam (dams shown in red).

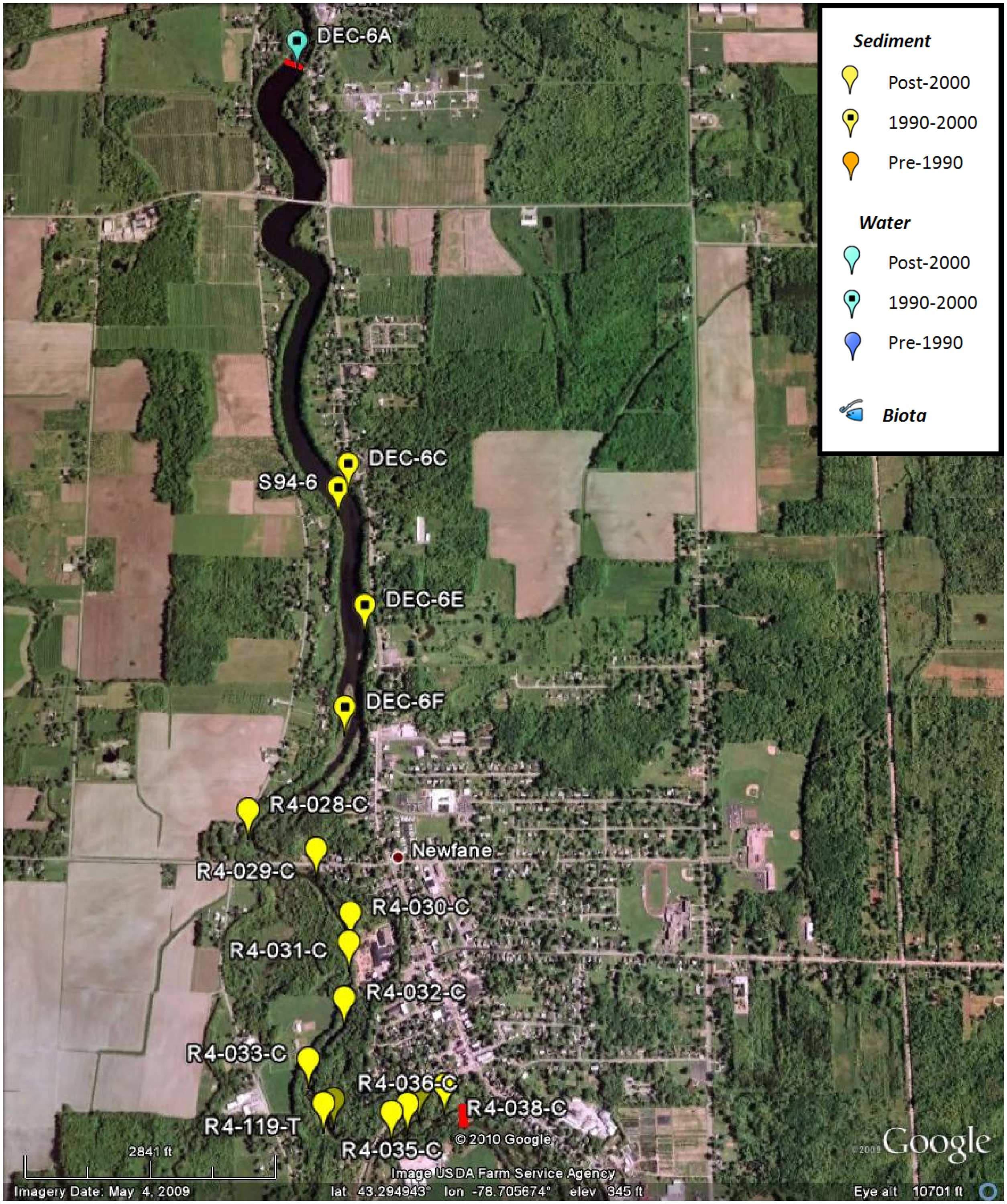
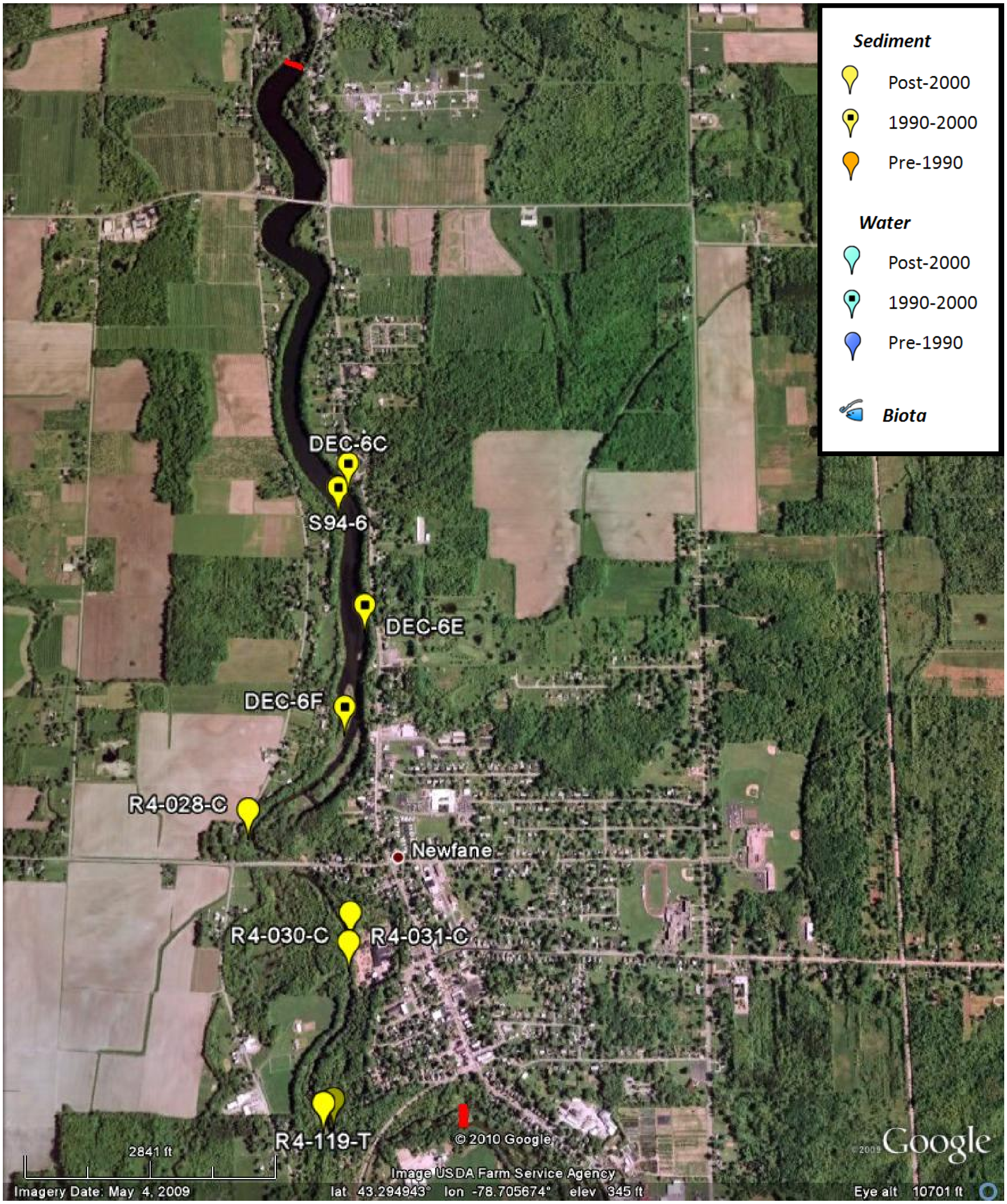


Figure 7. Sampling locations for DDTs in Section 2, between Newfane Dam and Burt Dam (dams shown in red).



APPENDIX A

SCOPE OF WORK

Technical Support to U.S. Army Corps of Engineers Buffalo District on Food-web Modeling of the Eighteenmile Creek Area of Concern

Prepared By

U.S. Army Engineer Research and Development Center
Environmental Laboratory

08 September 2009

BACKGROUND: Eighteenmile Creek is one of forty-three areas of concern (AOCs) established within the Great Lakes due to loss of “beneficial uses” from degraded water quality. The AOC encompasses Eighteenmile Creek from it’s entry into Lake Ontario, upstream to the Burt Dam (approximately 2 miles). The AOC has three identified use impairments linked to sediment contamination: (1) restrictions on fish and wildlife consumption; (2) degradation of benthos; and (3) restrictions on dredging activities.

Previous studies indicate elevated levels of PCBs, chlorinated pesticides, and metals in surficial sediments throughout most of the AOC. Invertebrate bioaccumulation testing also suggests that organic contaminants moving through the food chain are creating environmental risks. Contamination sources to the river are not well understood. However, recent investigations by New York State Department of Environmental Conservation (NYSDEC) have focused on a contamination source in Lockport, NY, near the upper reach at the Erie Canal (approximately 12 miles upstream of Burt Dam). High levels of PCBs have been detected in sediments near the facility and fish tissue contaminant levels are also elevated (samples above 2 mg/kg total PCBs wet weight) in the river reach above the Burt Dam.

Although there have been several contaminant data collection efforts on sediments, surface water, and biota to define the geographic extent of contamination and impact to fish and wildlife, these have not focused on understanding contaminant bioaccumulation, movement in the food chain, and consequent environmental risks. Developing such an understanding will assist site managers as they move toward greater resolution on the nature of impairments at the site, develop remedial actions, and ultimately delist the area.

OBJECTIVE: Evaluate organic contaminant bioaccumulation, trophic transfer and consequent risks in river sections above and below Burt Dam of the Eighteenmile Creek.

APPROACH: Over the course of the support period (October 2009 to October 2010), ERDC scientists will review technical materials, conduct a data gaps analysis, conduct additional field data collection efforts, and develop a food web bioaccumulation model based on stakeholder input for two segments of Eighteenmile Creek (above and below Burt Dam). During this time, ERDC personnel will conduct a site visit, participate in conference calls and meetings, and prepare written reports. Technical support will be provided for the following tasks in the expected time frame:

<u>Task 1: December 1-December 31, 2009: Assemble Existing Data</u>. Assemble data from various investigations of contamination in sediment, water, and biota. ERDC will develop an electronic database from existing studies provided by USACE Buffalo District. Timeliness of the effort will depend on the format (paper, scanned, electronic spreadsheet) and content of the received information (e.g., do samples possess supporting information such as corresponding location, sample depth, organic content [sediments]; species, sex, size, date, lipid, fillet/whole [fish]), and number of iterations required to assemble necessary information.

Task 2: January 1-February 28, 2010: Data gap review. Review existing data for gaps in chemical or physical evaluations of areas, contaminants, or types of organisms. The database will be examined to understand to what level it can support food chain bioaccumulation modeling of the system. For a model to adequately represent a system, sufficient data must exist to populate essential parameters, calibrate model results, and verify/validate model output. This type of information will be identified and recommendations developed for targeted analyses to fill these data gaps. **Product:** interim memo, compiling existing data, recommending additional field data collections if necessary.

Task 2a: May 1 – August 31, 2010: Field sampling. A field sampling plan designed to supplement existing data and support food web bioaccumulation modeling will be developed and implemented if deemed appropriate. **Product**: Field data collection report describing collection efforts.

Task 3: March 1, 2010-August 31, 2010: Food web model development. A food web model of contaminant bioaccumulation and trophic transfer will be developed for the Eighteenmile Creek aquatic system above and below Burt Dam. TrophicTrace or a similar Gobas-type food web bioaccumulation model will be the preferred model platform. Additional data collection and compilation will be required such as food web structure, species profiles regarding diet, home range, and growth rate and temperature profiles in the system. Model calibration and validation will use existing or newly collected data sets. **Product:** Conceptual Site Model (CSM) memo. As a first step in the food web model development, a CSM that identifies contaminant exposure pathways and receptors in the system will be developed. The CSM will be informed by the analyses conducted in Task 2 and inform the sampling plan identified in Task 2a. To develop the CSM, a workshop will be held to obtain input from Buffalo District staff and others as appropriate.

Task 4: September 1, 2010-December 31, 2010: Foodweb model calibration, validation, and application to food webs above and below Burt Dam. Empirical data and model output on fish tissue concentrations will be compared between the two river segments to examine differences in fish tissue bioaccumulation and consider mechanisms for any such variation. As new data is provided from ongoing field collection efforts, the projects database and bioaccumulation models will be updated. **Product:** Final report, documenting development of the food web models, evaluations and comparisons between river areas, and developing conclusions from the empirical data, bioaccumulation model evaluations, and environmental risks to receptors per the CSM.

PERIOD OF SERVICE:
December 1, 2009 to December 31, 2010

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APPENDIX B

The *TrophicTrace* Bioaccumulation Model

Introduction

The *TrophicTrace* model is capable of evaluating the potential human health and ecological risks and hazards associated with exposure to contaminants originating in sediments from the site area. The *TrophicTrace* model is based on the steady-state solution for contaminant uptake developed by Dr. Frank Gobas and his students at Simon Frasier University (Gobas, 1993). The underlying mathematical framework is well-accepted and has been used in a number of regulatory applications. The model was originally developed for the US Army Corps of Engineers specifically to evaluate the human health and ecological implications of dredged material management disposal decisions. *TrophicTrace* is parameterized with site-specific data to the extent possible and where available, or using values from the literature. The algorithms incorporated in TrophicTrace follow USEPA and USACE risk assessment guidance (USEPA, 1989; 1997; USEPA/USACE, 1998; Cura et al., 1999) and the model is publicly available (http://el.erdc.usace.army.mil/trophictrace/).

TrophicTrace Data Requirements

The *TrophicTrace* model requires the following user-specified inputs for a site-specific application:

Environmental inputs:

- Sediment and (freely dissolved) water concentrations
- Water temperature
- Total organic carbon in sediment

Biological inputs:
- Benthic invertebrate percent lipid
- Pelagic invertebrate percent lipid
- Fish (from several trophic levels) percent lipid
- Fish weight
- Fish feeding preferences
- Exposure parameters for human receptors (e.g., body weight, fish ingestion rate)
- Exposure parameters for ecological receptors (e.g., body weight, fish ingestion rate, incidental sediment ingestion rate, if appropriate)
- Toxicity factors for human receptors (e.g., reference doses and/or carcinogenic potency factors)
- Toxicity reference values for the ecological receptors

Contaminant inputs:

- Log K_{ow} for the contaminants of concern

Ideally, the sediment and water exposure concentrations would be collected at spatial and temporal scales that best correspond to exposure as represented by the available fish tissue data. Sediment data are a necessity, but it is possible to use equilibrium partitioning in sediments to generate water concentrations. These would represent an upper-bound exposure (e.g., actual field exposures are likely to be less than those predicted using equilibrium partitioning). The only scenario in which this would not be true would be if there is evidence that disequilibrium conditions exist such as observed flux from sediment under specific flow conditions, or as a result of bioturbation or other physical processes in the sediment. These will need to be explored as part of the site characterization.

If the available water data are for whole water samples only, then an estimate of DOC and POC will also be required to predict a freely dissolved water concentration. It is possible to use literature values for those but that can increase the uncertainty of the prediction since it is unknown how well values from other systems are representative of the system under consideration. That said, DOC and POC are less sensitive than other model inputs. Some of the other model inputs can be obtained from generic literature searches (e.g., fish lipid, exposure parameters, etc.) although the more site-specific the information is, the greater the likelihood that the model will perform better (e.g., close correspondence between predicted and observed species-specific body burdens) with respect to generating predictions for decision making. Bioaccumulation modeling analyses have shown that Log K_{ow} and percent lipid show high sensitivity (e.g., small changes in these inputs lead to large changes in predicted body burdens). In addition, fish tissue concentrations are required for model verification. This provides increased confidence that the model is accurately representing bioaccumulation in the system.

Uncertainty Analysis in *TrophicTrace*

Each model input can be specified by more than one number to quantitatively evaluate the uncertainty in predicted risks and hazards. Fuzzy set theory (Zadeh, 1965; Zimmerman, 1985) can be used to propagate uncertainty in a mathematical model when there is insufficient information to use a more sophisticated framework (e.g., probabilistic approaches) or when the equations are too complex to allow for analytical approaches (Hammonds et al., 1994). Fuzzy set approaches have been used for risk assessment applications (Guyonnet et al., 1999; Huang et al., 1999; Lee et al., 1994), for risk-cost optimization analyses (Stansbury et al., 1999), and for fate and transport studies (Dou et al, 1995; Bardossy et al., 1995).

In general, the approach is to define input parameters using either three or four numbers instead of a single number. These values represent two ranges: a possible range (upper bound and lower bound for the value – the possible range cannot be strictly interpreted as a confidence interval, but the underlying input values are typically based on confidence limits on the mean), and a probable range (expected values). In terms of predictions, the probable range represents the best estimate of risk and hazard based on using estimates of central tendency values for each input parameter (e.g., arithmetic mean and median or geometric mean). The possible range represents the lowest and highest possible predicted risks based on using a 5% lower confidence and 95%

upper confidence interval, respectively, for each input parameter. We generally use the *probable* predicted risk, noncancer hazard, and ecological toxicity to make a determination of potential risk, and use the *possible* range to describe our confidence in the determination of potential risk.

The fuzzy set algorithm has been programmed into the *TrophicTrace* model. Using fuzzy set theory, *TrophicTrace* allows users to characterize uncertainty using trapezoidal fuzzy numbers (e.g., a possible range and a probable range) and propagates these uncertainties through the analysis using fuzzy set principles (Zadeh, 1965; Zimmerman, 1985). The results of the risk assessment are described in terms of possible and probable ranges following the fuzzy propagation. The exact parameterization and interpretation depend on the goals of the analysis. For example, in this case, the goal is to predict potential impacts based on central tendency (or average) exposures. Consequently, we will define the probable range to represent the best estimate of central tendency (e.g., several choices include arithmetic mean, geometric mean, median), while the possible range reflects the uncertainty in the central tendency (e.g., 95% confidence interval on the mean). If the goal is to predict an “upper-bound” or “reasonable maximum exposure” type of scenario, then it is reasonable to use an upper percentile for the probable range (e.g., 90th and 95th) and the associated confidence interval for that percentile as the possible range.

Such model and uncertainty applications have been conducted in the past, including a site-specific application of the *TrophicTrace* model (including uncertainty analysis) at the Moss Landing site in Moss Landing, California, which was successfully completed and peer reviewed.

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