APPENDIX E

LAKE ERIE WATER QUALITY MODELING REPORT

Lake Erie Water Quality Modeling Report

ITC Lake Erie Connector

Prepared by HDR

Prepared for ITC Lake Erie Connector, LLC

May 4, 2015

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List of Acronyms

As - arsenic

Cd - cadmium

Cr - chromium

Cu - copper

d50 - median particle diameter

DHI - Danish Hydraulic Institute

DP - dissolved phosphorus

EPA - Environmental Protection Agency

FM - Flexible Mesh

GLENDA - Great Lakes Environmental Database

GLERL - Great Lakes Environmental Research Laboratory

Hg - mercury

HVDC - high-voltage direct current

IESO - Independent Electricity System Operator

IGLD - International Great Lakes Datum

kV - kilovolt

MDL - method detection limit

MOEE - Ontario Ministry of Environment and Energy

mt – metric ton

MW - megawatt

NGDC - National Geophysical Data Center

Ni - nickel

NOAA - National Oceanic and Atmospheric Administration

PADEP - Pennsylvania Department of Environmental Protection

Pb - lead

PCB - polychlorinated biphenyl

POI - point of interconnection

PP - particulate phosphorus

PWQO - Provincial Water Quality Objectives

TP - total phosphorus

TS - transformer station

TSS - total suspended solids

US - United States

USGS - US Geological Survey

WQS - Water Quality Standard

Zn - zinc

1 Introduction

ITC Lake Erie Connector, LLC is proposing to construct and operate the Lake Erie Connector Project (Project), an approximately 116.5 km (72.4 mile) 1,000 megawatt (MW) +/-320 kilovolt (kV) high-voltage direct current (HVDC) bi-directional electric transmission interconnection to transfer electricity between Canada and the United States (US) through a submarine transmission cable across Lake Erie. The HVDC transmission line consists of two transmission cables, one positively charged and the other negatively charged, along with a fiber optic cable for communications between the converter stations. Figure 1 presents the Lake Erie study area along with the preferred underwater cable route.

In the US, the Project would consist of one 1,000-MW HVDC transmission line and an HVDC converter station with ancillary aboveground facilities. The cable would make landfall in Springfield Township in Erie County, Pennsylvania and be installed primarily along existing roadways to a new HVDC converter station (Erie Converter Station) to be constructed in Conneaut Township in Erie County, Pennsylvania. The Erie Converter Station would convert +/- 320 kV DC power to 345 kV AC power or vice-versa and connect to a nearby point of interconnection (POI) at the existing Penelec Erie West Substation that is part of the PJM grid. In Canada, the Lake Erie Connector facilities include another HVDC converter station (the Haldimand Converter Station), which would be located near a POI at the Nanticoke TS switchyard in Haldimand County near the Hamlet of Nanticoke, Ontario. The Haldimand Converter Station would convert 500 kV AC power to +/- 320 kV DC power or vice-versa. The Haldimand Converter Station would connect to the Ontario Independent Electricity System Operator (IESO) grid at a POI 1.3 km (0.8 miles) away, located close to the Nanticoke transformer station switchyard in the Hamlet of Nanticoke.

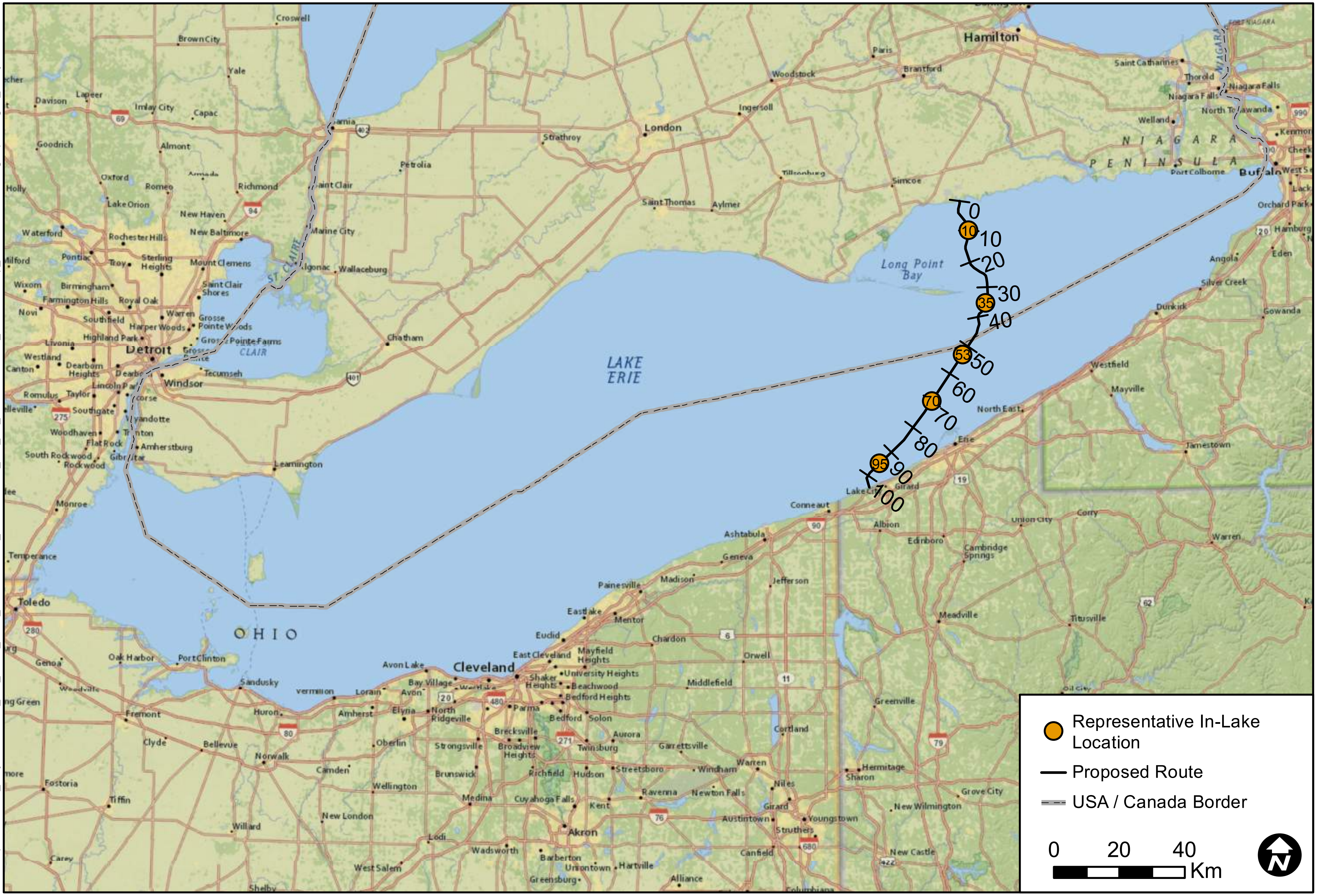
The proposed underwater portion of the transmission line is approximately 103.8 km (64.5 miles) in length and will be buried to a target depth of 2 to 3 meters (6.6 to 9.8 feet) in the sediment of Lake Erie using a jet-plow installation method in fine sediment areas of the lake. The jet-plow installation method provides a trench to lay the cable and uses water jets to fluidize the sediment in the trench before cable laying. The jet-plow fluidizes the sediment in front of the installation plow and the cable slides into the trench from the back, then settles to the bottom of the trench and is buried with the resuspended sediment.

This report does not address potential water quality impacts where cable installation in bedrock areas is required and underwater blasting or selective bedrock removal might occur. These bedrock areas are limited to distances of less than 2 km (1.2 miles) from the Canada and US shorelines; and underwater blasting would only be used where other less intrusive bedrock installation methods are used. In these bedrock installation areas, blasting mats will be placed over the blast holes to help minimize suspension of blasted material and any sediment present. Therefore, it is anticipated that any mobilization of sediments in bedrock installation areas would be much more limited in duration and areal extent compared to the jet-plow installation method in fine sediments, which is the subject of the water quality modeling presented in this report.

This report provides a description of the water quality model used in this study, the model data inputs, and model outputs used to assess the potential Project-related water quality impacts. The intent of this work is to provide sufficient information for regulatory agency review of the lake-related water quality impacts from the Project, including compliance with applicable Pennsylvania Department of Environmental Protection (PADEP) Water Quality Standards (WQS) and Ontario Ministry of Environment and Energy (MOEE) Provincial Water Quality Objectives (PWQO).

The water quality assessment presented in this report focuses on five representative in-lake locations (see Figure 1), which include:

- Kilometer 10 (KM10) – this location is in the northern/Canada side of the lake and is representative of jet-plow installation in shallower water depths;
- KM35 – this location is on the Canada side of the lake and is representative of jet-plow installation in deeper water depths;
- KM53 – this location is in the middle of the lake along the Canada/US border and is representative of jet-plow installation in average water depths; and
- KM70 and KM95 – these locations are in the southern/US side of the lake and are representative of jet-plow installation in shallower water depths.



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ITC Lake Erie Connector
Lake Erie Study Area and Proposed Cable Route

Figure 1

March 31, 2015

2 Hydrodynamic Lake Circulation Model

The model used in this project is the Danish Hydraulic Institute (DHI) three-dimensional hydrodynamic and water quality model called MIKE3 Flexible Mesh (FM). This is an industry standard model, which is commonly used by experts in the water quality field to model and analyze complex hydrodynamic conditions that may impact water quality. The modeling system is based on the numerical solution of the three-dimensional incompressible Reynolds averaged Navier-Stokes equations, subject to the assumptions of Boussinesq and of hydrostatic pressure (DHI, 2009). The model consists of continuity, momentum, temperature, salinity and density equations and is closed by a turbulence closure scheme. The density does not depend on pressure but only on temperature and salinity. The free surface is taken into account using a sigma-coordinate transformation approach.

The following effects are accounted for in the model:

- Flooding (wetting) and drying of model segments;
- Momentum dispersion;
- Bottom shear stress;
- Coriolis force;
- Wind shear stress;
- Precipitation/evaporation;
- Heat exchange;
- Sources and sinks of modeled parameters; and
- Water quality.

The solution technique uses the cell centered finite volume method with the spatial domain discretized by subdivision of the spatial and vertical continuum into non-overlapping elements. In the horizontal plane, an unstructured mesh is used, while a structured mesh is used in the vertical domain. Elements can be prisms or bricks whose horizontal faces are triangles or quadrilateral elements.

2.1 Model Mesh

The MIKE3 model uses a multi-layer triangulated or rectangular mesh to calculate water circulation, water elevation, temperature and water quality concentrations. Based on lake bathymetry and shoreline features, the horizontal mesh for Lake Erie used coarse triangular elements except in the areas of interest (i.e., representative locations) where much finer rectangular elements were used. The finer rectangular mesh was developed for five representative locations of interest along the proposed cable route that provided for a 15 meter (50 foot) square element resolution. Figure 2 presents the model mesh used for the representative location at KM53, which shows the fine elements at KM53 and the coarser elements at other locations.

The bathymetry or water depths in Lake Erie are presented in Figure 3 and are relative to the chart datum: International Great Lakes Datum (IGLD) elevation 173.5 meters. The bathymetric data used were obtained from NOAA's National Geophysical Data Center (NGDC) (https://www.ngdc.noaa.gov/) and digitized from accumulated historic soundings from the US Army Corp of Engineers, the NOAA National Ocean Service and the Canadian Hydrographic Service.

The vertical model segmentation uses 20 sigma layers (equally spaced vertical model segments) with variable fractions of the total depth depending on the location in the lake. Sigma layers provide for the same number of vertical segments in all model elements. For the cable installation water quality model projections, a bottom layer thickness of 2 meters (measured from the lake bottom up and into the water column) was used to assign the sediment resuspension sources as discussed in Section 3.3.

2.2 Model Setup

The model was developed and applied to data from 2009 and was calibrated to lake-outflow, water surface elevation and temperature including vertical temperature profiles from that year. The 2009 data set was considered as an acceptable time period for model application in this project as data required for inputs were most complete during this year and it is not believed that any lake conditions have significantly changed since 2009 that would warrant applying the model to a more recent year. The model was set up using data for 2009 as described below. Figure 4 presents the station locations where data for the river and meteorological inputs were obtained for the model.

2.2.1 River Inputs

The model inputs include daily flow and temperature for the 24 rivers that flow into Lake Erie and are listed in Table 1. Data was obtained from the USGS and Environment Canada for assigning these river inputs for the year 2009. River temperature data for 2009 was not available for any of the river inputs assigned in the model. In order to estimate river temperatures for 2009, the River Raisin temperature data from 2012 were used as a complete daily temperature record was available. The River Raisin temperatures were considered representative of the other river inflows because land uses within this watershed are relatively similar to land uses in other contributing watersheds. This river temperature estimate for the other river inputs should not significantly affect calculated lake temperatures because these river inflows represent about 9% of the total river inflow to Lake Erie. In addition, water temperature data for 2009 in Lake St. Clair was used for the Detroit River.

Where flow records were incomplete, drainage area ratios were applied in order to extrapolate flows for different river inputs. These river flow inputs exit the northeastern part of the lake through the Niagara River. Measured Niagara River flows (Figure 5) and water elevations were utilized to develop a rating curve boundary condition for assigning model inputs for 2009. Figures 5 to 8 present the model input river flows for eight major rivers entering Lake Erie.

Table 1. River Inputs Assigned in Model	
Ashtabula River (OH)	Grand River (OH)
Big Creek (Ontario)	Huron River (OH)
Big Otter Creek (Ontario)	Kettle Creek (Ontario)
Black River (OH)	Maumee River (OH)
Buffalo Creek (NY)	Ottawa River (OH)
Catfish Creek (Ontario)	Portage River (OH)
Cattaraugus Creek (NY)	River Raisin (MI)
Chagrin River (OH)	Rocky River (OH)
Conneaut Creek (OH)	Sandusky River (OH)
Cuyahoga River (OH)	Swan Creek (OH)
Detroit River (MI)	Vermilion River (OH)
Grand River (Ontario)	Welland Canal Diversion (Ontario)

2.2.2 Meteorological Data

Hourly meteorology data for 2009 were obtained from NOAA's National Climatic Data Center (ncdc.noaa.gov) and MesoWest (mesowest.utah.edu) data sources. Additional precipitation and evaporation data were obtained from NOAA Great Lakes Environmental Research Laboratory (GLERL) for 2009 as lake-wide totals. The data obtained and used in the modeling are summarized below and presented in Figure 9 for the Buffalo Airport station (BUFN6). These data were considered representative for application to Lake Erie and wind speed/direction were interpolated spatially from the Buffalo (BUFN6) and the West Erie (45005) data (see Figure 4 for locations).

- Wind speed and direction (spatially interpolated from the Buffalo (BUFN6) and the West Erie (45005) data);
- Lake-wide precipitation (GLERL, 2009);
- Lake-wide evaporation (GLERL, 2009);
- Air temperature (BUFN6);

- Humidity (BUFN6); and
- Cloud cover (BUFN6).

2.3 Hydrodynamic Model Calibration

The model was calibrated to measured Niagara River discharge flows (USGS); water surface elevations and temperatures at various monitoring stations in the lake (Environment Canada and NOAA); and vertical temperature profiles in the lake (Great Lakes Environmental Database, GLENDA). Figures 10 and 11 present the locations of river flow, elevation and temperature monitoring stations where model-data comparisons were completed. Figures 12 through 28 present the model-data comparisons for the model calibration period from April to November 2009. In these figures, the blue or black circles represent the observed data and the black solid or dashed lines represent the model output.

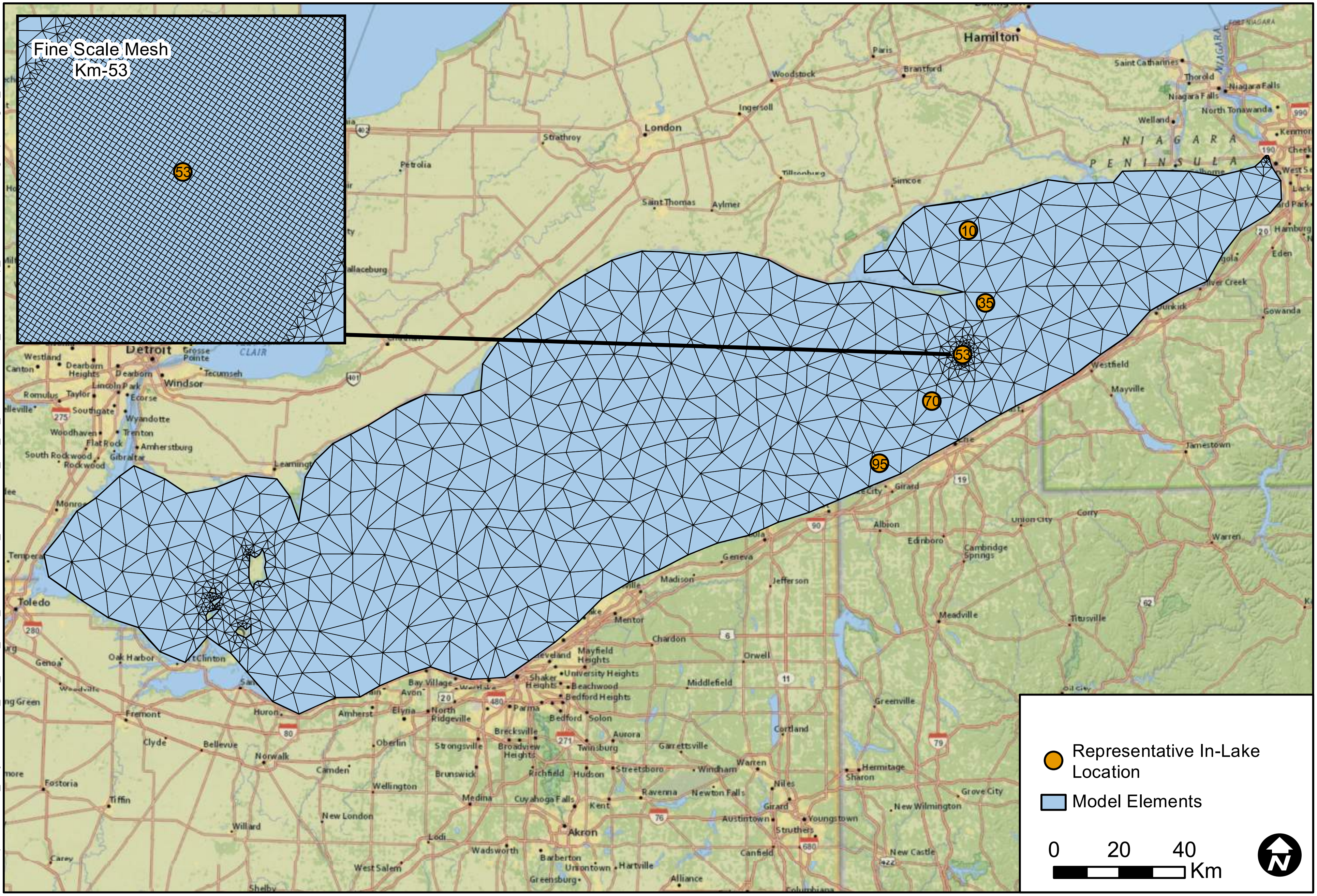
Overall the model reproduces the Niagara River flows well on a seasonal basis and also the variations due to lake seiches that are on a time-scale of days. The model also reproduces the observed water elevations well at Buffalo (NY), Port Colborne (Ontario), Port Stanley (Ontario), Erieau (Ontario), Kingsville (Ontario) and Bar Point (Ontario) including lake seiche events.

The model comparison to observed water temperatures is also good at the West Erie buoy 45005, Middle Erie buoy 45132, and East Erie buoys 45142 and BUFN6. The model captures the seasonal temperature cycle and meteorological events fairly well but tends to over-calculate the water temperatures during the fall cooling period. Measured vertical temperature profiles were also compared to model output. The comparison is good at most stations with calculated vertical temperature stratification at times not as great as observed. Overall the model reproduces the observed temperatures ranging from 5-25℃ and completely mixed to vertically stratified temperature conditions.

For the proposed underwater cable installation months, the model reproduces observed river outflow in the Niagara River, lake surface elevation and temperature well at most stations. Given the good comparisons between model output and observed data, the hydrodynamic model is considered well calibrated and capable of representing water circulation in the lake for the subsequent water quality modeling of the proposed cable installation in Lake Erie.

2.4 Calculated Water Velocities

The model-calculated current velocities show higher currents at the surface, as would be expected, with bottom currents at each of the five representative locations ranging from 0.04-17.8 cm/s. Figure 29 presents the model calculated water currents in the surface and bottom layers at the five representative locations for the April to November modeling period. The calculated water current directions are variable during the April to November modeling period, but generally flow in an east/west direction and roughly perpendicular to the cable installation route.



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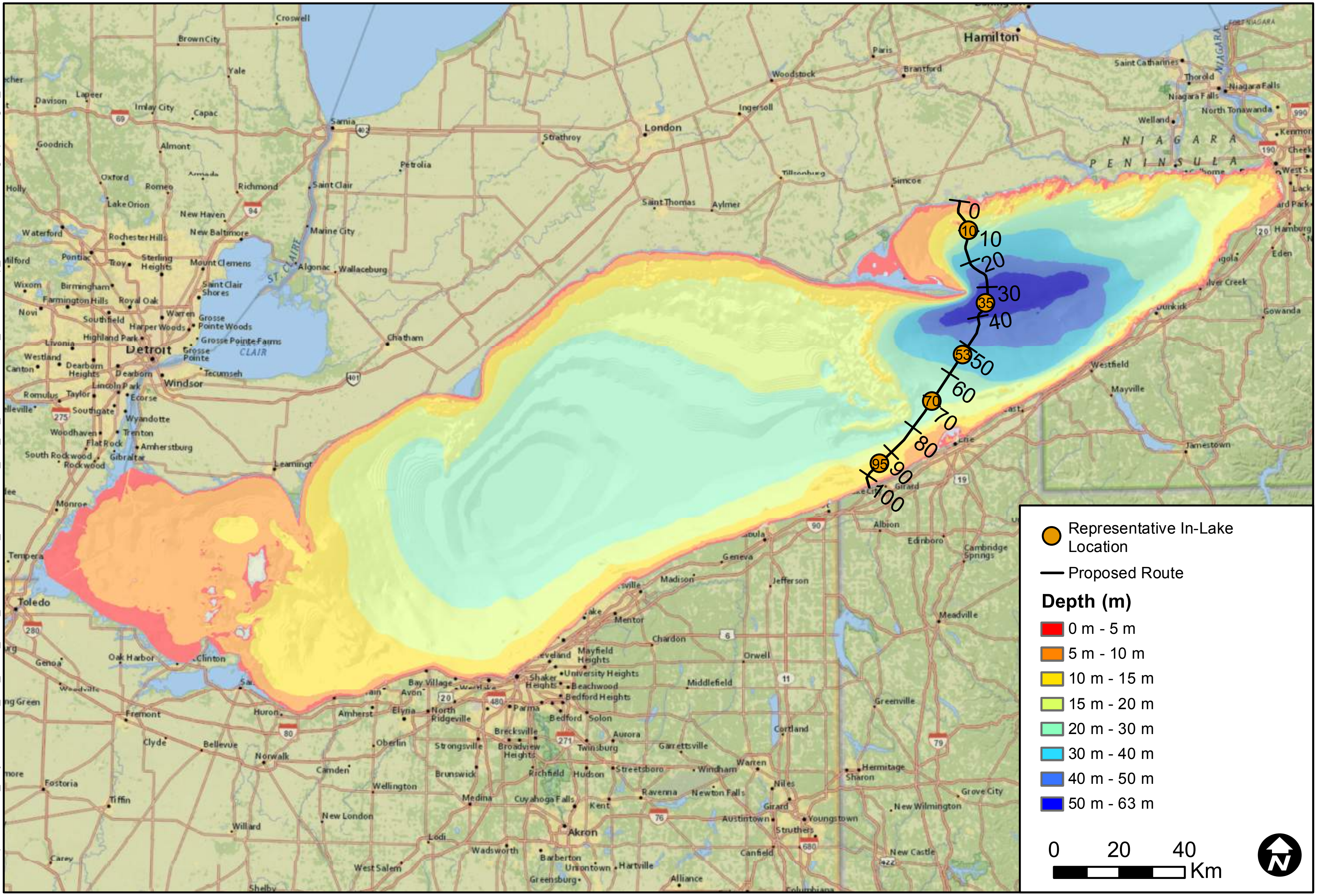
ITC Lake Erie Connector
Lake Erie Model Grid and Fine Scale Mesh Used at KM53

Figure 2

April 02, 2015



ITC Lake Erie Connector
Lake Erie Bathymetry (Water Depths)

Figure 3

March 31, 2015

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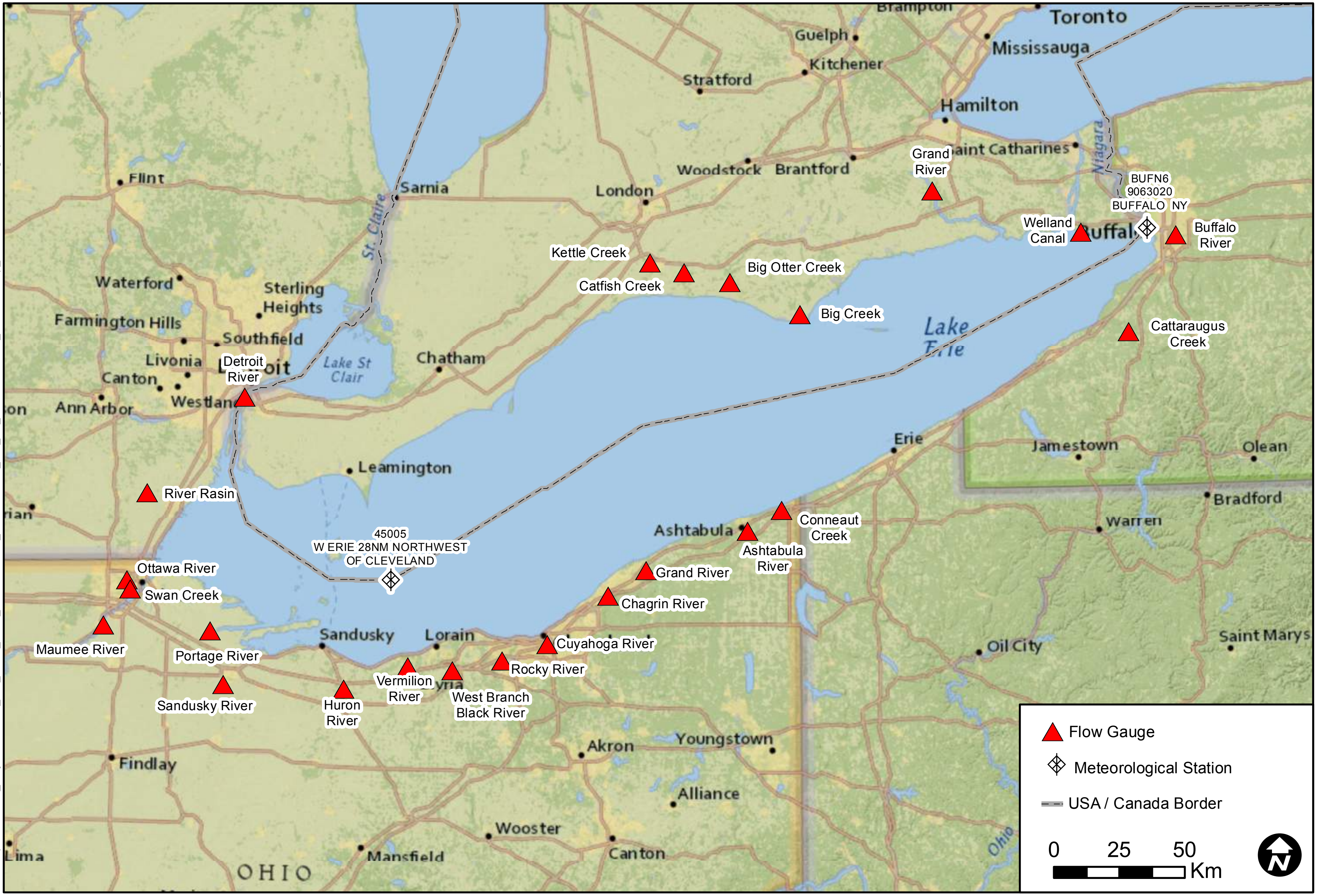

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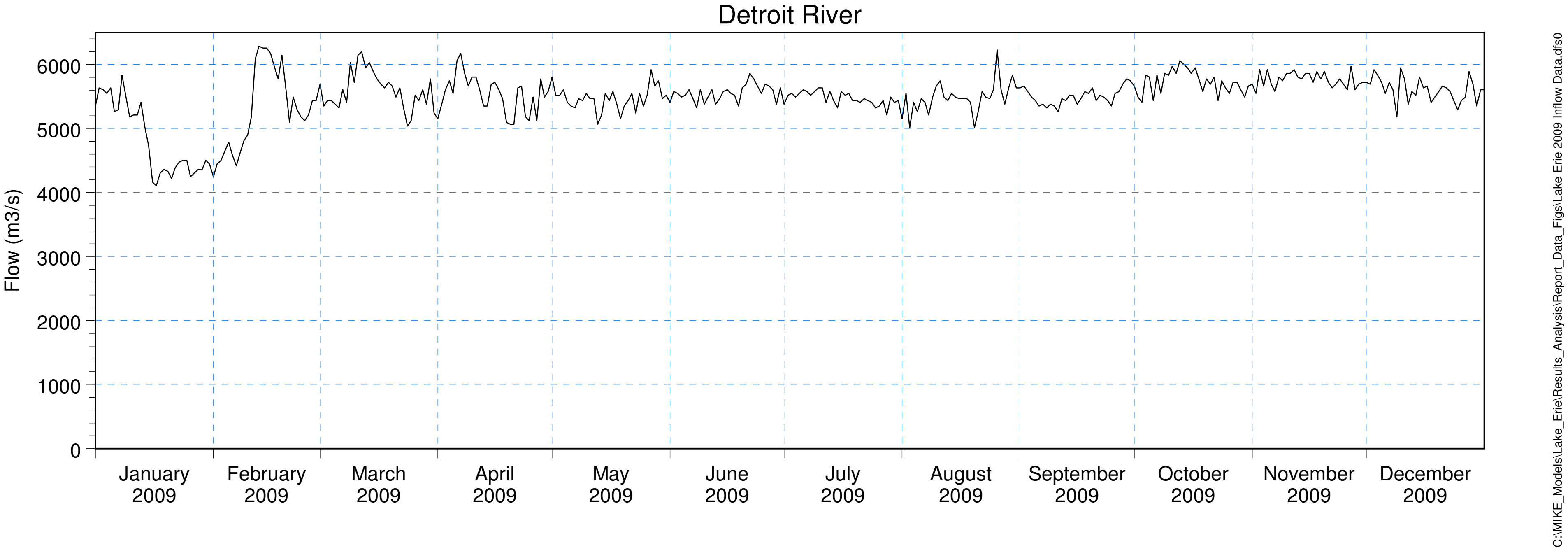
ITC Lake Erie Connector
Lake Erie Flow Gauging and Meteorological Stations

Figure 4

April 01, 2015



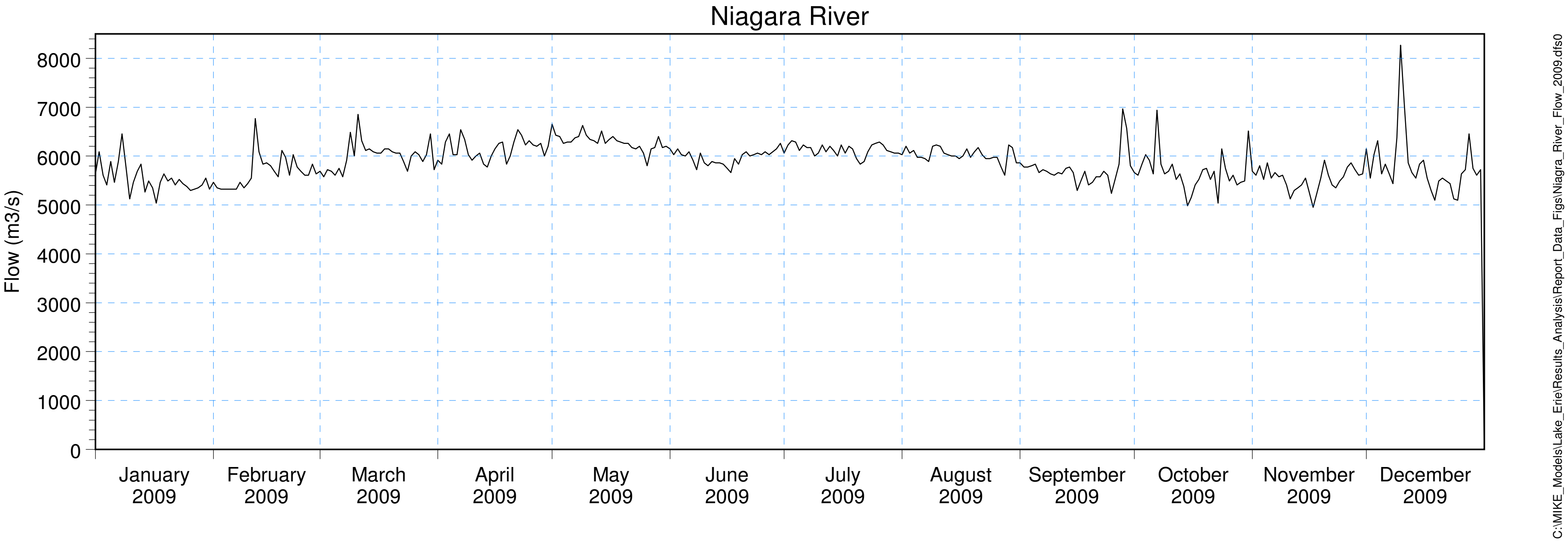
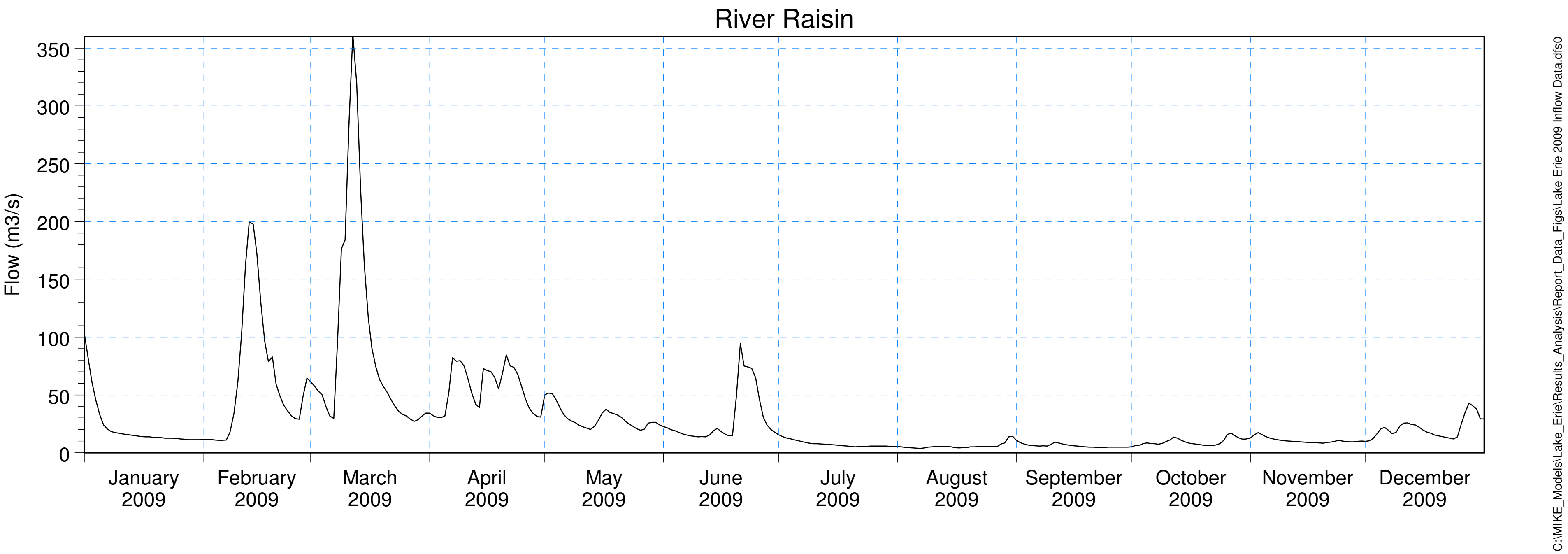


Figure 5. Detroit River and Niagara River Flows for 2009



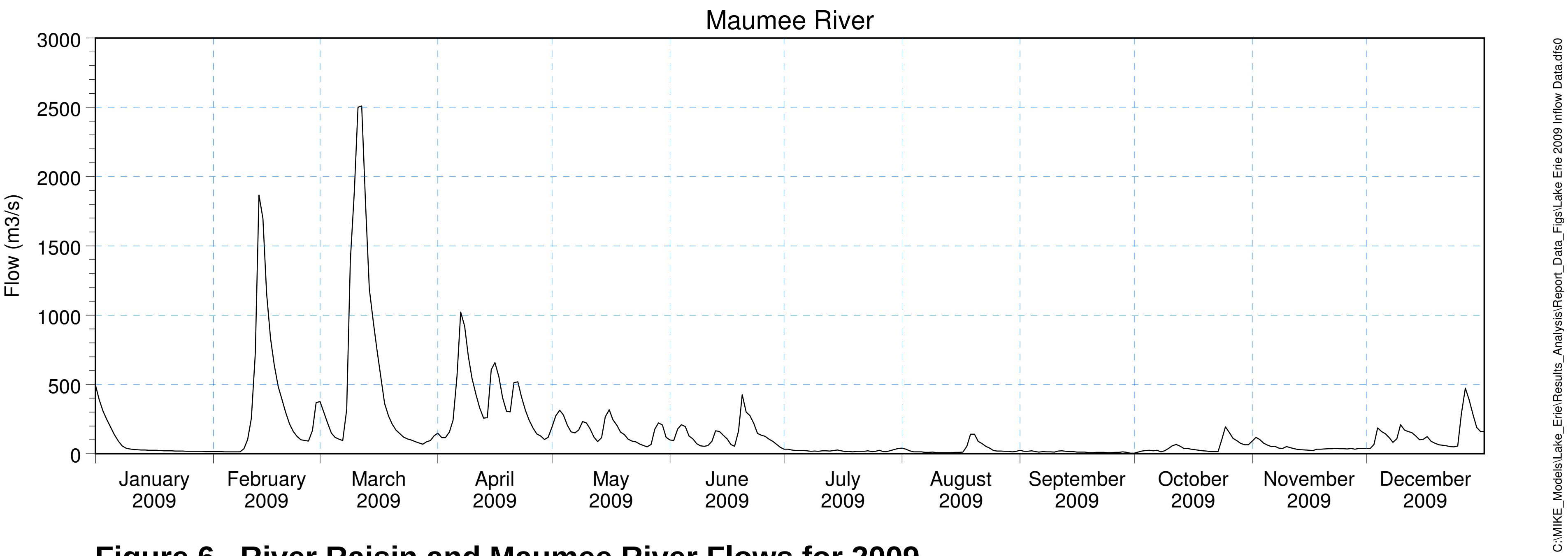
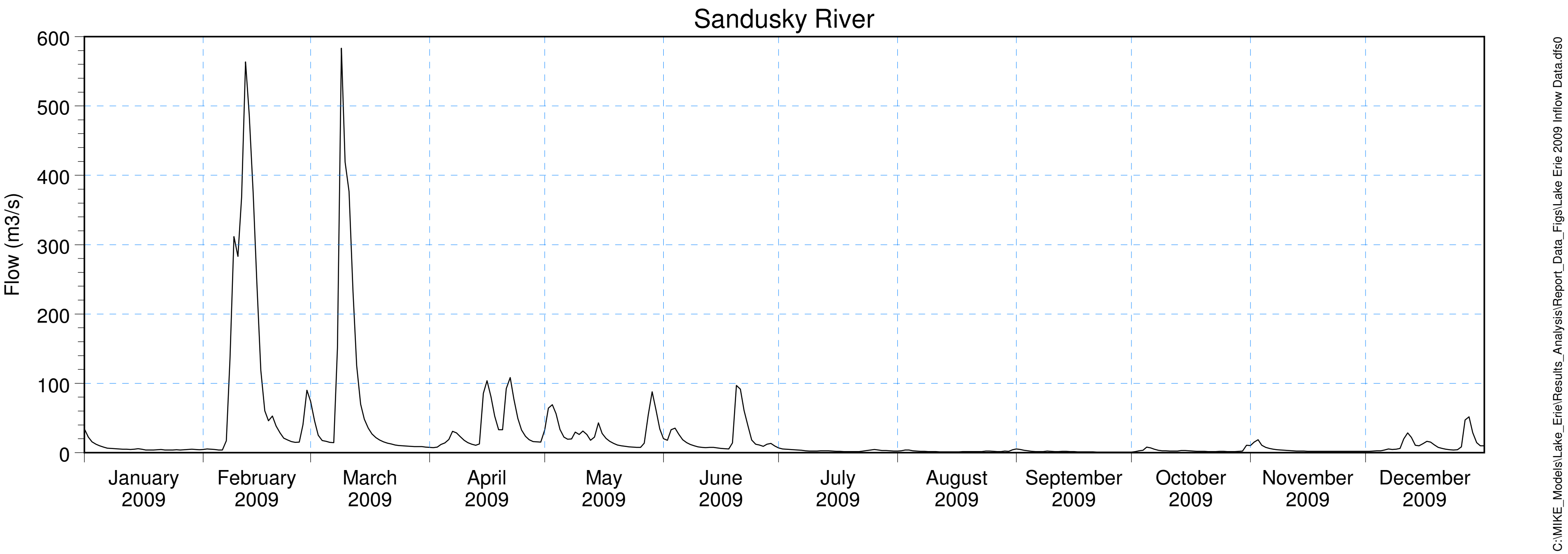


Figure 6. River Raisin and Maumee River Flows for 2009



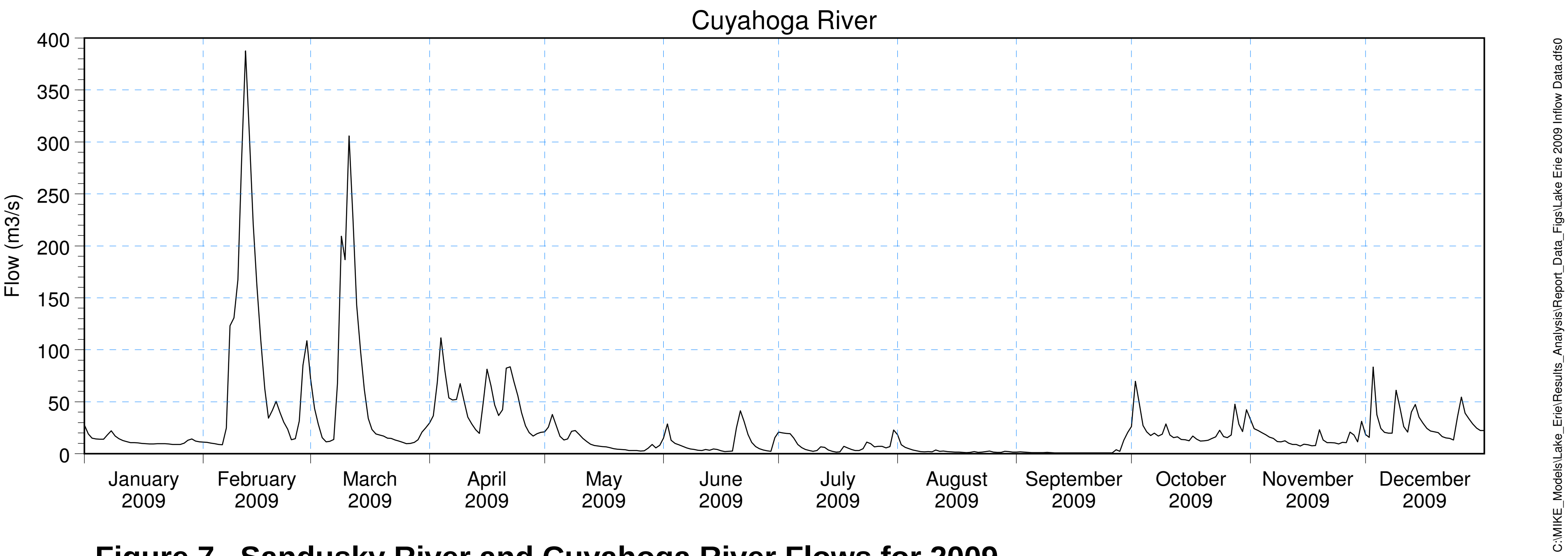
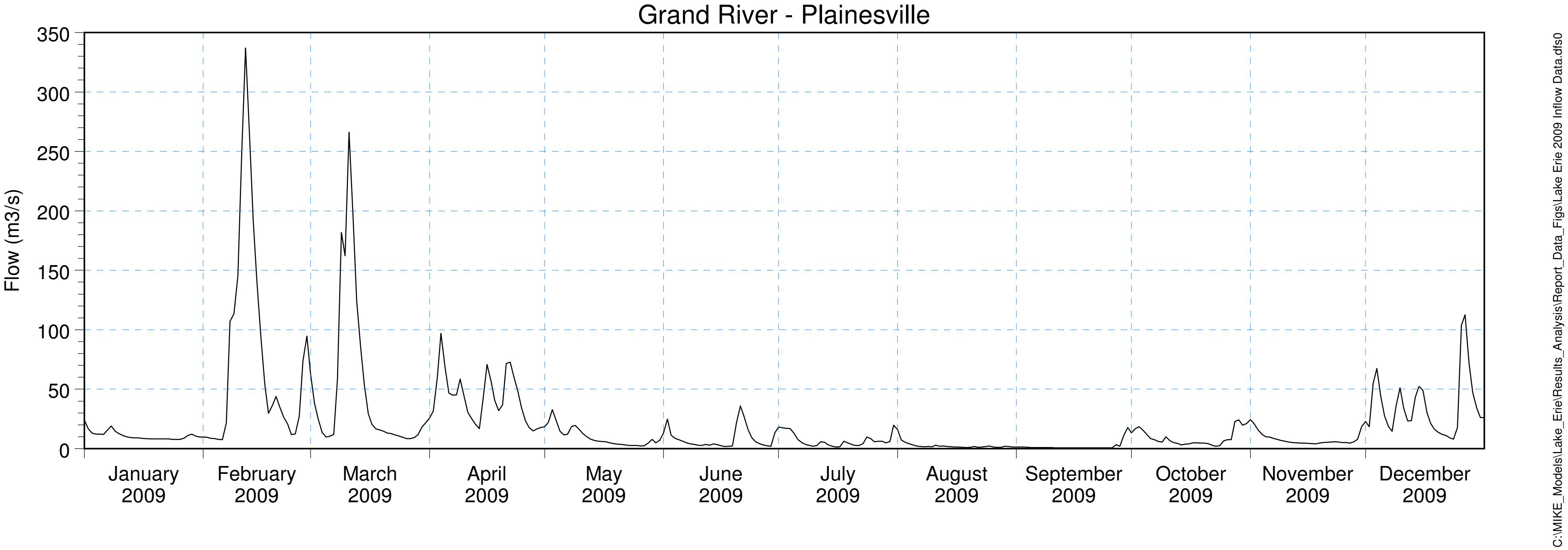


Figure 7. Sandusky River and Cuyahoga River Flows for 2009



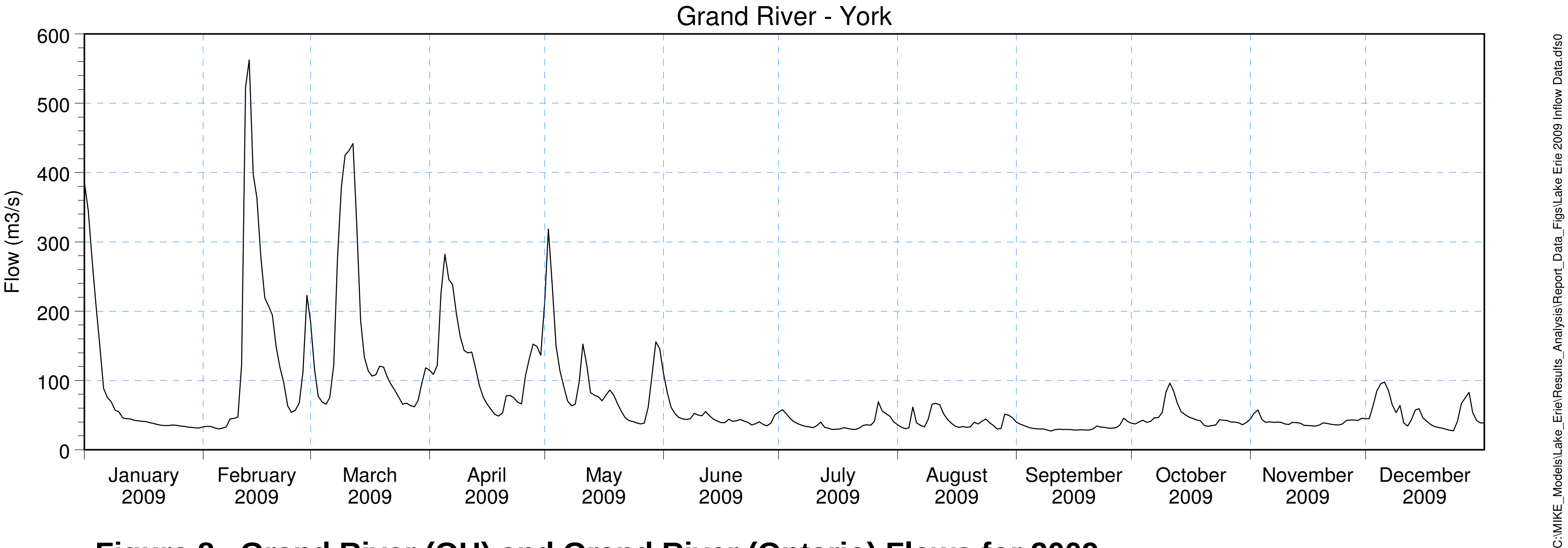


Figure 8. Grand River (OH) and Grand River (Ontario) Flows for 2009

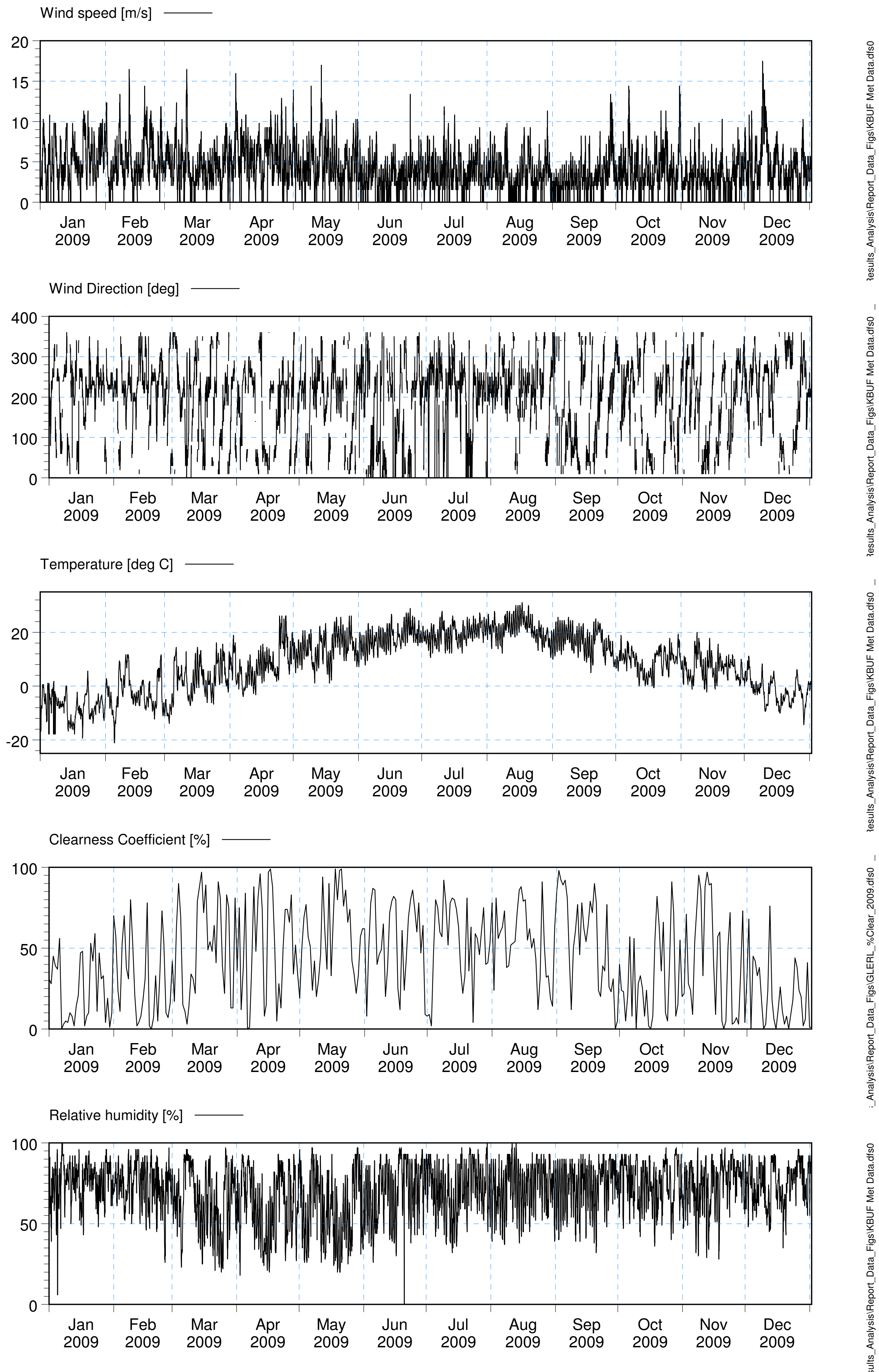
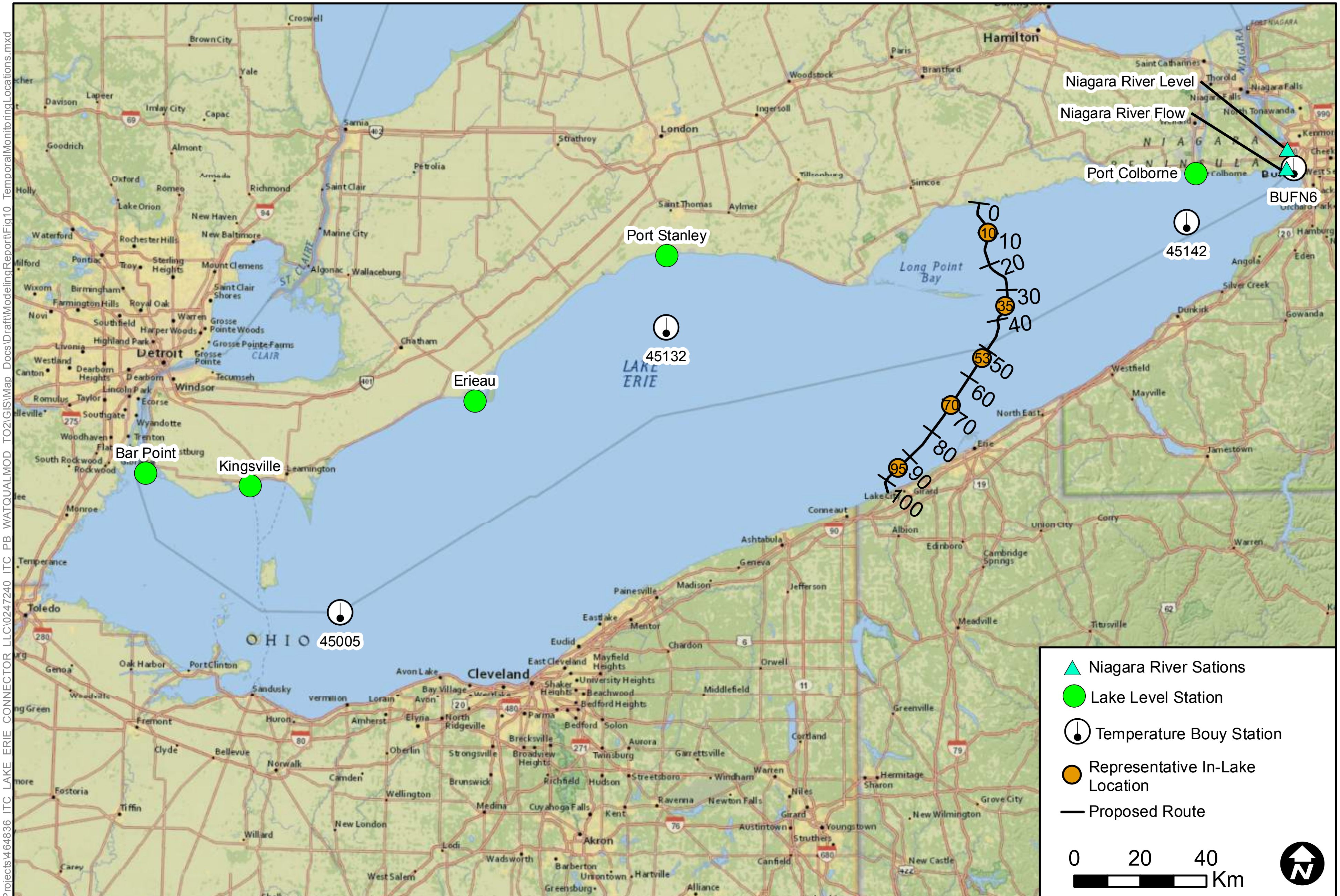


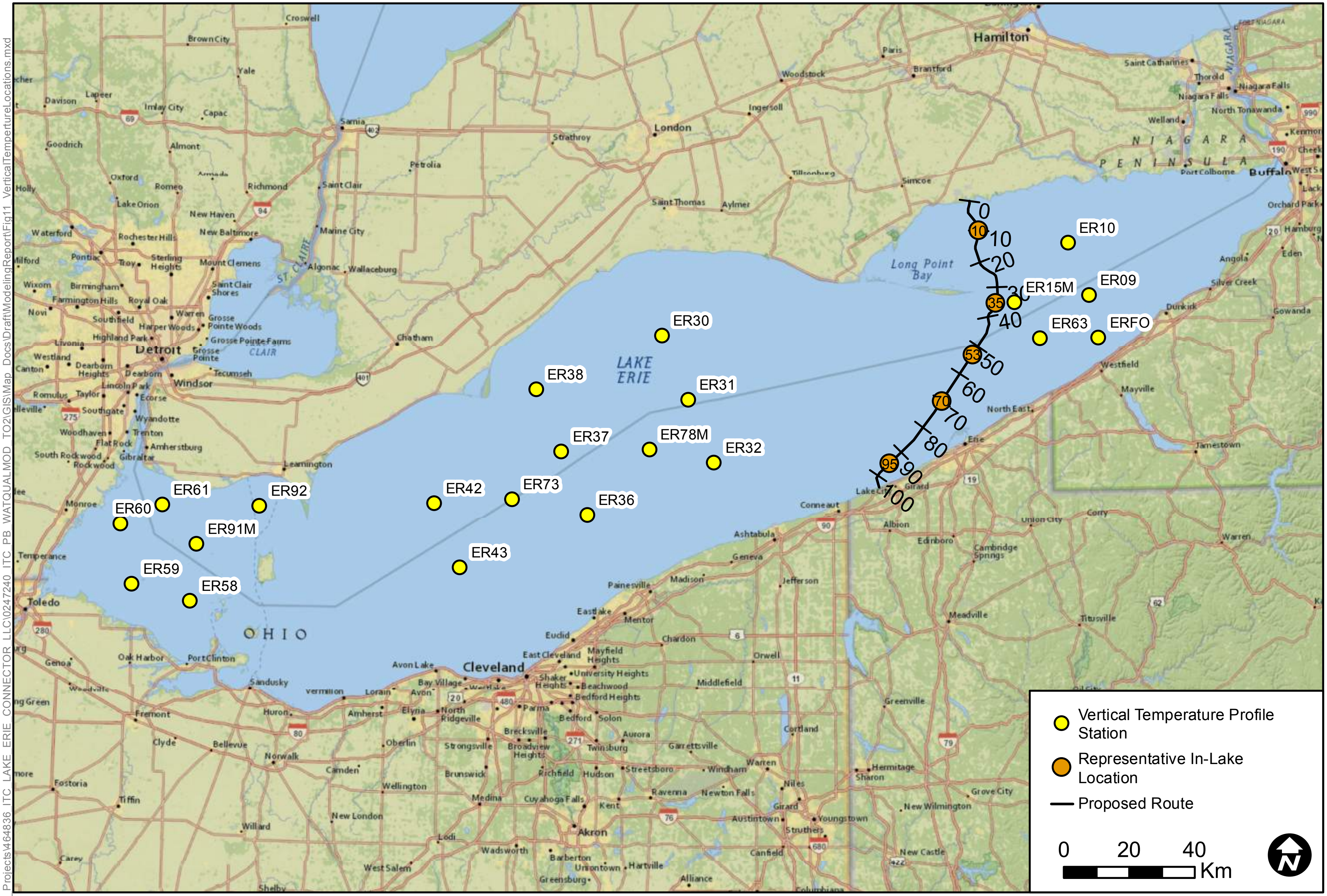
Figure 9. Meteorological Conditions (BUFN6) for 2009



ITC Lake Erie Connector
Temperature, Elevation and Flow Monitoring Stations

Figure 10

April 01, 2015



ITC Lake Erie Connector
Vertical Temperature Profile Stations

Figure 11

April 02, 2015

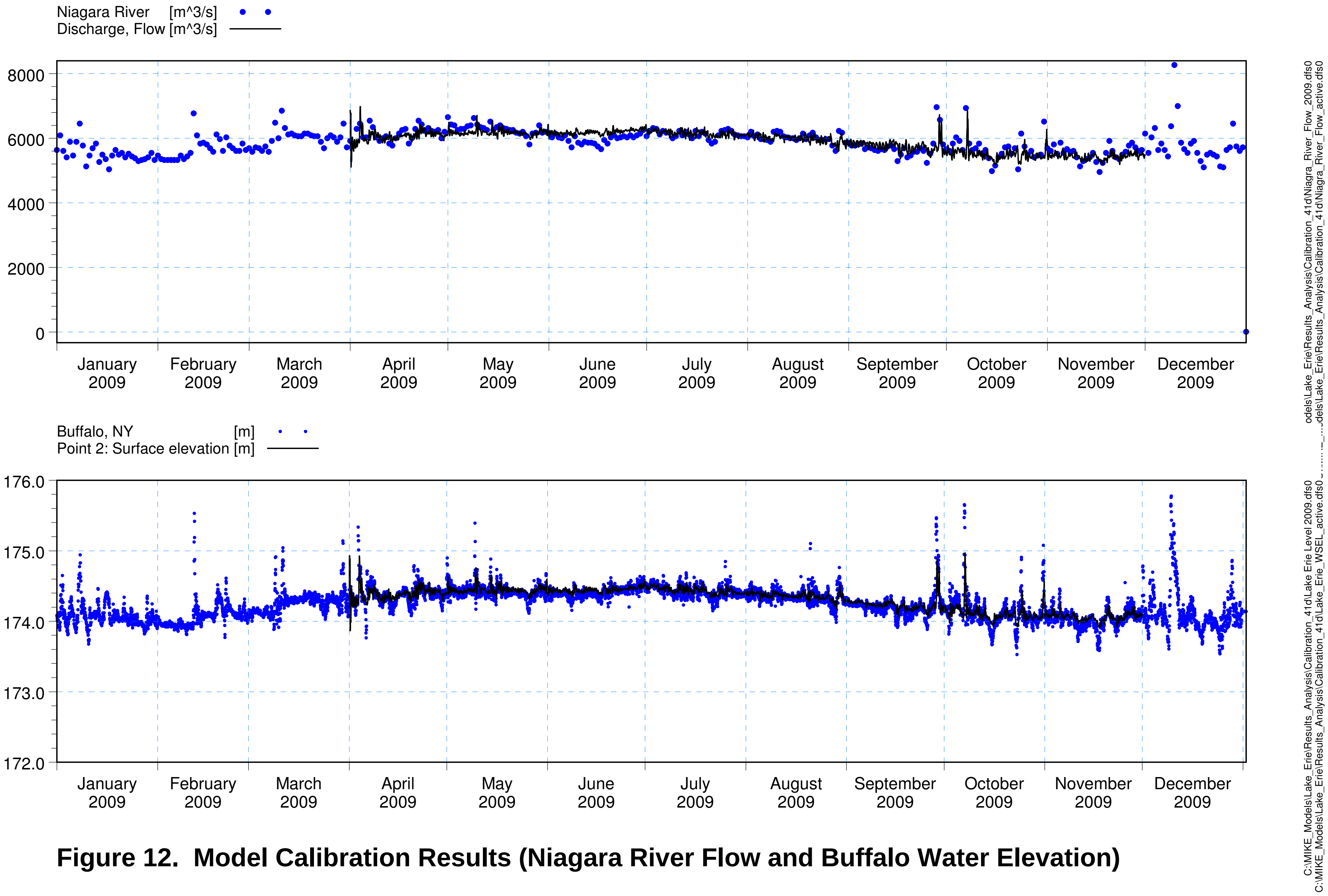


Figure 12. Model Calibration Results (Niagara River Flow and Buffalo Water Elevation)

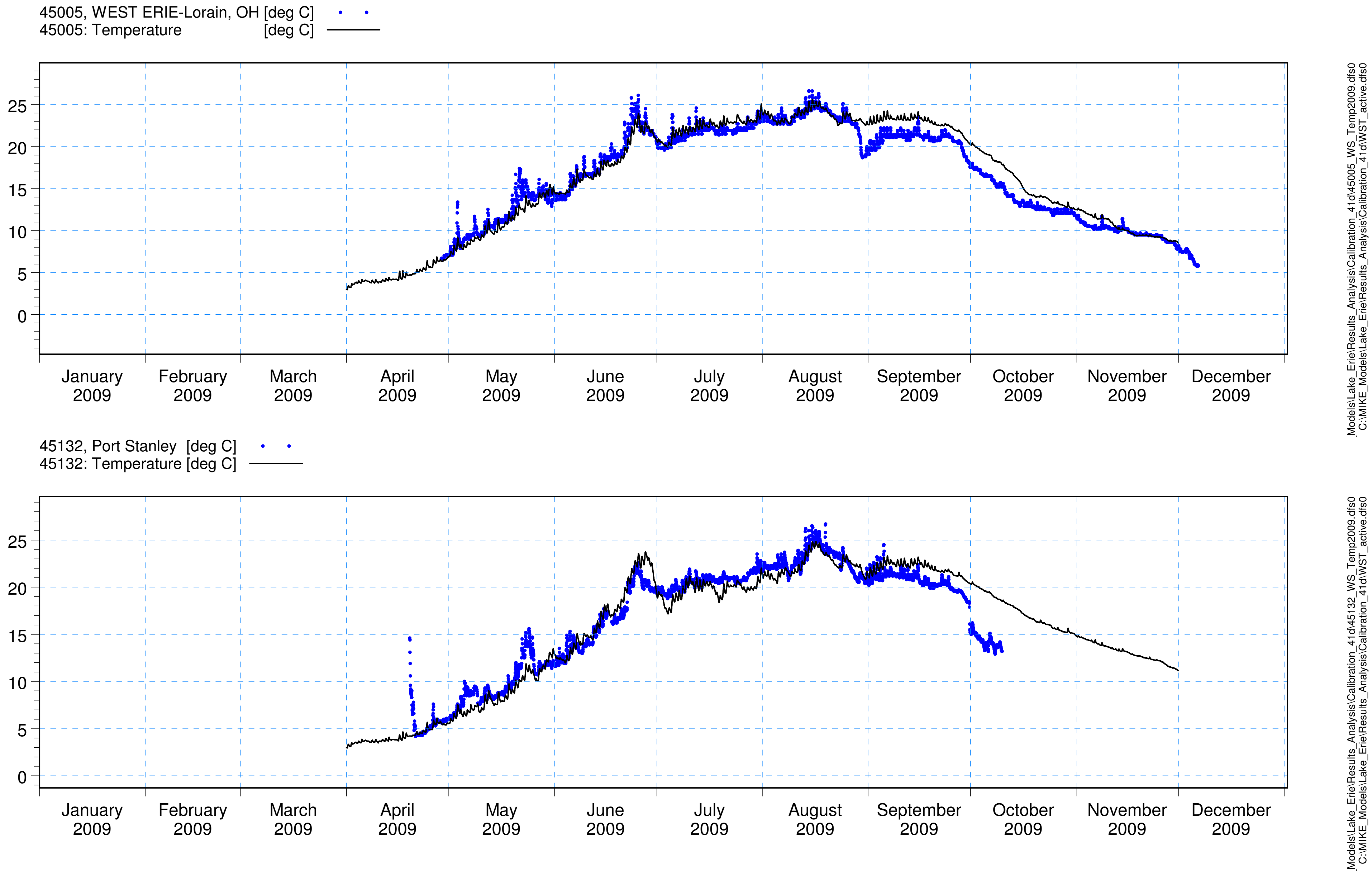
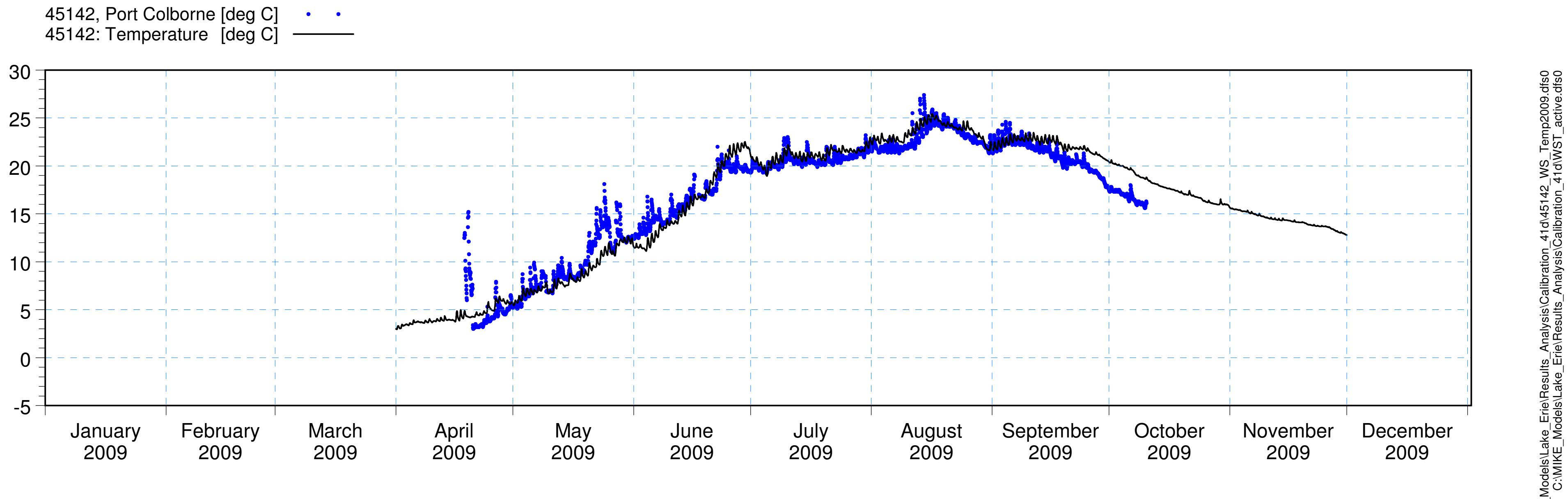


Figure 13. Model Calibration Results (Water Temperature at West Erie and Port Stanley)



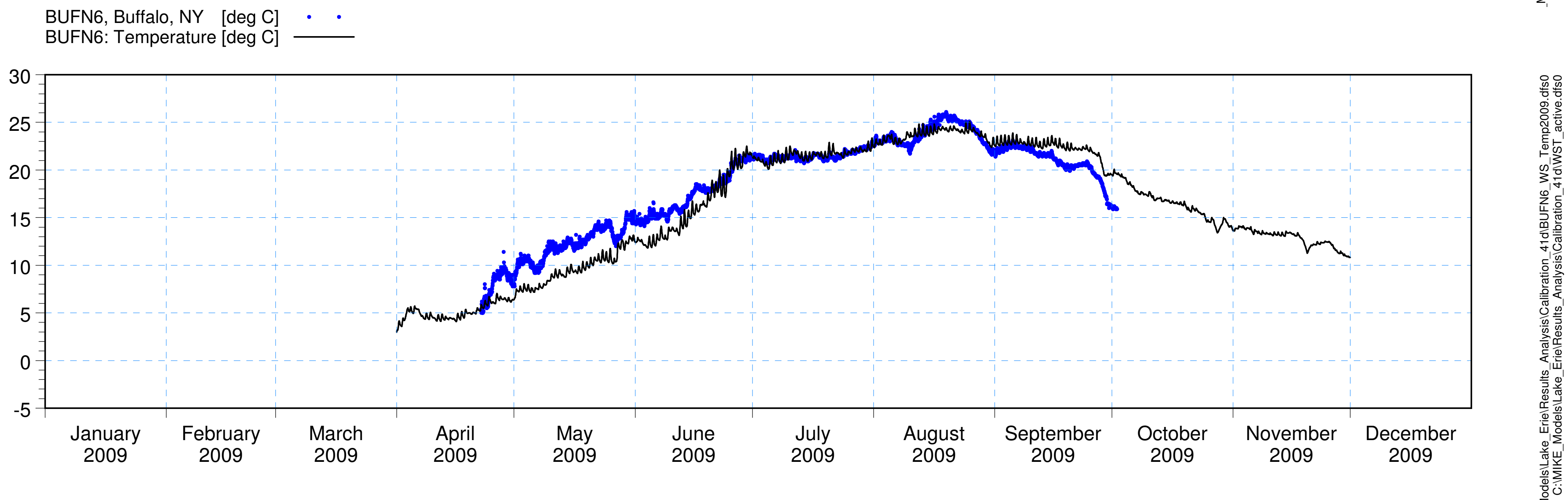


Figure 14. Model Calibration Results (Water Temperature at Port Colborne and Buffalo)

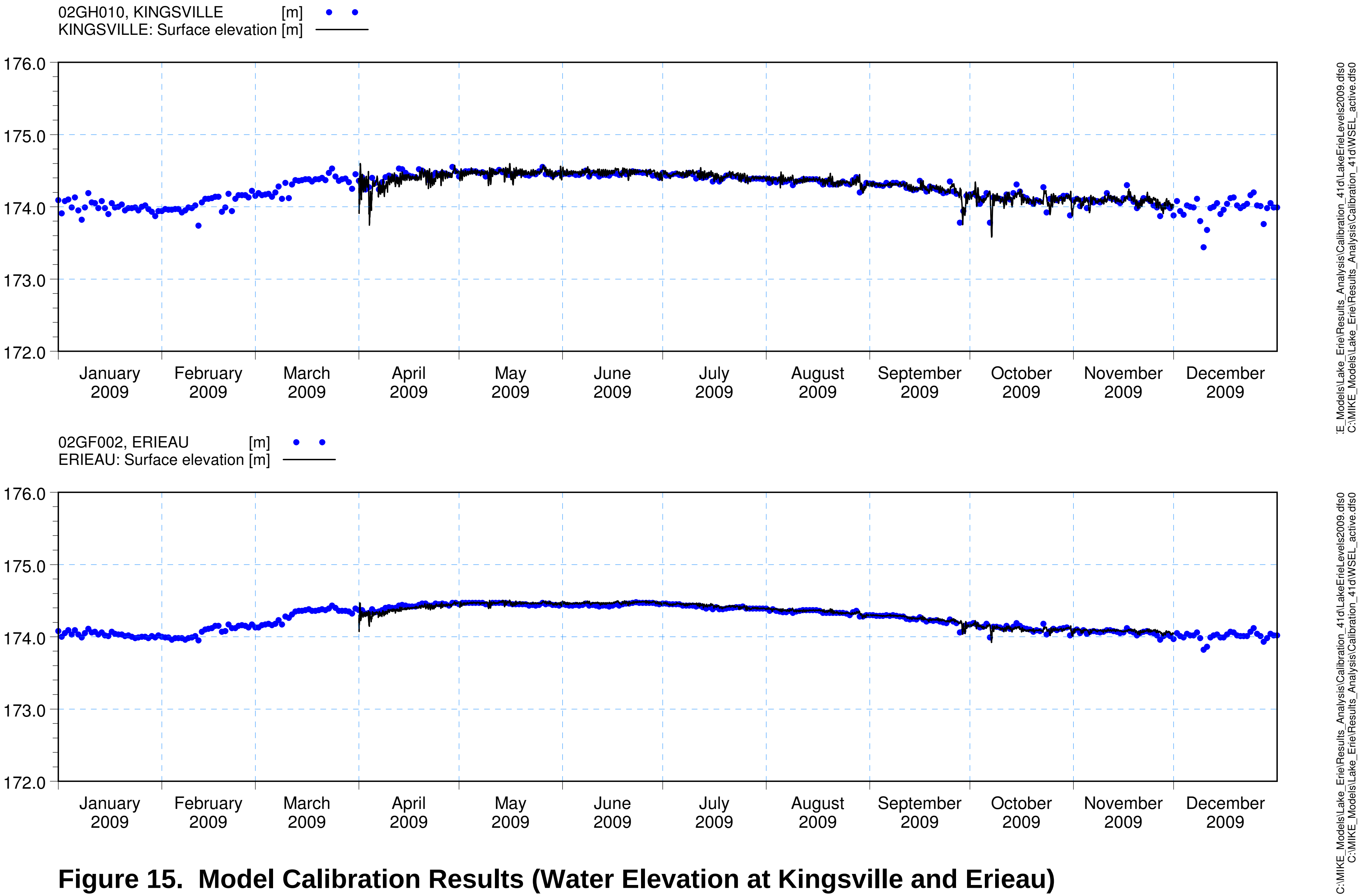
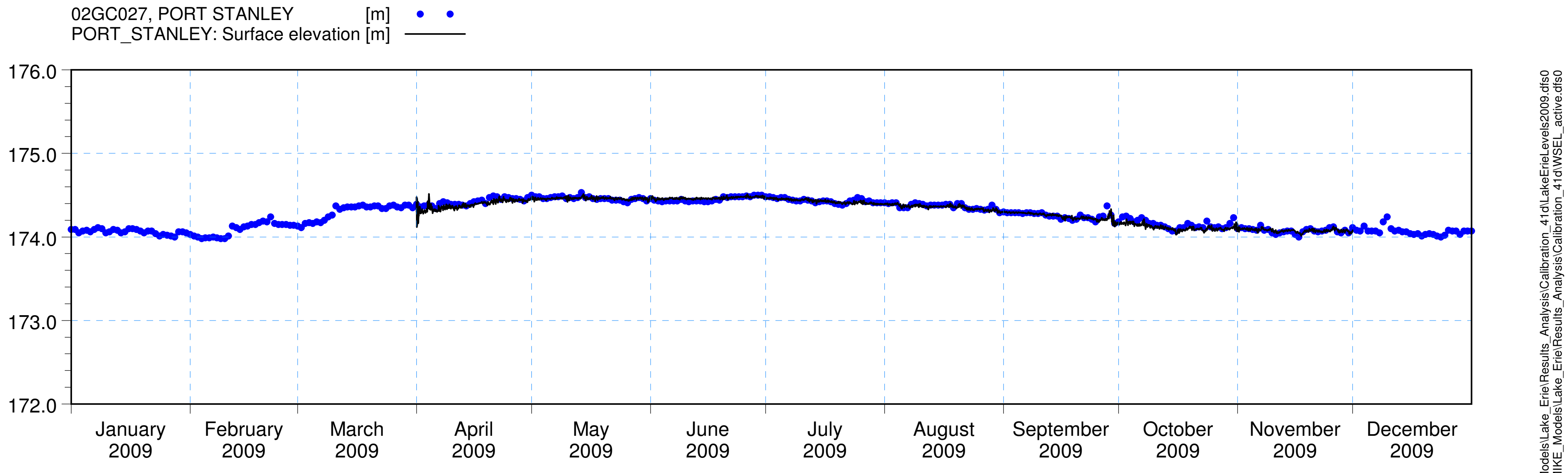


Figure 15. Model Calibration Results (Water Elevation at Kingsville and Erieau)



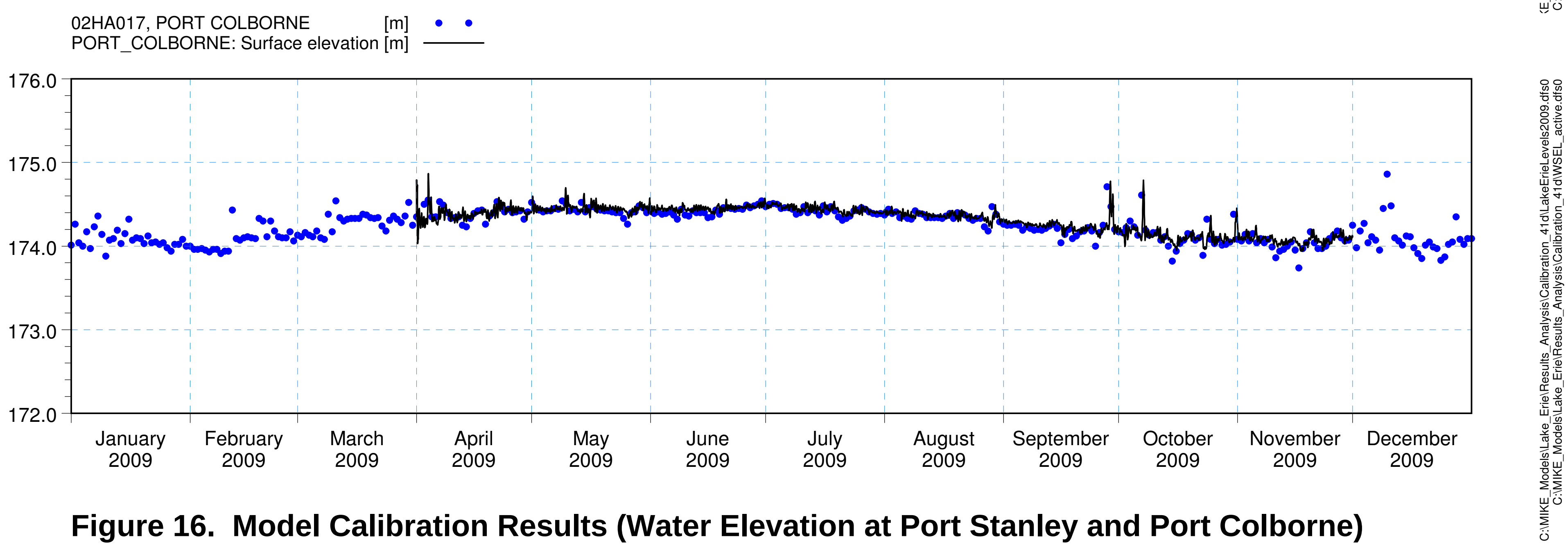


Figure 16. Model Calibration Results (Water Elevation at Port Stanley and Port Colborne)

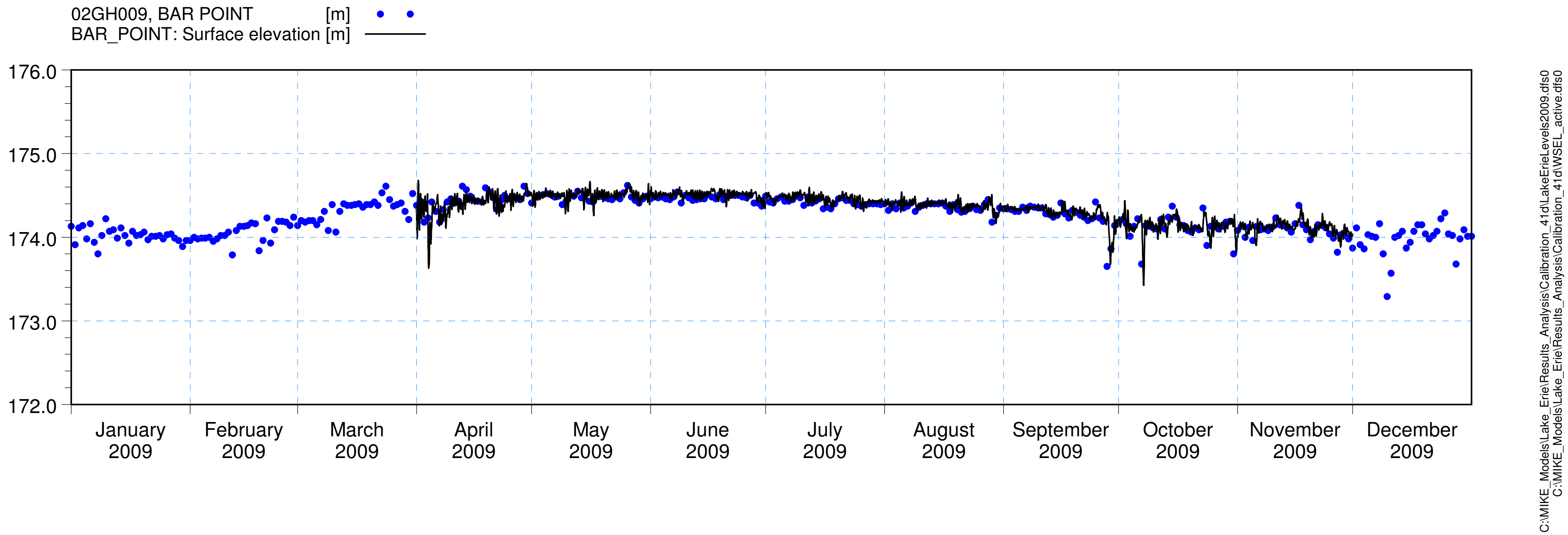


Figure 17. Model Calibration Results (Water Elevation at Bar Point)

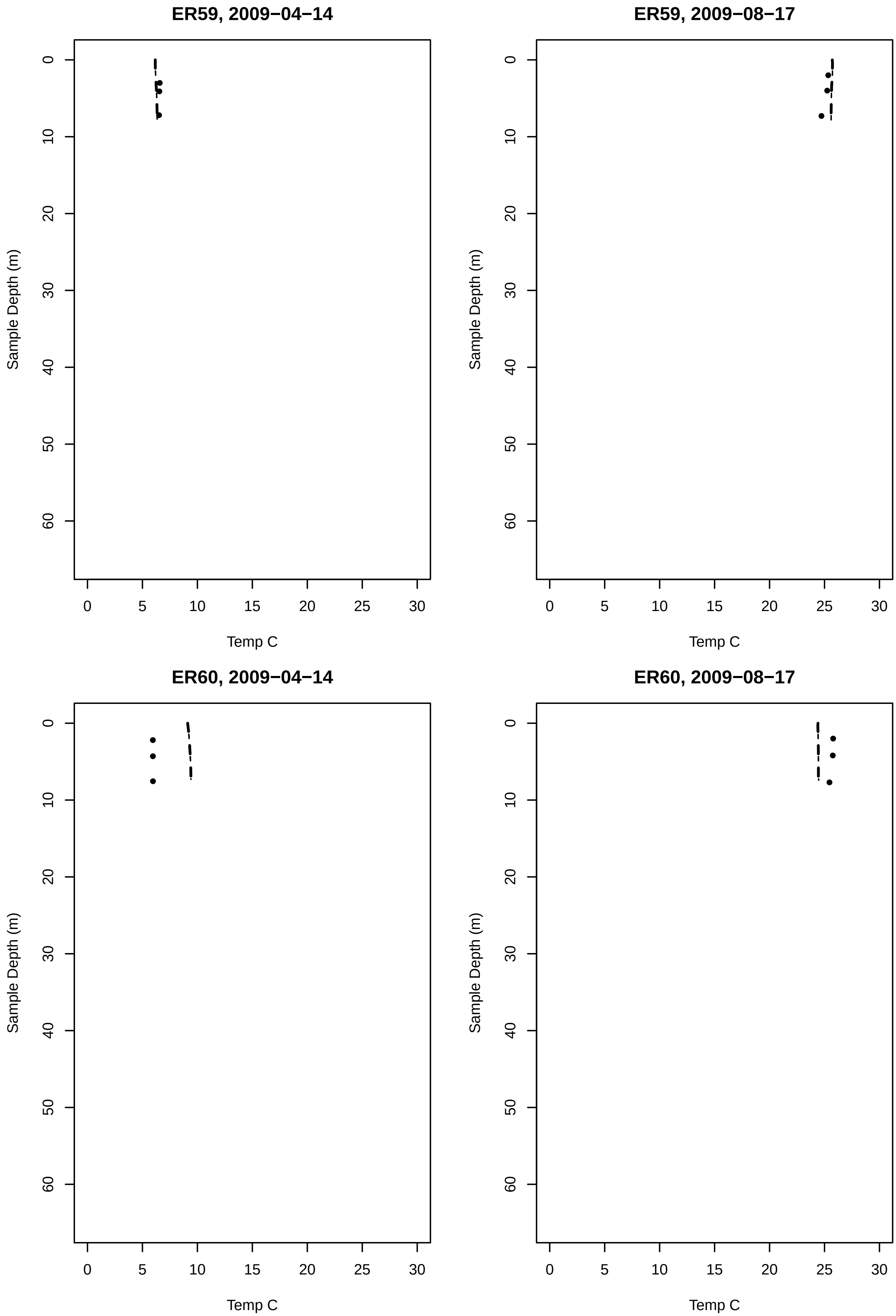


Figure 18. Model Calibration Results (Vertical Temperature Profiles)

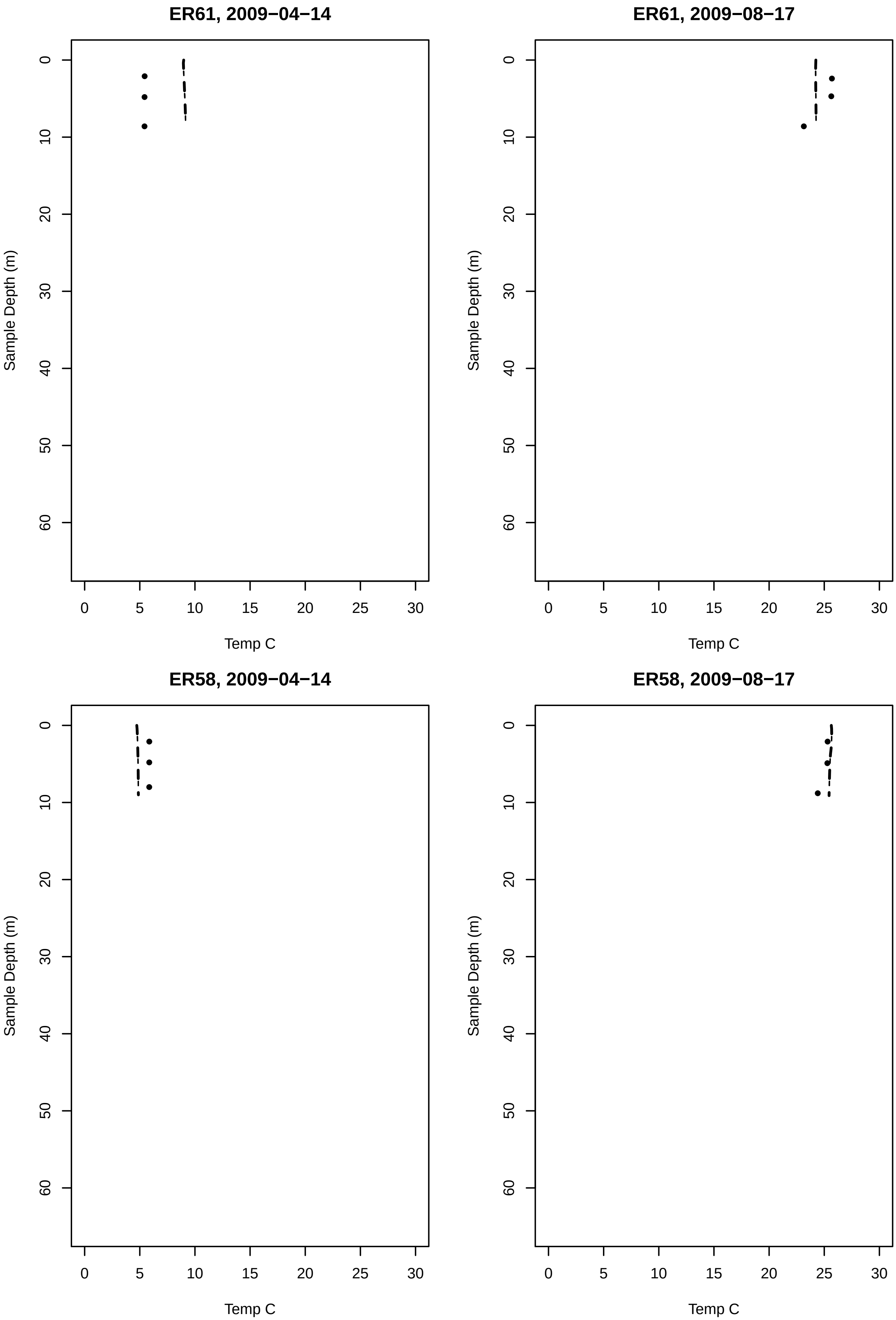


Figure 19. Model Calibration Results (Vertical Temperature Profiles)

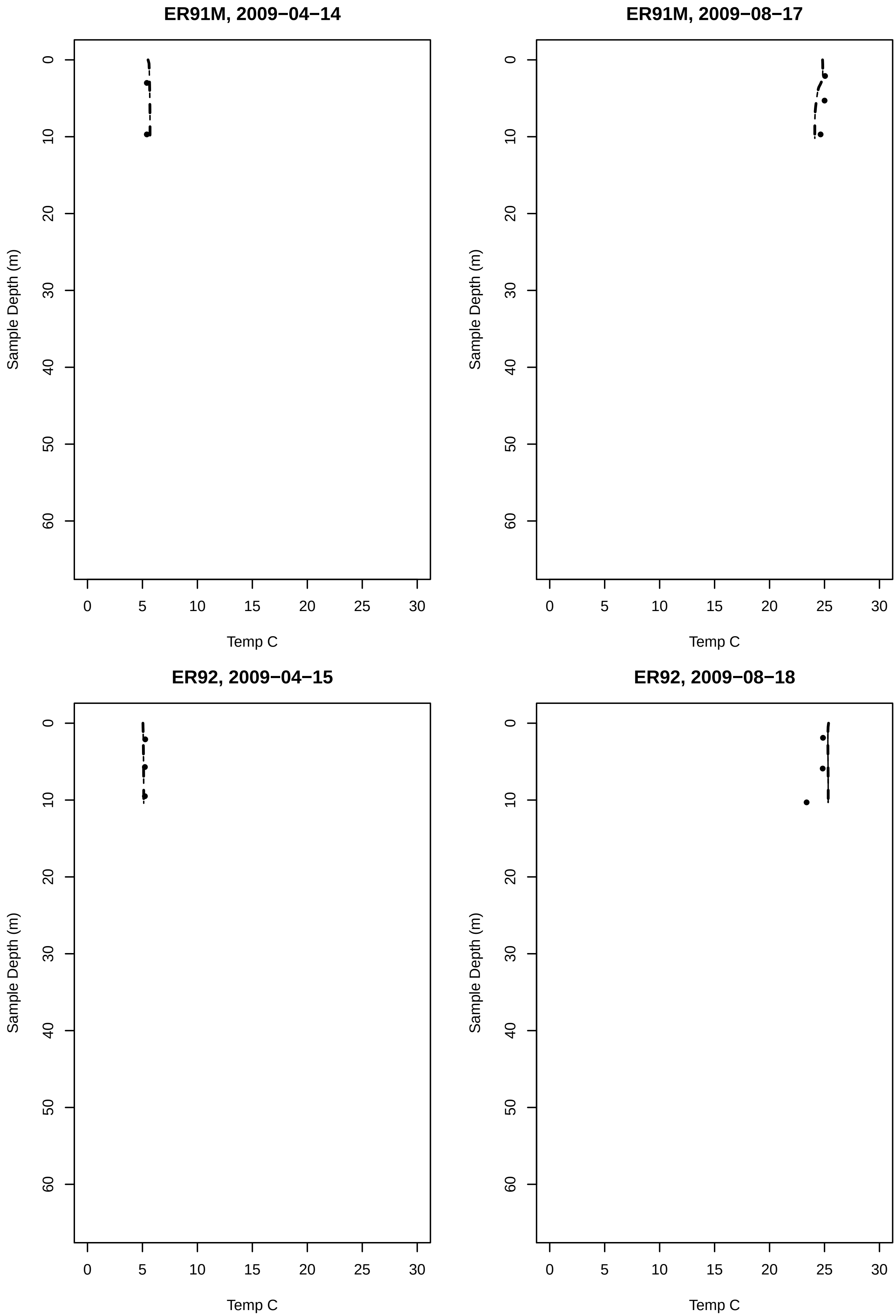


Figure 20. Model Calibration Results (Vertical Temperature Profiles)

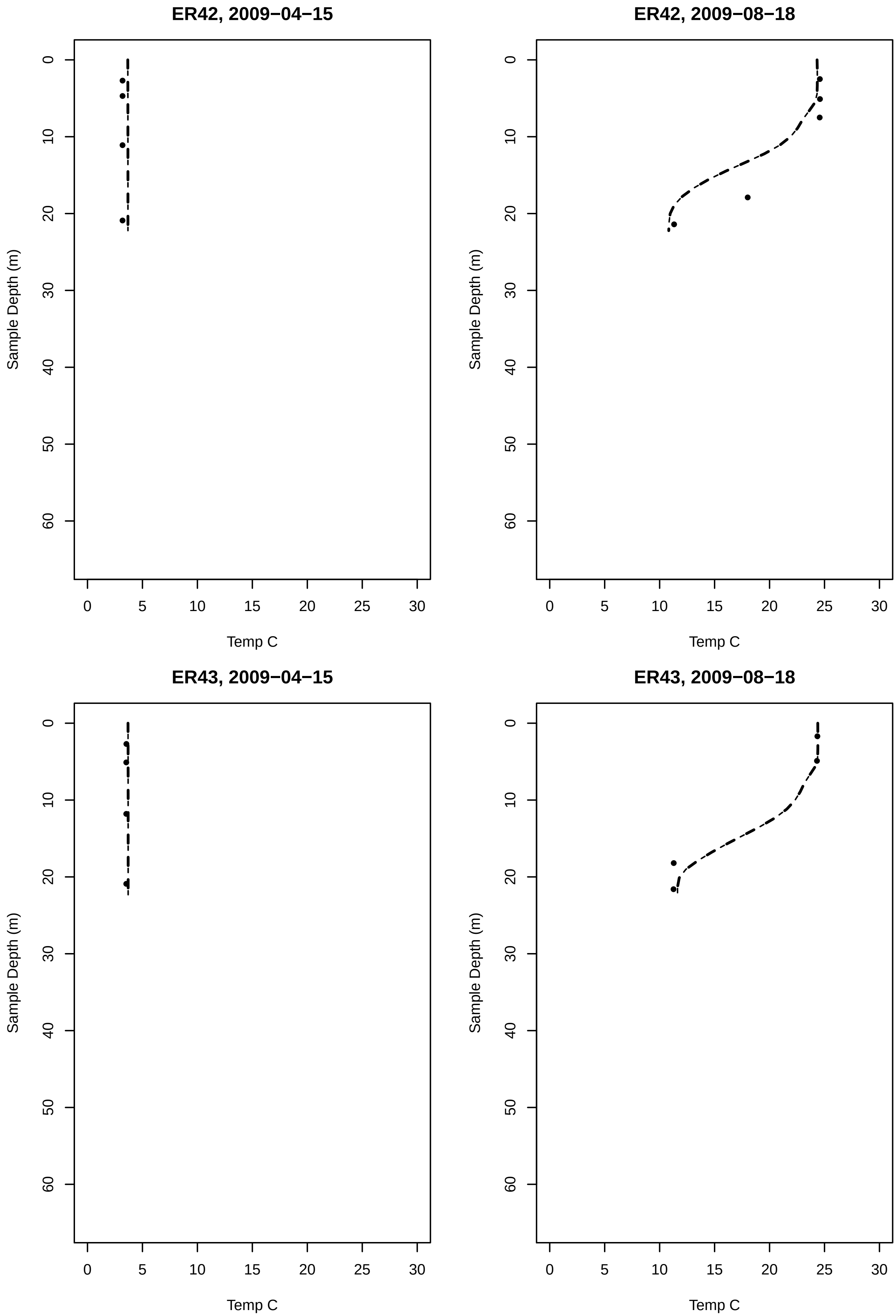


Figure 21. Model Calibration Results (Vertical Temperature Profiles)

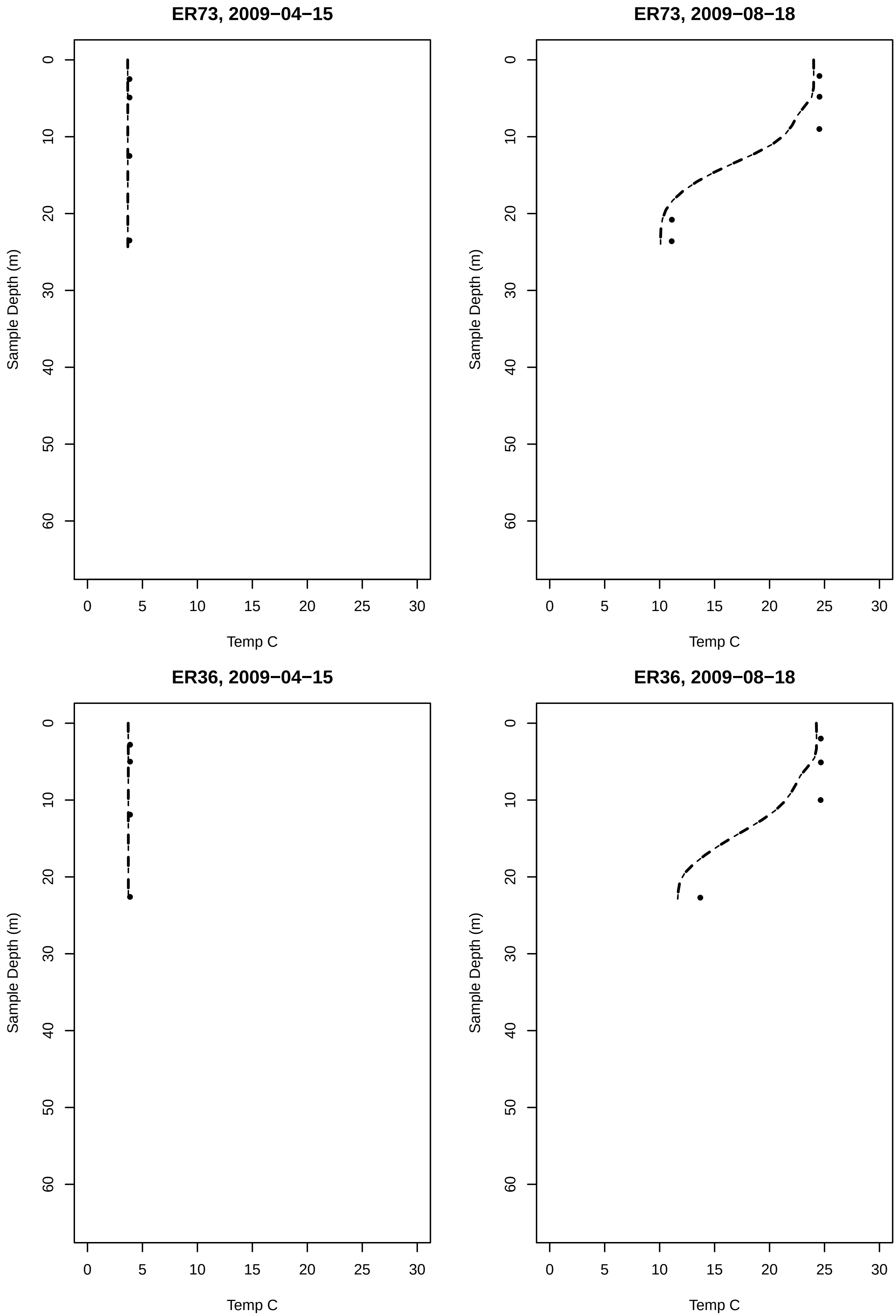


Figure 22. Model Calibration Results (Vertical Temperature Profiles)

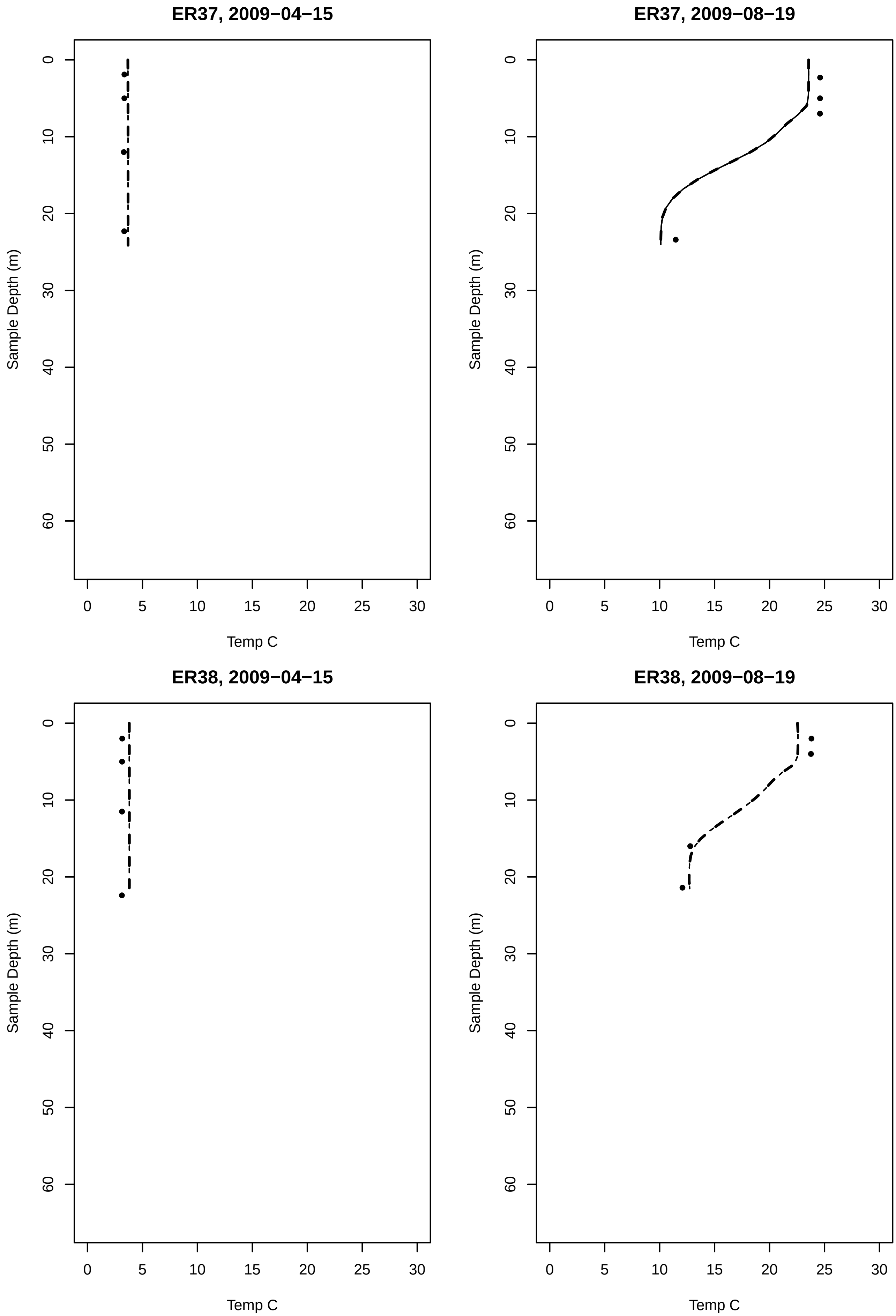


Figure 23. Model Calibration Results (Vertical Temperature Profiles)

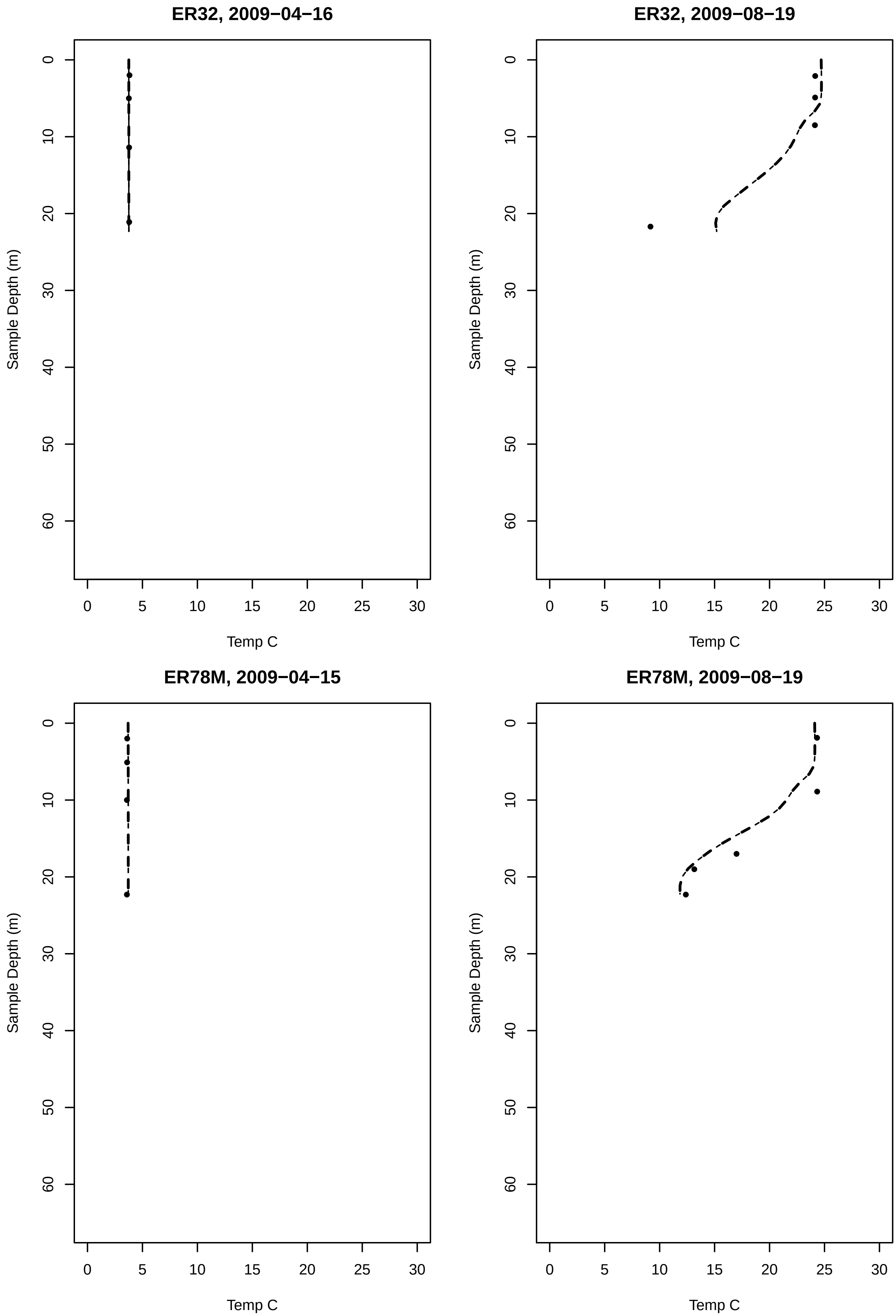


Figure 24. Model Calibration Results (Vertical Temperature Profiles)

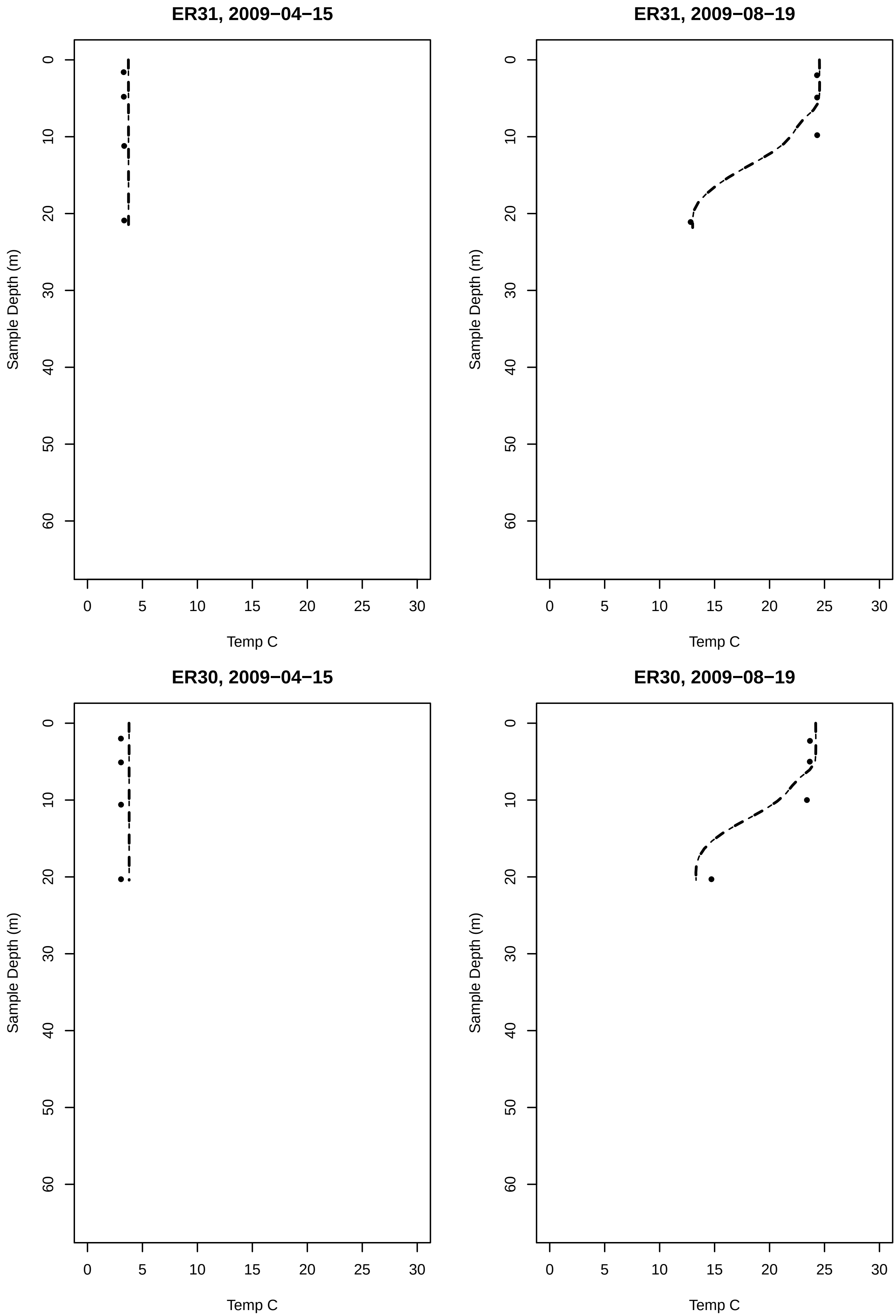


Figure 25. Model Calibration Results (Vertical Temperature Profiles)

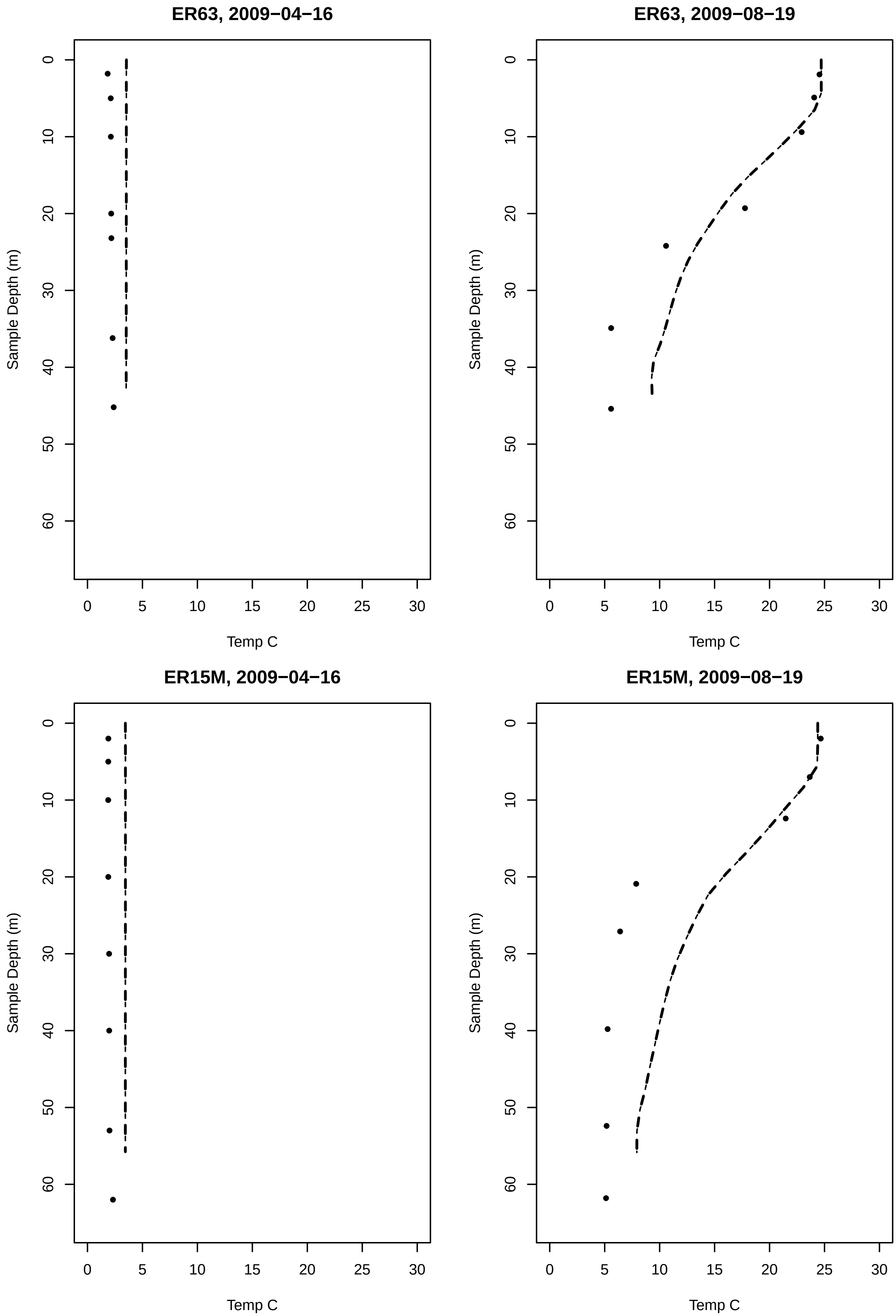


Figure 26. Model Calibration Results (Vertical Temperature Profiles)

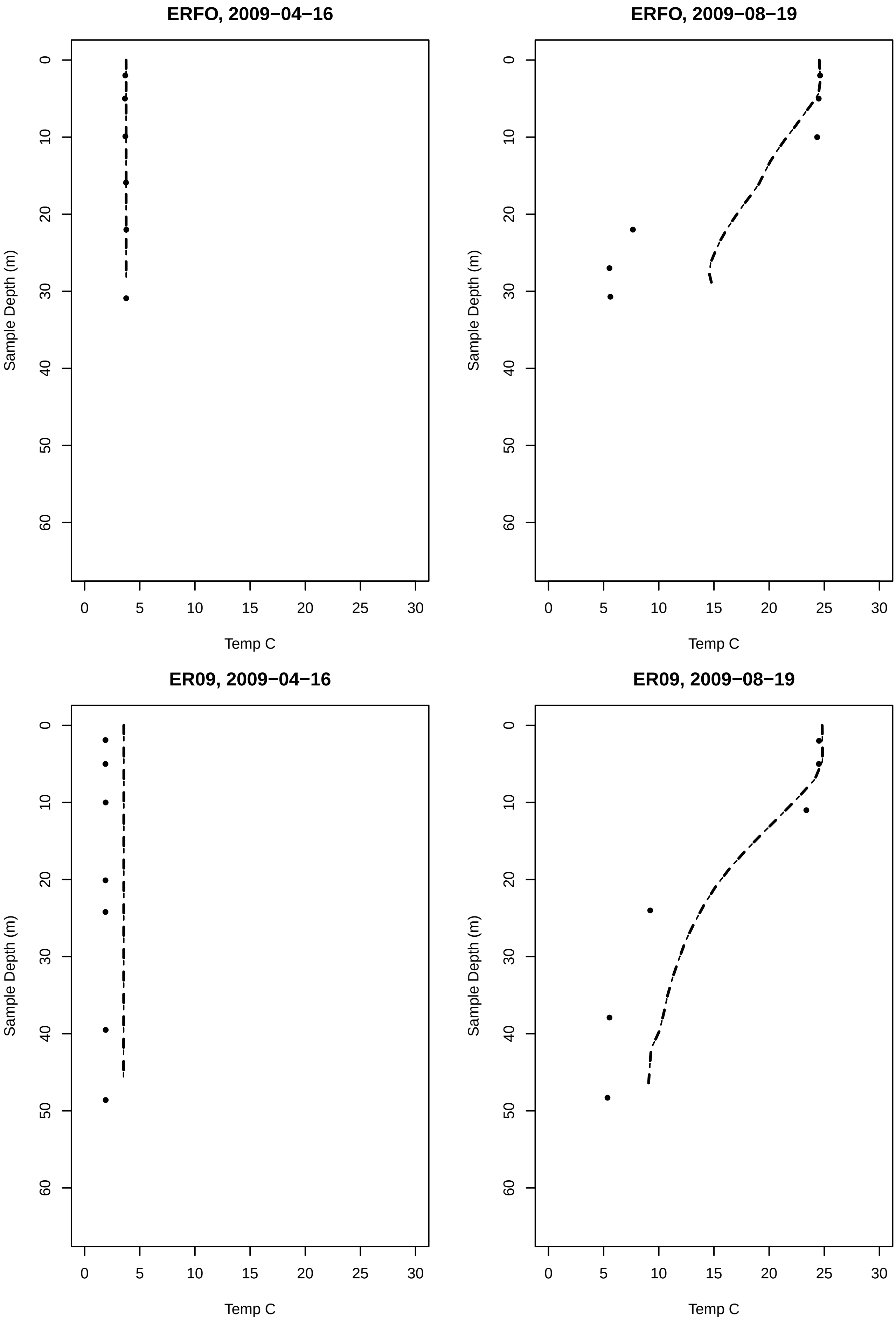


Figure 27. Model Calibration Results (Vertical Temperature Profiles)

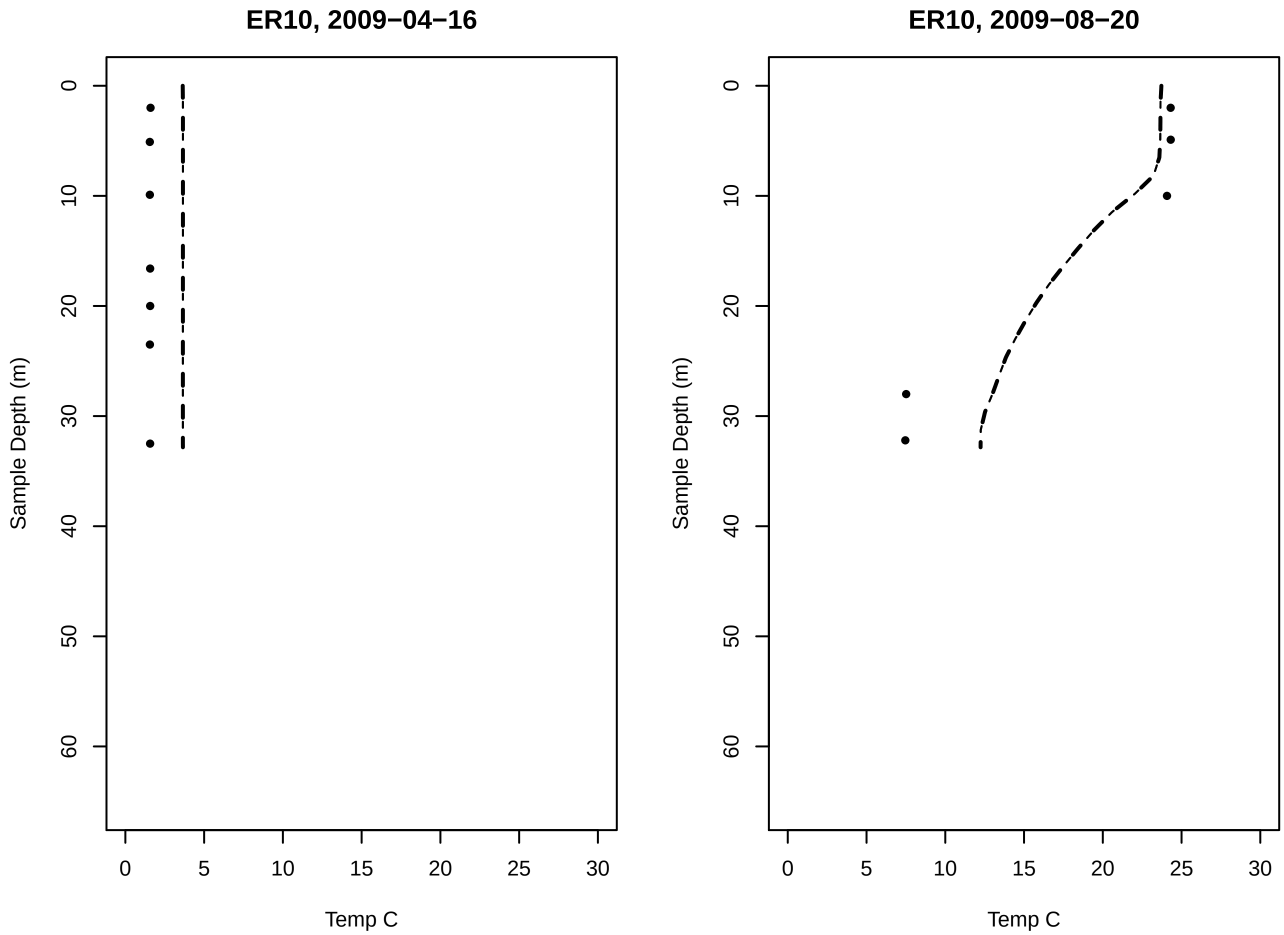


Figure 28. Model Calibration Results (Vertical Temperature Profiles)

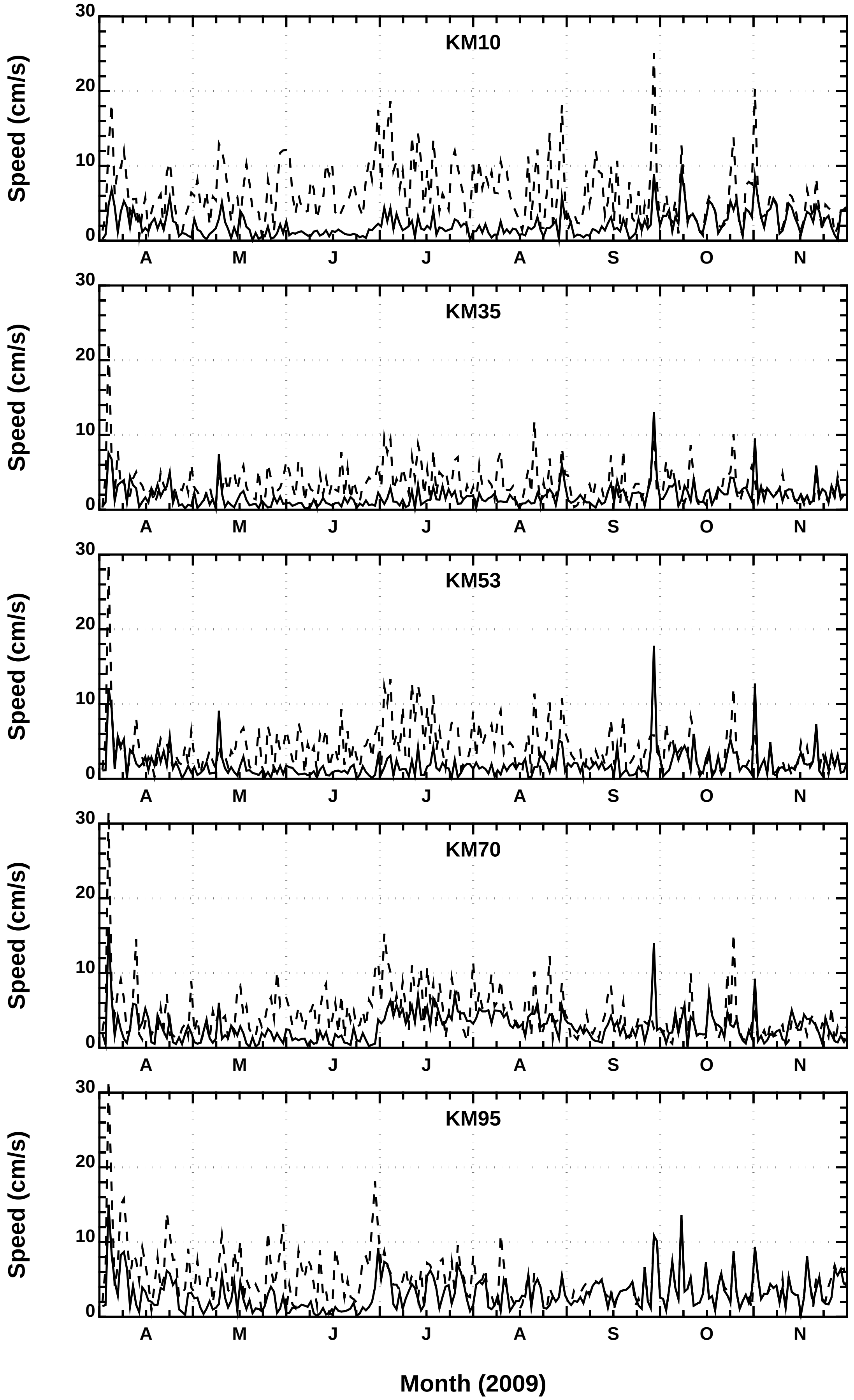


Figure 29. Model Calculated Current Speeds
(Solid Line - Bottom Layer, Dashed Line - Surface Layer)

3 Water Quality Model of Cable Installation

The water quality parameters modeled were selected to evaluate the potential short-term impact of lake bottom sediments and associated constituents that may be disturbed and resuspended into portions of the water column as a result of the cable installation process, including solids, metals and nutrients. Water quality standards (WQS) or Provincial water quality objectives (PWQO) for metals are typically set based on protecting aquatic life over both short-term (acute) and long-term (chronic) time periods. Aquatic life standards address acute and chronic toxicity with acute toxicity resulting from short exposure duration (e.g., 1-hour) and chronic toxicity resulting from a longer exposure (e.g., 4-day). While water quality changes associated with the cable installation will be of short duration at any one location and the associated sediment resuspension will be transient, for purposes of this analysis, the results of the water quality modeling for the proposed cable installation will be compared to both acute standards (1-hour average) and chronic standards (4-day average) for metals.

The metals concentration in the water column consists of particulate and dissolved forms. The sediment released by the cable installation will increase such metal concentrations in the water primarily via the particulate form, because of metals' affinity for adsorption onto solids (i.e., partitioning), but the dissolved form is more important for water quality assessments because it allows a direct comparison to the WQS or PWQO for dissolved metals.

The water quality component of the MIKE3 model was used to calculate the distribution of a number of parameters associated with the resuspended sediments where the cable installation is proposed. These parameters included both particulate and dissolved fractions and, therefore, the water quality model included the advective and dispersive transport of these parameters along with settling of the particulate fractions. The water quality assessment for the cable installation was completed assuming use of a jet-plow installation for the non-bedrock installation areas of the cable route.

As discussed above, the water quality assessments were completed at the five representative in-lake locations of KM10, KM35, KM53, KM70 and KM95. The remainder of this section presents the modeled parameters, applicable WQS and PWQO, data sources and sediment resuspension source calculations.

3.1 Selected Constituents and Water Quality Standards

The water quality model was setup for total suspended solids (TSS), particulate phosphorus (PP), dissolved phosphorus (DP) and for eight metals. In order to compare the model output to water quality targets for total phosphorus (TP), the model results for PP and DP were summed. Both the PADEP and Ontario MOEE have developed water quality guidelines for their jurisdictional areas. PADEP has established both general WQS as well as criteria specific to the Great Lakes System. Table 2 presents the eight metals included in the water quality model and the associated acute and chronic criteria contained in the PADEP WQS and the Ontario MOEE PWQO for the Lake Erie. Where the metals criteria are hardness or alkalinity dependent, an average hardness of 120 mg/L as $CaCO_3$ and an average alkalinity of 94 mg/L was used. The hardness and alkalinity values were based on GLENDA data from 2008-2012 for stations located in eastern Lake Erie where the proposed cable route is planned.

Currently, there is no PADEP WQS for TP in Lake Erie but the Ontario MOEE has an interim PWQO for TP. The interim Ontario PWQO for total phosphorus is 20 µg/L to avoid nuisance concentrations of algae in lakes and is applied as an average for the ice-free period. In Lake Erie, the ice-free period extends from approximately April to December. The Ontario MOEE also has a PWQO for turbidity and water clarity. The turbidity PWQO is stated that suspended matter added to surface waters should not change the natural Secchi disk reading by more than 10%. The water clarity PWQO is stated that bathing areas should have a Secchi disk transparency of at least 1.2 meters.

The model calculated concentrations of TSS, metals and TP will be used to complete the water quality assessment for the proposed cable installation project. That is, the model calculated parameter concentrations will be compared to the WQS and PWQO to determine whether the proposed cable installation would cause exceedances of the specific WQS and PWQO.

Table 2. Metals Parameters, Pennsylvania Water Quality Standards and Ontario Provincial Water Quality Objectives

Parameter	PADEP Acute WQS (µg/L)	PADEP Chronic WQS (µg/L)	Ontario MOEE PWQO (µg/L)
Arsenic	340	148	100
Cadmium*	5.20	2.56	0.2
Chromium (Hexavalent)	15.73	10.56	1.0
Copper*	15.96	10.47	5.0
Lead*	79.0	3.1	25**
Nickel*	546	61	25
Zinc*	137	138	30
Mercury	1.44	0.77	0.2

* - Hardness based criteria for PADEP WQS
** - Alkalinity based criteria for Ontario MOEE PWQO

References:

Pennsylvania Code. Title 25. Environmental Protection. Chapter 93. Water Quality Standards.

Water Management – Policies, Guidelines and Provincial Water Quality Objectives of the Ministry of Environment and Energy, 1994.

3.2 Data Sources

In order to determine the characteristics of the sediment that may be resuspended during installation, available sediment data along the cable installation route was compiled and used to represent the spatially varying sediment characteristics in Lake Erie. The sediment data was available from the following sources:

- *Sediment Contamination in Lake Erie: A 25-Year Retrospective Analysis* (Painter et al., 2001). This report provided total trace metal, nitrogen, phosphorus, iron, manganese and aluminum data from surficial sediment samples throughout Lake Erie in 1997/1998.

- *Great Lakes Fact Sheet – Contaminants in Sediments of Canadian Tributaries and Open-Water Areas of the Lower Great Lakes* (Environment Canada, 2007). This report provided data on sediment PCB levels.

- *Application of a Sediment Quality Index to the Lower Laurentian Great Lakes* (Marvin et al., 2004). This report provided data on sediment PCB levels.

- *Surficial Sediments of Lake Erie* (Thomas et al., 1976). This report provided data on the size of sediment particles throughout Lake Erie.

- *Phosphorus Transport in Lake Erie* (Rumer, R.R., 1977). This report provided data on pore water phosphorus levels.

3.3 Constituent Resuspension

The cable laying operation using the jet-plow represents a moving source that displaces and re-suspends sediment along the cable route. This resuspension will increase the particulate and dissolved components in the water column on a temporary basis. This resuspension source is assigned a status of on or off along the cable route in each model segment based on the length of time that the cable installation occurs in a specific segment. For example, if a model segment is 15 meters long (i.e., size of the fine mesh elements) and the installation speed is 1.75 km/day (1.1 miles/day) or 1.2 meters/minute, the resuspension source will be active for 18.2 minutes until the source moves to the next model segment. In the water quality model, the resuspension source is assigned into the bottom model layer for the jet-plow installation. The bottom model layer is 2 meters thick as measured from the lake bottom up into the water column.

3.3.1 Constituent Concentrations

The sediment data for the five representative locations where water quality modeling was completed are presented in Table 3. There were 8 locations along the cable route with sediment data and these data were grouped (averaged) where necessary with resulting values assigned for the sediment characteristics at the five representative assessment locations. Figure 30 presents the monitoring locations where sediment data was available for calculating the resuspension source. The sediments along the cable route represent fine silts and clays (<5 µm particle diameter) and are about two orders of magnitude smaller than median sand particle diameters (250-500 µm).

Table 3. Lake Erie Sediment Characteristics					
Parameter	**KM10**	**KM35**	**KM53**	**KM70**	**KM95**
Water Depth (m)	20.4	61.1	36.9	23.2	13.4
Station Data Used	1107+1108	1042	1043+1044	Average KM53/95	1048+1049+ 1112
Porosity (%)	90	90	90	90	90
Specific Gravity	2.68	2.68	2.68	2.68	2.68
Median Particle Diameter, d50 (µm)	4.19	4.19	4.19	3.38	3.38
Arsenic (mg/kg)	2.80	2.40	7.70	6.87	6.03
Cadmium (mg/kg)	0.8	0.8	0.8	0.8	0.8
Chromium (mg/kg)	19.35	32.00	28.20	25.43	22.67
Copper (mg/kg)	20.95	32.60	29.75	23.64	17.53
Lead (mg/kg)	8.50	25.50	16.75	22.61	28.47
Nickel (mg/kg)	23.05	39.00	34.95	27.99	21.03
Zinc (mg/kg)	69.60	130.90	106.70	120.48	134.27
Mercury (mg/kg)	0.031	0.072	0.051	0.078	0.105
DP (mg/L)	0.221	0.221	0.221	0.221	0.221
PP (mg/g)	0.65	0.89	0.823	0.67	0.51
See Section 3.2 for list of data source references.					

In order to calculate the TSS concentration at a specific location for calculating the sediment resuspension source, porosity and specific gravity data are used in the equation below:

$$TSS = (1 - \varphi) \times \rho_S \times 1000$$

where: TSS – total suspended solids (g/m^3 or mg/L);

φ – porosity (dimensionless); and

ρ_S – density of solids (kg/m^3) or 1000 x specific gravity.

As the WQS and PWQO are based on the dissolved form of the metals, reported sorbed metals concentrations (see Table 3) were converted to dissolved concentrations using metal specific partition coefficients. The partition coefficient is the ratio of the sorbed concentration to the dissolved concentration and is represented by the following equation.

$$K_d = \frac{C_S}{C_D}$$

where: K_d – partition coefficient (L/kg);

C_S – sorbed concentration (mg/kg); and

C_D – dissolved concentration (mg/L).

Table 4 presents the partition coefficients used to convert the sorbed metals data to dissolved concentrations.

Table 4. Metals Partition Coefficients

Metals	Log Partition Coefficient (L/kg)
Arsenic	2.5
Cadmium	3.6
Chromium	4.5
Copper	4.2
Lead	5.1
Nickel	4.0
Zinc	3.7
Mercury	4.9
EPA, 2005. Partition Coefficients for Metals in Surface Water, Soil and Waste. EPA/600/R-05/074. July 2005.	

In order to analyze TP concentrations, the sediment sorbed phosphorus data was converted to particulate phosphorus (PP) by multiplying the sorbed phosphorus concentration by the sediment TSS concentration, which was calculated using the above formula. Table 5 presents the dissolved metals concentrations at the five representative locations that were used to calculate the sediment resuspension source in the water quality model. It should be noted that the existing sediment dissolved metals concentrations are all less than the applicable acute and chronic WQS. They are also less than the PWQO except for cadmium and chromium. For these two metals, the existing sediment dissolved metals concentrations are just slightly greater than the PWQO.

Table 5. Lake Erie Sediment Concentrations					
Parameter	**KM10**	**KM35**	**KM53**	**KM70**	**KM95**
Arsenic (µg/L)*	8.85	7.59	24.35	21.71	19.08
Cadmium (µg/L)*	0.201	0.201	0.201	0.201	0.201
Chromium (µg/L)*	0.61	1.01	0.89	0.80	0.72
Copper (µg/L)*	1.32	2.06	1.88	1.49	1.11
Lead (µg/L)*	0.068	0.203	0.133	0.180	0.226
Nickel (µg/L)*	2.31	3.90	3.50	2.80	2.10
Zinc (µg/L)*	13.89	26.12	21.29	24.04	26.79
Mercury (µg/L)*	0.0004	0.0009	0.0006	0.0010	0.0013
DP (mg/L)	0.22	0.22	0.22	0.22	0.22
PP (mg/L)	174	239	221	179	137
* - Dissolved metal concentration					

3.3.2 Resuspension Calculation

This resuspension source is calculated using the cross-sectional area of the installation trench, the cable installation speed and the sediment concentration. The flow rate associated with the cable installation is calculated as:

$$Q = A_T \times U_P$$

where: Q – flow rate associated with installation (m^3/s);

A_T – cross-sectional area of the trench (m^2); and

U_P – plow speed (m/s).

The plow speed for the jet-plow installation method is 1.75 km/day (1.1 mi/day) or 0.02 m/s. The cross-sectional area for the jet-plow was assumed to be 2.98 m^2 (32.1 ft^2) based on the expected burial depth and a conservative estimate of the width of the trench. The flow associated with the installation is therefore 0.060 m^3/s for the jet-plow installation method.

The resuspension source is then calculated using a sediment concentration as:

$$W_R = Q \times C \times R$$

where: W_R – resuspension source (kg/s);

C – sediment concentration (kg/m^3); and

R – release fraction.

3.3.2.1 Release Fraction

A key component of the water quality model assessment is what fraction of the trench sediments are resuspended during cable laying operations (i.e., release fraction). In practice, the total volume of the trench sediments is not completely introduced into the water column and the typical modeling approach is to assume that a certain fraction remains in the trench (or conversely that a certain fraction is released into the overlying water column). As part of this effort, readily available information was reviewed in order to determine what sediment release fraction should be used.

A review was performed of previous water quality modeling efforts that assessed jet-plow cable installations and received regulatory review and approval. Table 6 presents the jet-plow release fractions used in these previous modeling efforts.

Table 6. Jet-Plow Release Fraction from Other Modeling Studies

Modeling Study	Waterbody	Release Fraction Used
Bayonne Energy Center[1]	Upper NY Bay and Gowanus Bay	0.25 (0.03 for clamshell dredging installation)
Poseidon Project[2]	Raritan Bay and NY Bight	0.25
Roberts Bank Installation[3]	Roberts Bank, Strait of Georgia (British Columbia, Canada)	0.25-0.30

1 - *Results from Modeling of Sediment Dispersion during Installation of the Proposed Bayonne Energy Center Submarine Cable* (10/2008)
2 - *Modeling of Sediment Dispersion during Installation of the Submarine Cable for the Poseidon Project* (9/18/2013)
3 - Jiang, J., D.B. Fissel and K. Borg, 2007. *Sediment Plume and Deposition Modeling of Removal and Installation Underwater Electrical Cables on Roberts Bank, Strait of Georgia, British Columbia, Canada (Presented at ECM10 2007 ASCE Conference)*

Additionally, reports prepared to estimate the release fraction associated with jet-plow installation, based on observations and other calculation methods, were reviewed and are discussed below.

- Bohlen Report (*Attachment 4C – Preliminary Sediment Transport Analysis.* In *Northport NY to Norwalk CT 138kV Submarine Cable Replacement Project – Application to the NYSPSC for a Certificate of Environmental Compatibility and Public Need, LIPA*; 10/2001).

This report is frequently referenced as the justification for use of a 30% jet-plow release fraction. Dr. Bohlen reviewed available video imaging provided by cameras mounted on operating jet-plow equipment and concluded that the majority of the sediments displaced by the jetting process settle rapidly into and along the trench following passage of the jet-plow. He estimated that sediment loss was 30% of the trench volume and that there was significant coverage of the placed cable along with a slight residual depression in bottom contours along the cable route.

- Nexans Sediment Disturbance Description (Document o*btained during Neptune Cable Project by HDR from the installer*; 2002).

  This study reviewed video recordings and, based on observations that the majority of the sediment settled back into the trench, estimated that 50-90% of the trench sediment will remain in the trench (i.e., a 10-50% release fraction) depending on ambient current and sediment conditions. A 30% release fraction for jet-plow installation was estimated in this study. This document was in part based on the Bohlen Report and its estimated release fraction for jet-plow installation.

- Resuspension of Sediment by the ITG Jet Plow during Submarine Cable Installation (Paper obtained from Neptune Cable Project online File Summary; 2002).

  This document is the most quantitative approach taken to estimate the sediment release fraction associated with jet-plow cable installation. The report presents calculations involving estimated trench volume (with and without surface collapse of sediment trench walls) and fluidized volume (sum of original trench volume and water volume required to fluidize the sediment in the trench). Based on the difference between these two volumes, the authors estimated release fractions for different trench assumptions ranging from 10-35% depending on the sediment water content (with higher release rates associated with higher sediment water content).

Many of the modeling efforts for similar projects that have undergone regulatory review and gained regulatory approval have used a jet-plow release fraction of between 25% and 30% for similar fine grained sediments as present in Lake Erie. In addition, previously completed studies suggest that 30% is a reasonable value, with one quantitative study suggesting a range of 10-35%. Therefore, this modeling effort used a jet-plow release fraction of 30%.

3.3.3 Settling Velocity

As solids introduced into the water column will settle, a settling rate is required in the model for properly assessing the distribution of TSS and PP. The sediment core median particle diameter data (d50), sediment specific gravity and Stokes Law were used to calculate the settling rate along the cable route. The calculated solids settling rate varied from 0.90 to 1.39 m/d (0.010-0.016 mm/s).

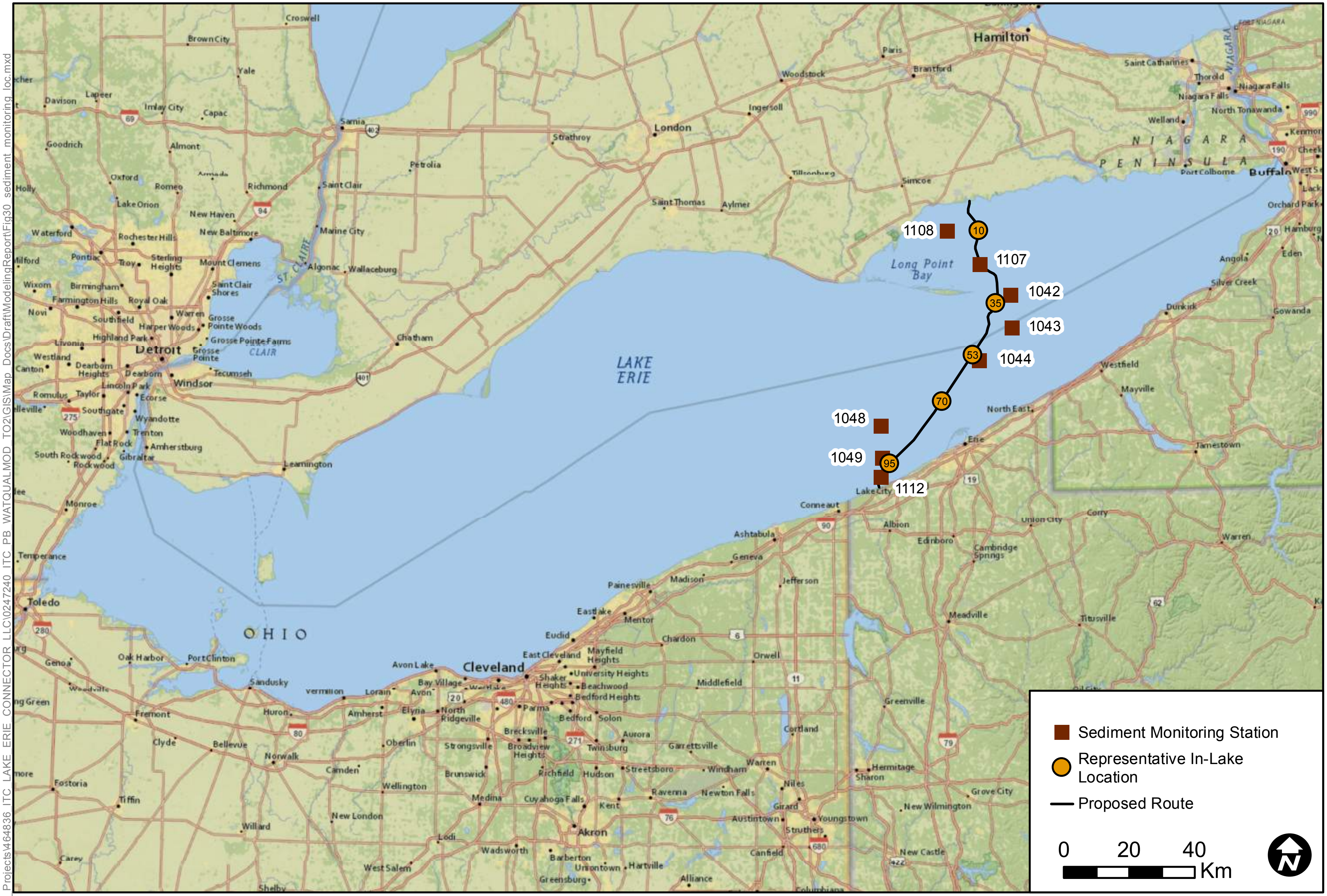
The use of Stokes Law calculated settling rates is very conservative in that this calculation does not account for the flocculation of cohesive fine grained sediments (silts and clays) that is observed to occur in lake environments. Lake Erie sediments along the cable route generally consist of cohesive fine grained silts and clays. These fine grained sediments flocculate into larger effective diameter flocs that can settle faster than individual particles.

Theoretical relationships between sediment concentration and settling rates have been developed and can be used to estimate settling rates for flocs in addition to modeling studies where the floc settling rate was determined based on calibration to observed data (Chao, X. and Y. Jia, 2011; Delft, 2005). In addition, field and laboratory measurement have been completed relating settling rates to floc size (Manning, A.J. et al., 2010; Fathi-Moghadam, M. et al., 2011; Manning, A.J. et al., 2011; Maa, J.P. and J. Kwon, 2007; Manning, A.J. and D.H. Schoellhamer, 2013). Based on these studies of measured floc settling rates, the minimum settling velocity measured was approximately 0.1 mm/s or 8.6 m/d.

In order to account for the naturally-occurring flocculation of the cohesive fine grained silts and clays present in Lake Erie along the cable route, a minimum settling velocity of 0.1 mm/s (8.6 m/d) will be used. That is, if the Stokes Law calculated settling rate is less than 0.1 mm/s it will be set equal to 0.1 mm/s (8.6 m/d).

3.4 Simulation Period

The calibrated model was setup using the resuspension loading sources presented in the following sections for a summer period with low bottom current speeds (September 1-4). The bottom current speeds for this time period ranged from 1.2-2.7 cm/s at the five representative locations. It is not anticipated that model results for these time periods would be significantly different for cable installation model results at other times of the year.



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HDR

ITC Lake Erie Connector
Sediment Monitoring Stations

Figure 30

April 01, 2015

4 Model Results

The Lake Erie water quality model results for TSS, TP, DP and the eight metals (arsenic, cadmium, chromium, copper, lead, nickel, zinc and mercury) are presented in a number of different graphical formats and tables in the next sections. These model results are based on the model setup and various model inputs described in Section 3 and reflect concentration increases due to the cable installation (i.e., the increase above background levels for any given parameter). The model concentration increases were compared to applicable WQS and PWQO. In addition, the model maximum concentrations at the five representative locations (KM10, KM35, KM53, KM70 and KM95) were also presented as a function of time to present the relative time duration of water quality concentration increases associated with the cable installation.

4.1 TSS

The calculated TSS concentrations are based on the porosity and specific gravity data along the cable route. In addition, the model-calculated bottom current speeds and assigned settling rates affect the temporal, magnitude and spatial distribution of TSS along the cable route. The model output is presented at the five representative locations along the cable route (KM10, KM35, KM53, KM70 and KM95) as spatial maps in the horizontal and vertical directions along with concentration time-series at these five locations. This model output information was used to assess water quality changes as a result of the cable installation.

4.1.1 Turbidity and Water Clarity

The Ontario MOEE has a PWQO for turbidity and water clarity. The turbidity PWQO is stated that suspended matter added to surface waters should not change the natural Secchi disk reading by more than 10%. The water clarity PWQO is stated that bathing areas should have a Secchi disk transparency of at least 1.2 meters. Because most of the jet-plow cable installation in the lake will take place in water depths greater than 10 meters and not near bathing areas, the water clarity PWQO does not apply since it is related to the safety of submerged swimmers.

In order to assess the turbidity PWQO, available Secchi depth data was obtained from Environment Canada in eastern Lake Erie for the time period from 2009-2014. The average Secchi depth was 6.5 meters and ranged from 0.3-13.0 meters. Since the jet-plow cable installation will take place in water depths greater than 10 meters (i.e., deeper than the average Secchi depth) and cable installation represents a short term increase in TSS levels near the bottom of the lake, it is not anticipated that the PWQO for turbidity will be exceeded.

4.1.2 TSS Spatial and Vertical Distributions

Figures 31-35 present the model calculated TSS distributions in the horizontal and vertical directions for the five representative locations along the cable route. These figures present the horizontal TSS distribution in the bottom layer (left panel) along with

200 meter offset distances on either side of the cable route (vertical gray lines) and lateral transect (horizontal gray line) that correspond to the vertical TSS distribution shown in the right panel. The gray circle noted in the vertical distributions indicates the location for which time-series TSS model output is presented in Figures 36-38. The horizontal and vertical concentration distributions are presented at the time when the installation is at the noted representative location and reflect the maximum concentrations at these locations.

The horizontal TSS distributions at the five representative locations indicate that the highest concentrations occur around the point of installation and then decrease rapidly as distance from the installation area increases. At a lateral distance of 30 meters from the installation point, the maximum resuspended TSS concentration increases are less than 100 mg/L and at 100 meters from the point of installation the TSS concentration increases are less than 3 mg/L, which is a typical method detection limit for laboratory TSS analytical measurements.

In the vertical direction, increased TSS concentrations are limited to the bottom one to six layers of the model (about the bottom 5-11 meters of the water column depending on the representative location). Above these depths from the bottom, the model calculated TSS concentration increases are less than 3 mg/L above background levels observed in the lake.

At all five of the representative locations, the model calculated TSS concentration increases due to the cable installation to be less than 3 mg/L above background lake TSS levels at 100 meters from the point of installation and within five to eleven meters of the lake bottom. These five representative locations were selected to be indicative of the TSS increases along the entire cable route due to the similar sediment characteristics and bottom lake currents.

4.1.3 TSS Time-Series

Figures 36-38 present the model calculated TSS concentration increases versus time for the five representative locations in order to provide duration information for the increased TSS concentrations during cable installation. These figures present the model calculated TSS concentration increases in the bottom model layer (layer 1, solid black line) as noted in the vertical distribution figures as well as the second model layer up from the bottom (layer 2, dashed black line). The bottom model layer is 2 meters thick as measured from the lake bottom up and into the water column; and the second model layer from the bottom represents a vertical slice of the water column ranging from 2 to 5 meters above the lake bottom. At the five representative locations, the model calculated peak TSS concentration increases ranged from about 1,100-2,500 mg/L and then rapidly decreased to less than 100 mg/L in about 30-60 minutes depending on the representative location.

At all five representative locations, the calculated TSS concentration increases reach a peak concentration at the point of installation and then experience a rapid decrease. TSS concentration increases of 100 mg/L occur in the first hour while increases less than

3 mg/L above background TSS levels are achieved in the first one to four hours depending on the representative location.

4.2 Phosphorus

The calculated phosphorus concentration increases (PP and DP) are largely based on the sediment concentrations for phosphorus obtained from the available information. In addition, the model calculated bottom current speeds and assigned settling rates (for PP) affect the temporal, magnitude and spatial distribution of TP along the cable route. Presentation of TP is a sum of the model-calculated PP and DP. The model output is presented at the five representative locations along the cable route (KM10, KM35, KM53, KM70 and KM95) as spatial maps in the horizontal and vertical directions along with concentration increase time-series at these same five locations using the same formats as used for TSS. This model output information was used to assess potential water quality changes as result of the cable installation.

4.2.1 Phosphorus Impact on Algal Growth

Algal (phytoplankton) growth is a function of ambient nutrient, light and temperature conditions as well as the effects of residence time. Excluding the effects of light and temperature, typically one nutrient serves at the limiting factor which controls the growth of algae. The limiting nutrient can be estimated based on comparing algal nutrient stoichiometry (i.e., the relative nutrient composition of algae, sometimes referred to as the Redfield ratios) to ambient data and also by comparing ambient concentrations to minimum levels that reduce algal growth. In freshwater lakes, phosphorus is usually the limiting nutrient that controls algal growth and, therefore, improving lake water quality typically focuses on phosphorus controls. The influence of nutrients on algal growth is generally seen over the longer term (i.e., seasonal or annual) rather than a short term (i.e., hours or days). As such, nutrient standards are usually expressed as seasonal or annual averages.

4.2.1.1 Lake Erie Phosphorus Standards

In order to interpret the model phosphorus results, the Lake Erie ambient phosphorus levels and the Ontario MOEE interim PWQO are used. Available phosphorus data from eastern Lake Erie were obtained from the GLENDA database for the recent time period from 2008-2013. The average TP concentration is 4.7 µg/L and ranged from 0.7-30.9 µg/L. There was no recent DP data available but for the time period from 1983-1996 the average was 2.3 µg/L and ranged from 0.1-11.9 µg/L.

In Lake Erie, the Ontario MOEE interim PWQO for TP is 20 µg/L to avoid nuisance concentrations of algae in lakes and is applied as an average for the ice-free period. In Lake Erie, the ice-free period extends from approximately April to December. From this perspective, the short term increases in TP levels in the lake (i.e., hours) should not significantly impact phosphorus and algal levels in the lake as long as they do not materially affect the ice-free period (April-December) mean TP concentrations.

4.2.2 Phosphorous Spatial and Vertical Distributions

Figures 39-43 present the model calculated temporary TP increase distributions in the horizontal and vertical directions for the five representative locations along the cable route. As with the TSS representations, the figures present the horizontal TP distributions in the bottom layer (left panel) as well as the location of 200 meter offset distances on either side of the cable route and the lateral transect (horizontal gray line) that corresponds to the vertical TSS distribution shown in the right panel. The circle in the vertical distributions indicates the location for which the time-series model output is presented in Figures 44-46.

The horizontal TP distributions indicate that the highest temporary concentration increases occur at the point of installation and then decrease rapidly as distance from the installation increases. At a lateral distance of 45-90 meters from the installation point, the temporary resuspended maximum TP concentration increases are less than 0.005 mg/L above background levels.

In the vertical direction, the model calculated temporary TP concentration increases are limited to the bottom 1-5 layers of the model (about the bottom 4-8 meters of the water column depending on the representative location). Above these depths from the bottom, the model calculated temporary TP concentration increases are less than 0.005 mg/L above background annual mean TP levels observed in the lake.

At all five of the representative locations, the model calculated temporary TP concentration increases due to the cable installation are less than 0.005 mg/L above background annual mean lake TP levels at 100 meters from the point of installation and within 4-8 meters of the lake bottom. These five representative locations were selected to be indicative of the TP increases along the entire cable route due to the similar sediment characteristics and bottom lake currents.

Because DP is readily available for phytoplankton growth and an important parameter to consider from a water quality perspective, similar spatial and vertical graphics are presented for DP in Figures 47-51. The time-series graphics for DP are presented in Figures 52-54. These figures indicate that maximum temporary DP increases are less than 0.003 mg/L at all locations at the five representative locations along the cable route.

4.2.3 Phosphorous Time-Series

Figures 44-46 and 52-54 present the model calculated temporary TP and DP concentration increases versus time for the five representative locations to provide duration information for the increased concentrations during cable installation in the same format as used for TSS. The bottom model layer (layer 1) is represented as the solid black line and the second model layer up from the bottom (layer 2) is represented by the dashed black line.

At all representative locations, the model calculated temporary peak TP concentration increases ranged from about 0.6-1.7 mg/L and then rapidly decreased to less than 0.005 mg/L above background levels in about one to four hours. At all five representative locations, temporary DP concentration increases reach a peak concentration at the point of installation and then decrease rapidly. The peak temporary DP concentration increases ranged from 0.001-0.003 mg/L.

4.2.4 Summary of Potential Phosphorus Impacts

At all five representative locations, TP concentration increases reach a temporary peak concentration at the point of installation and then decrease rapidly. The calculated time to reach 0.005 mg/L above background TP and DP concentrations is on the order of one to four hours. The model results indicate temporary increases in TP and DP over a relatively small spatial area in both the horizontal and vertical directions. TP increases were greater than DP due to the addition of the PP component, but due to the settling rate of PP represented only a short term increase (i.e., within one to four hours).

In order to provide a context for these values, an assessment of the total mass resuspended during cable installation was compared to total annual external phosphorous inputs. External TP loads to Lake Erie as presented in the Ohio EPA report titled *Ohio Lake Erie Phosphorus Task Force Final Report* (Ohio EPA, 2010) are presented in Table 7 as annual means for the period from 1998-2005. The external TP load to Lake Erie is 9,220 metric tons/year (9,220,000 kg/yr). Since the particulate fraction of phosphorus (PP) resuspended during cable installation settles back to the sediment on the order of hours and does not significantly contribute to concentrations in the lake, the total mass of DP used as model input over the entire cable route during installation of 21 kg or 0.021 metric tons (mt) was used for comparison to the external TP inputs. Based on this information, the cable installation represents less than 0.001% of the central/eastern basin or total external phosphorus inputs to Lake Erie. It should be noted, however, that the cable installation process does not introduce a new phosphorus source to the lake but rather the re-introduction of existing sediment sources into the water column on a short term basis.

Table 7. External Phosphorus Sources to Lake Erie

External Source	Annual TP Load (mt/yr)[1]			
	Detroit River	Western Basin	Central/Eastern Basin	Total
Nonpoint	522	3,987	1,094	5,604
Point	1,051	388	469	1,908
Upper Lakes	1,080	0	0	1,080
Atmospheric	n.a.	80	548	628
Total	2,653	4,455	2,111	9,220

1 – metric ton/year (mt/yr) = 1,000 kg/yr

4.3 Metals

The model calculated metals concentration increases are largely based on the sediment concentrations obtained from available information. As discussed in Section 3.3.1, concentrations of existing sediment dissolved metals along the length of the cable route (i.e., at the five representative locations) are all less than the PADEP acute and chronic WQS and all of the Ontario MOEE PWQO except for cadmium and chromium. Once these sediment dissolved metals are resuspended into the water column, all metals will be compliant with these WQS and PWQO. Because the metals concentrations are all less than or very close to the applicable WQS and PWQO, only the time-series figures for metals will be presented.

4.3.1 Metals Time-Series

Figures 55-74 present the model calculated metals concentration increases versus time for the five representative locations to provide duration information for the increased metals concentrations during cable installation. These figures present the calculated metals concentration increases in the bottom model layer (layer 1, solid black line) as noted in the vertical distribution figures; and the second model layer up from the bottom (layer 2, dashed black line). All of the calculated metals concentration increases are less than applicable acute and chronic WQS and PWQO, and, therefore, water quality impacts associated with the eight metals (arsenic, cadmium, chromium, copper, lead, nickel, zinc and mercury) due to the installation of the cable in Lake Erie are expected to be in compliance with the WQS and PWQO. In addition, the concentration increases are all less than method detection limits (MDLs) for these metals and are not measureable.

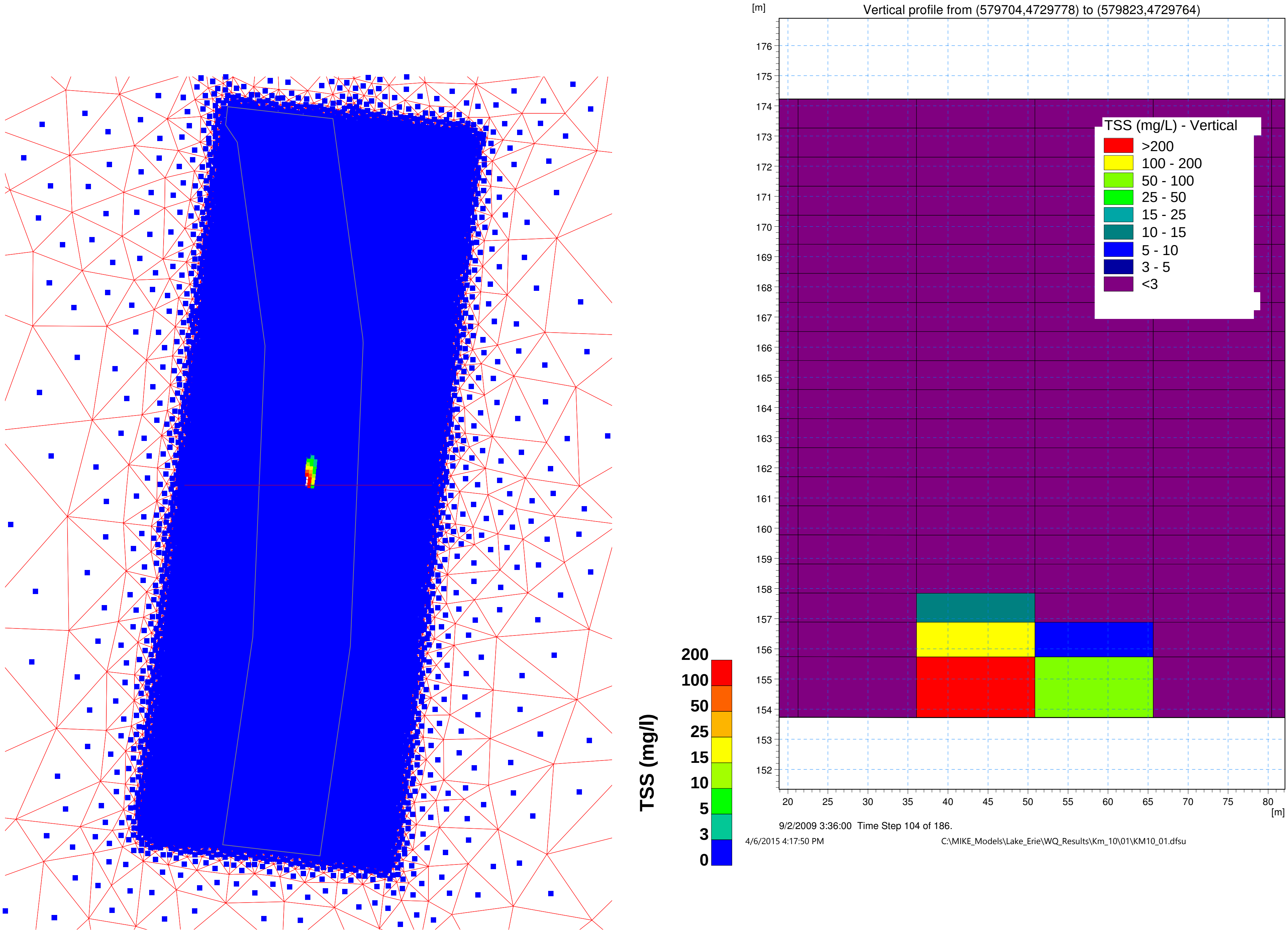


Figure 31. Lake Erie Water Quality Model - Calculated TSS at Km 10

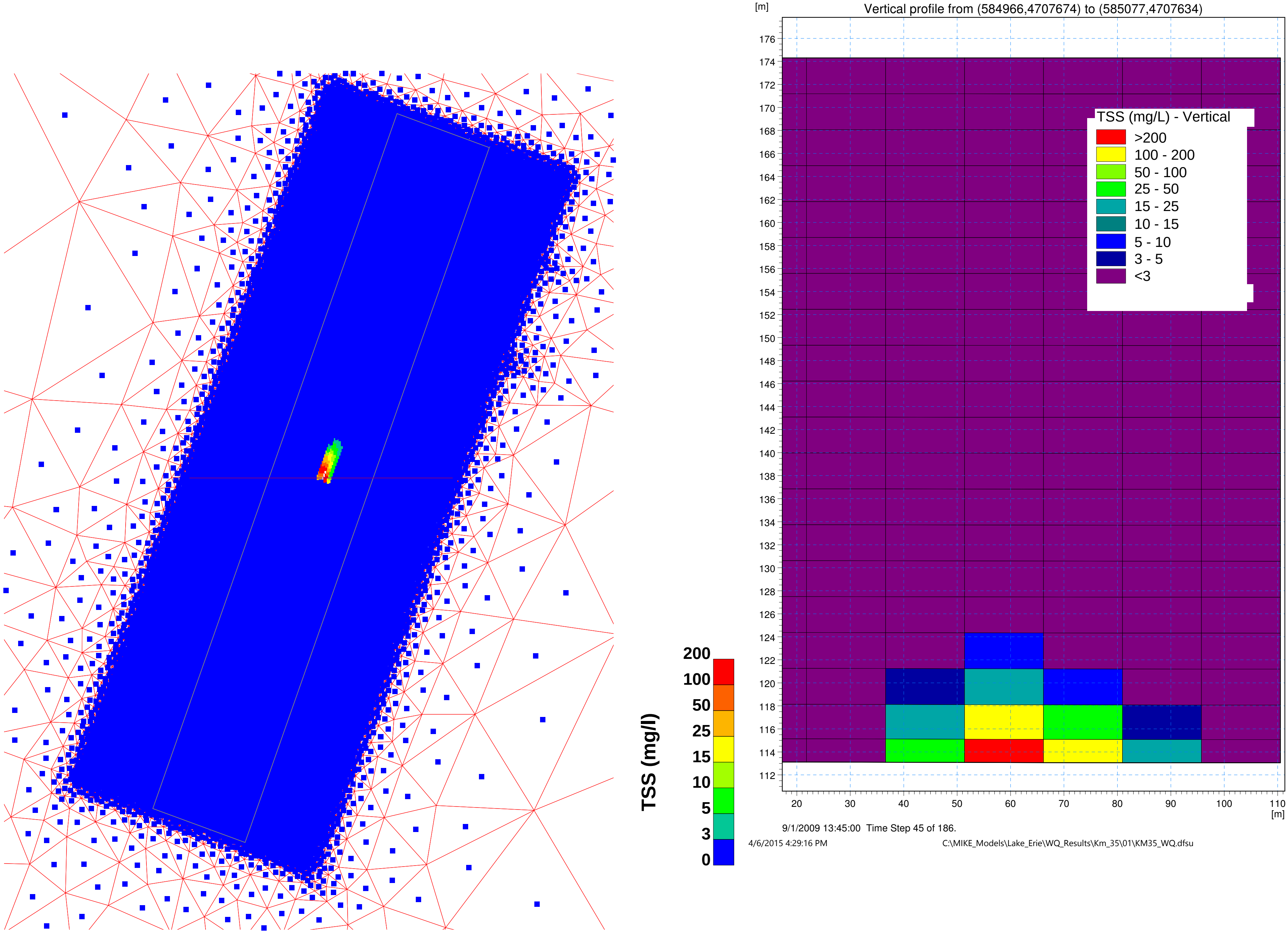


Figure 32. Lake Erie Water Quality Model - Calculated TSS at Km 35

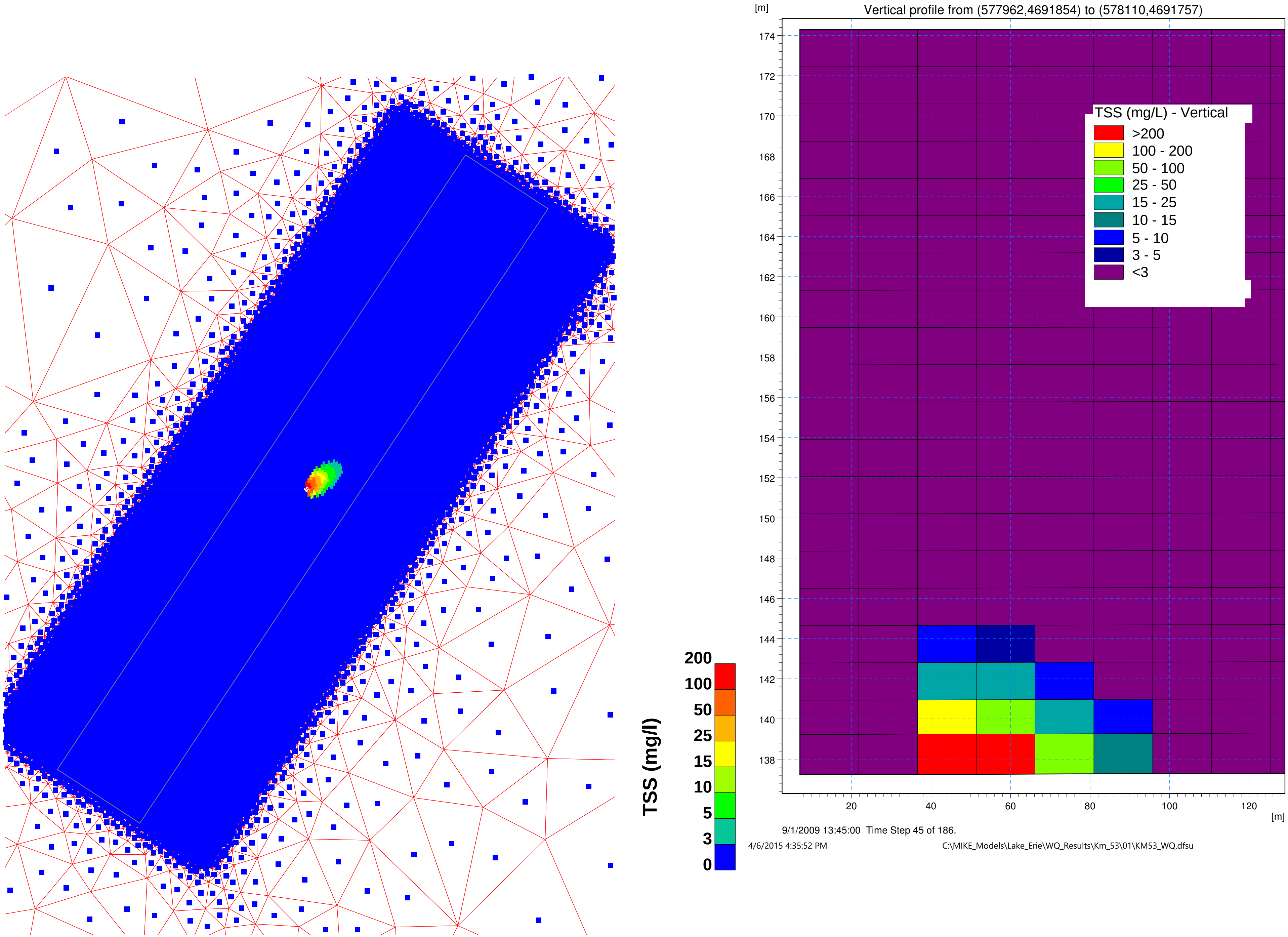


Figure 33. Lake Erie Water Quality Model - Calculated TSS at Km 53

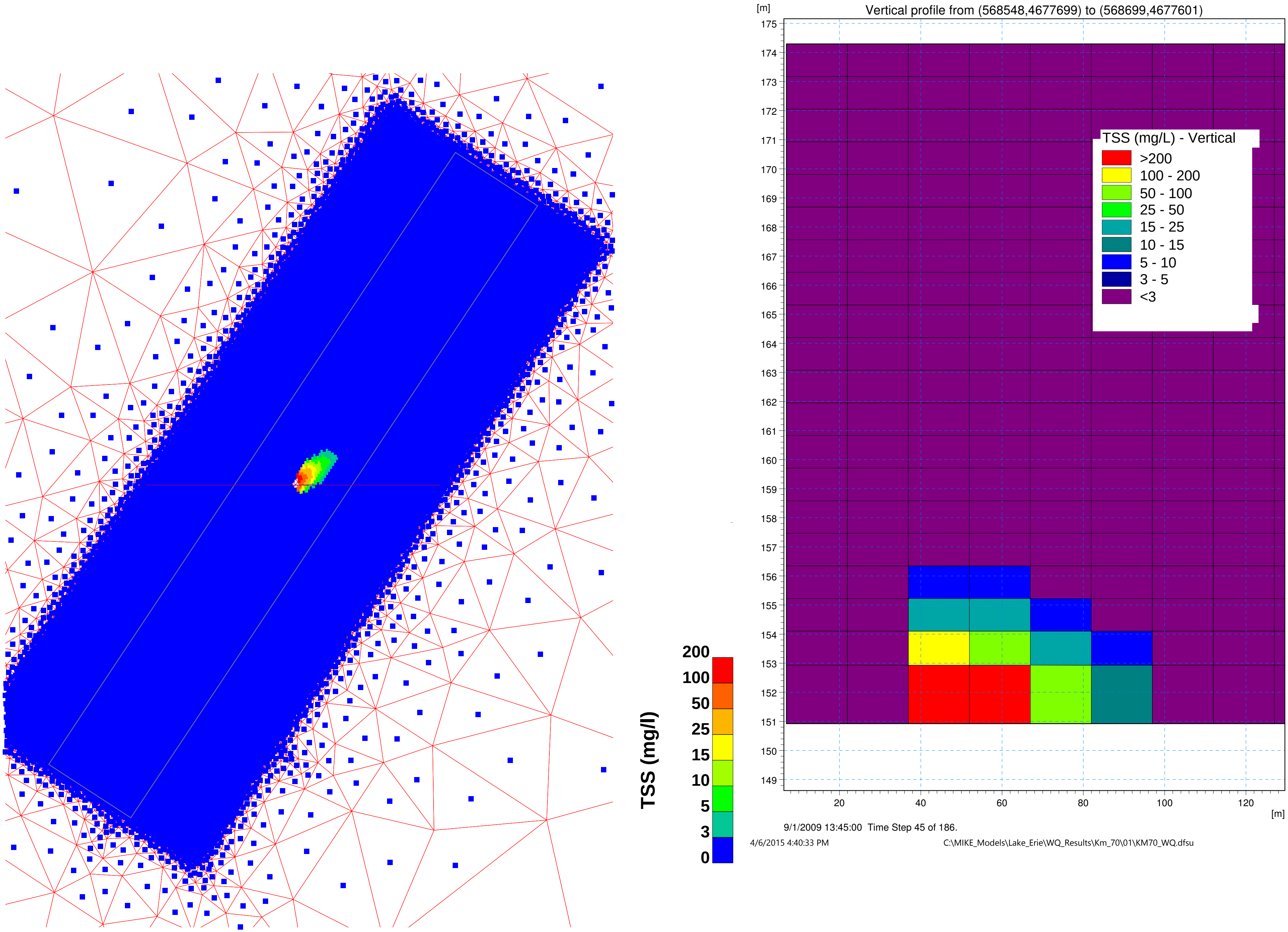


Figure 34. Lake Erie Water Quality Model - Calculated TSS at Km 70

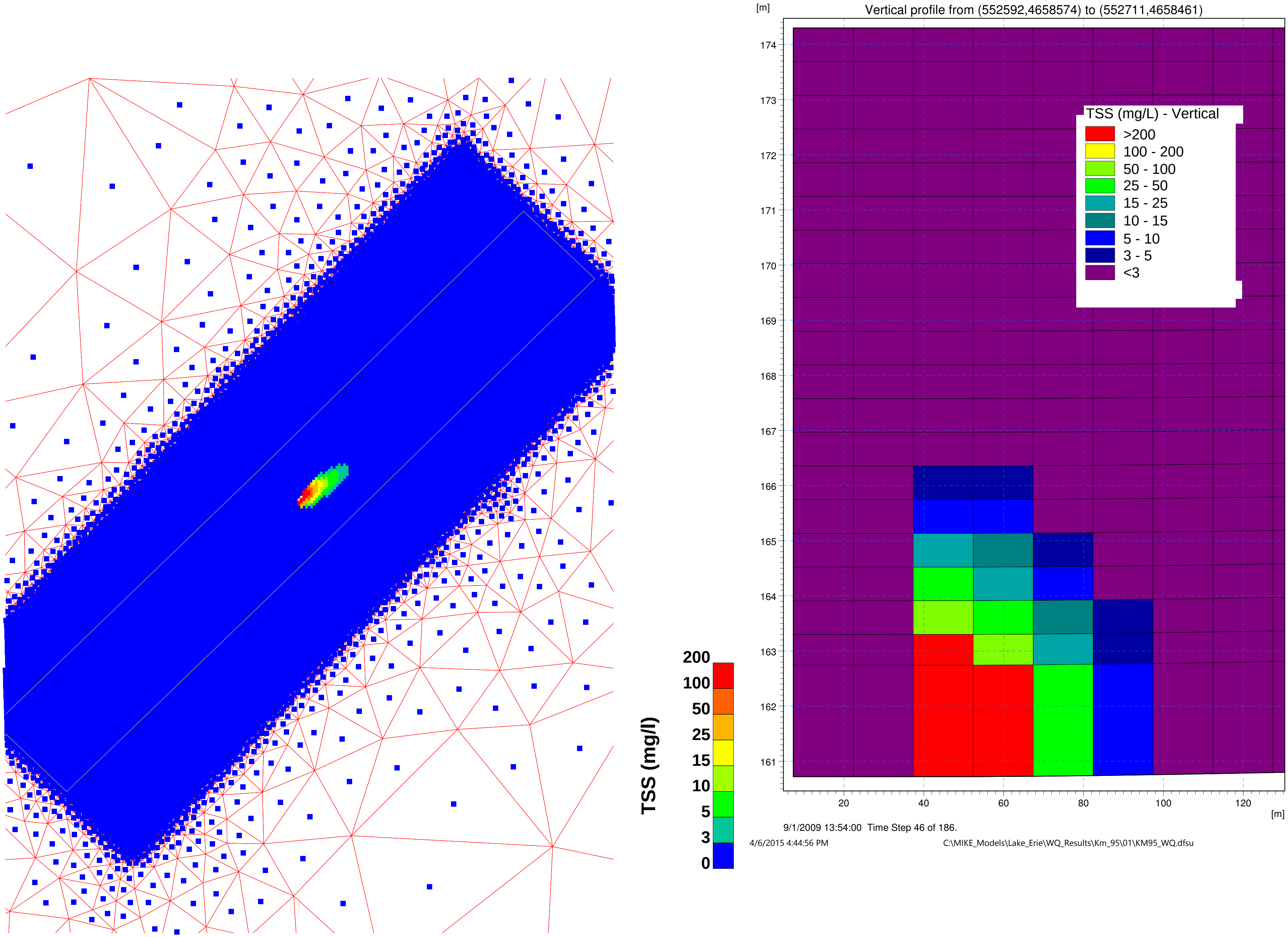


Figure 35. Lake Erie Water Quality Model - Calculated TSS at Km 95

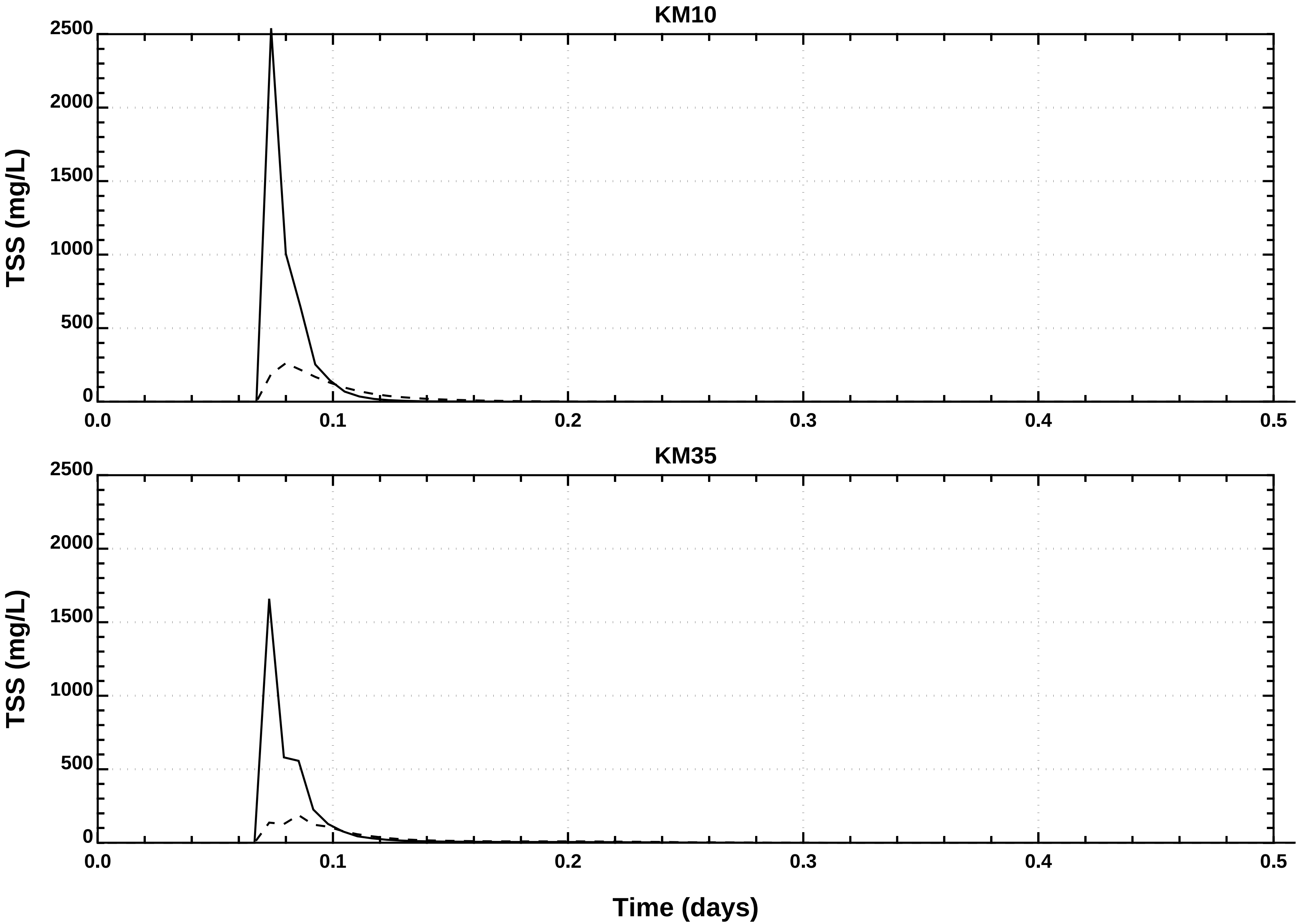


Figure 36. TSS Model Projection Results
(Solid Line - Bottom Layer, Dashed Line - One Layer above Bottom: 2-5 meters from bottom)

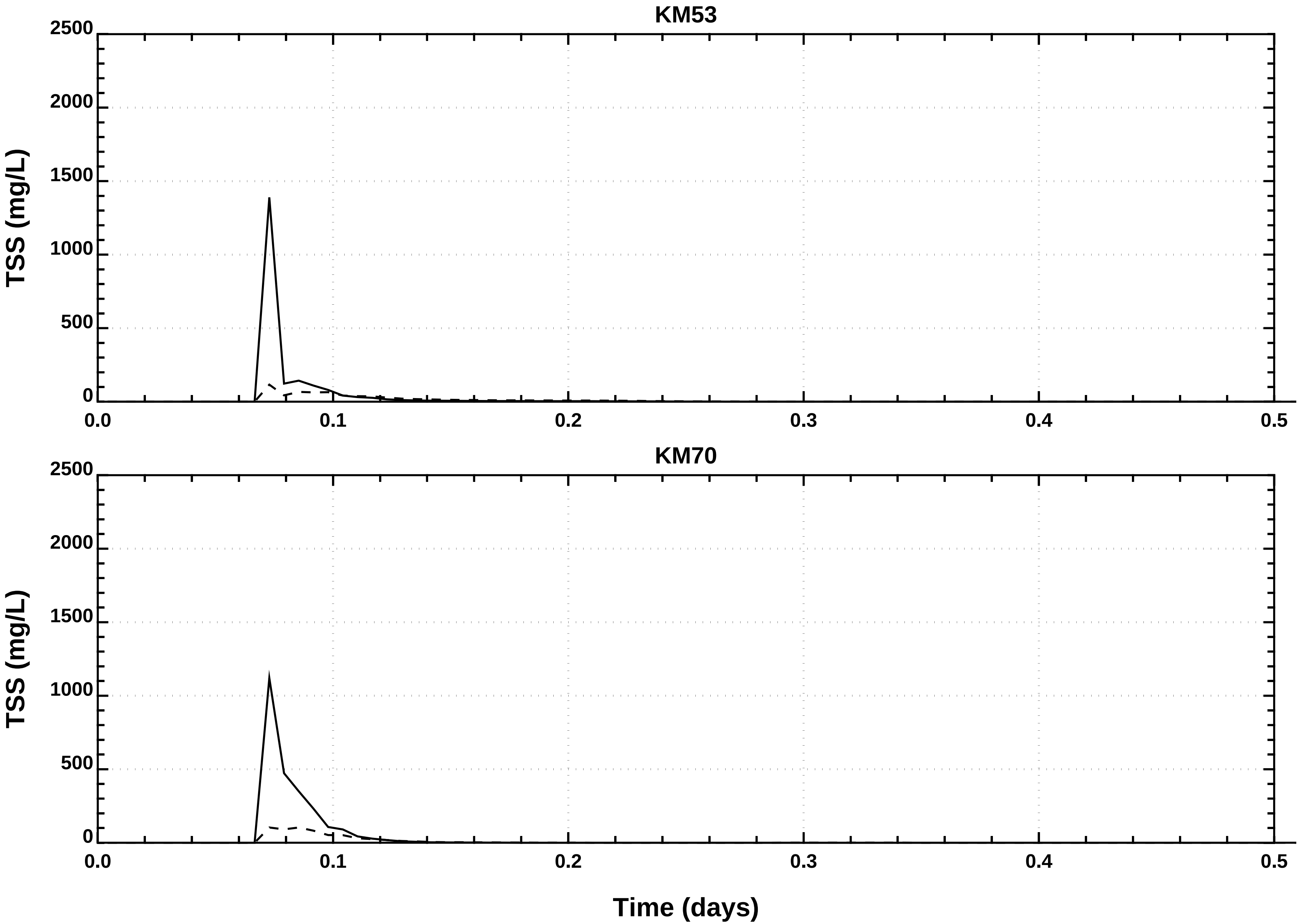


Figure 37. TSS Model Projection Results

(Solid Line - Bottom Layer, Dashed Line - One Layer above Bottom: 2-5 meters from bottom)

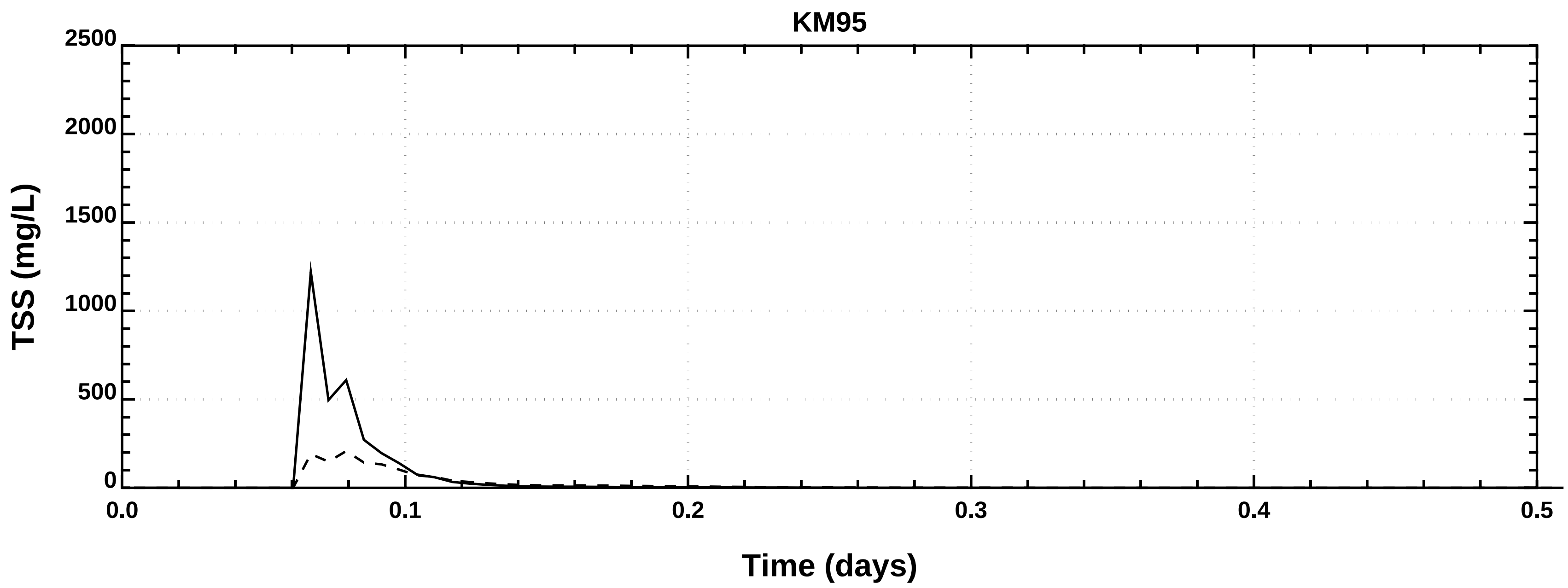


Figure 38. TSS Model Projection Results
(Solid Line - Bottom Layer, Dashed Line - One Layer above Bottom: 2-5 meters from bottom)

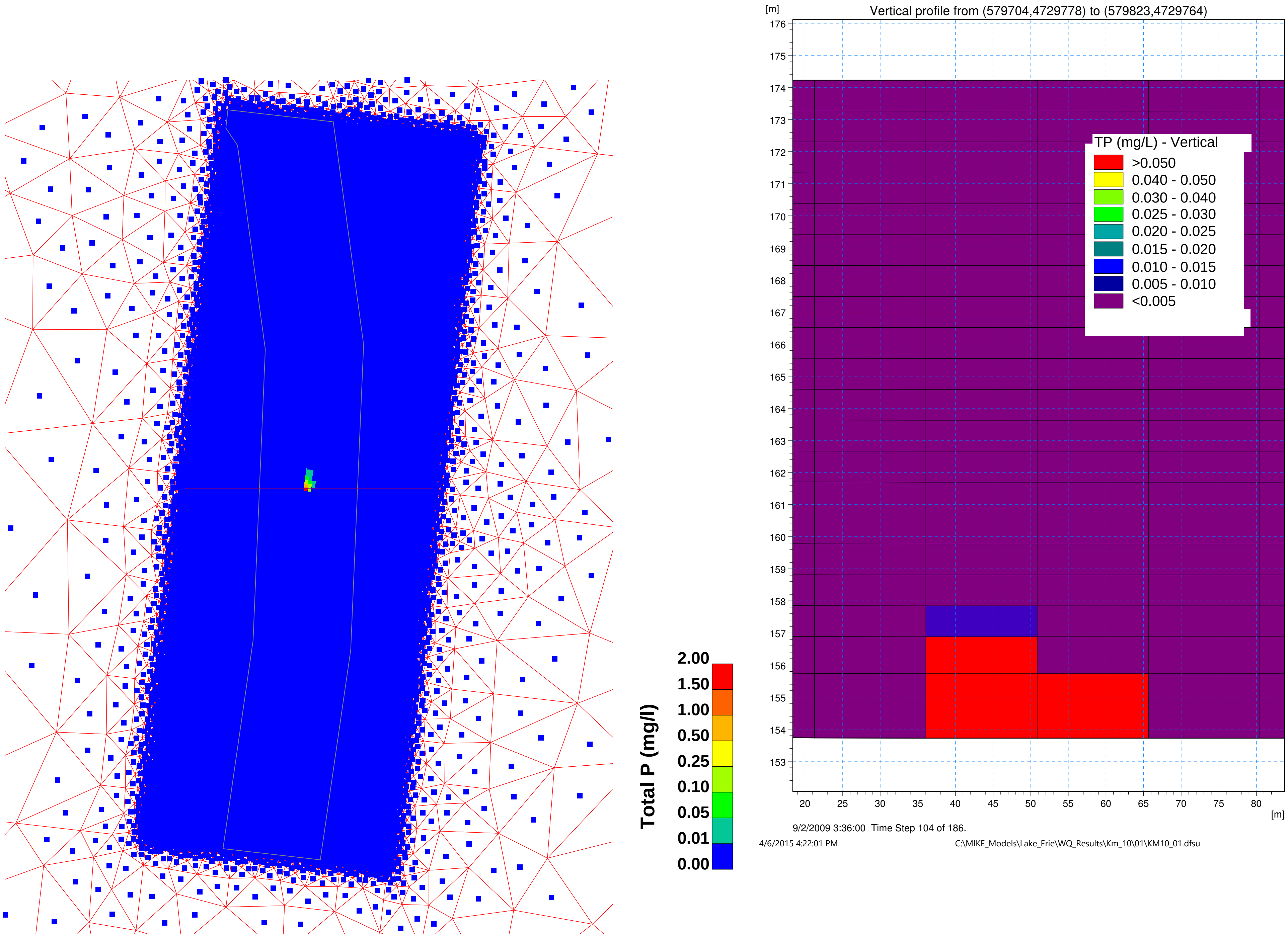


Figure 39. Lake Erie Water Quality Model - Calculated TP at Km 10

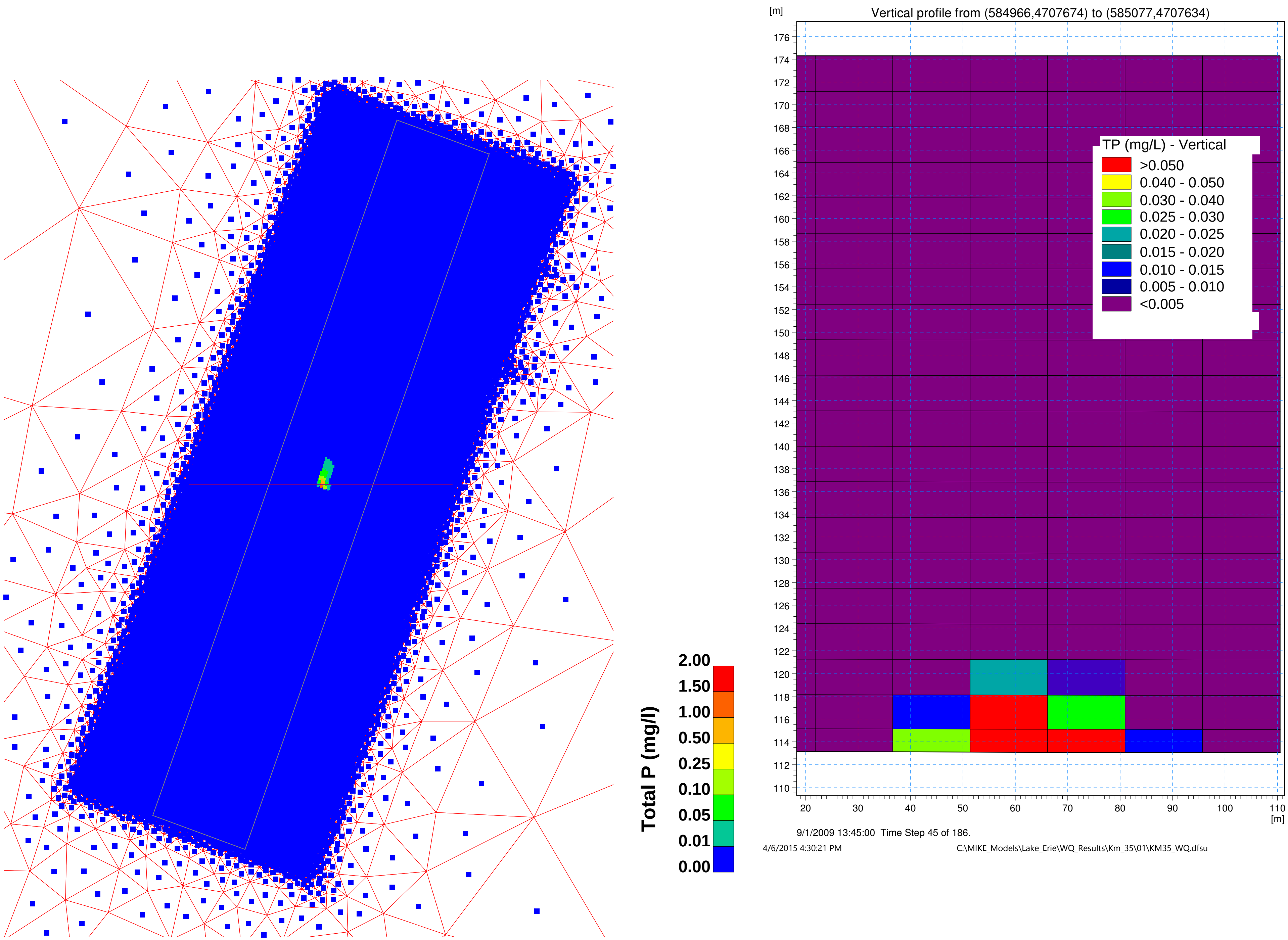


Figure 40. Lake Erie Water Quality Model - Calculated TP at Km 35

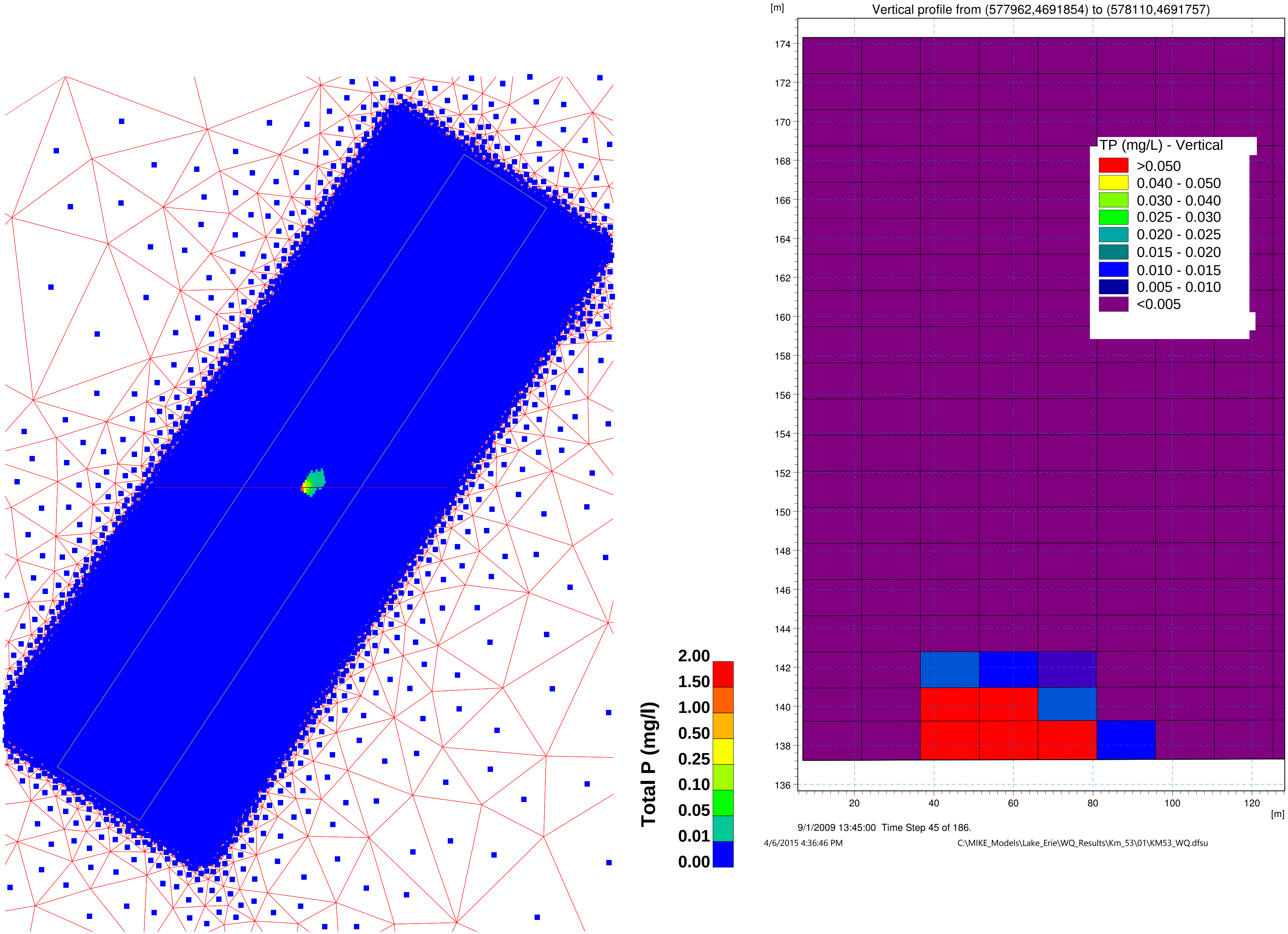


Figure 41. Lake Erie Water Quality Model - Calculated TP at Km 53

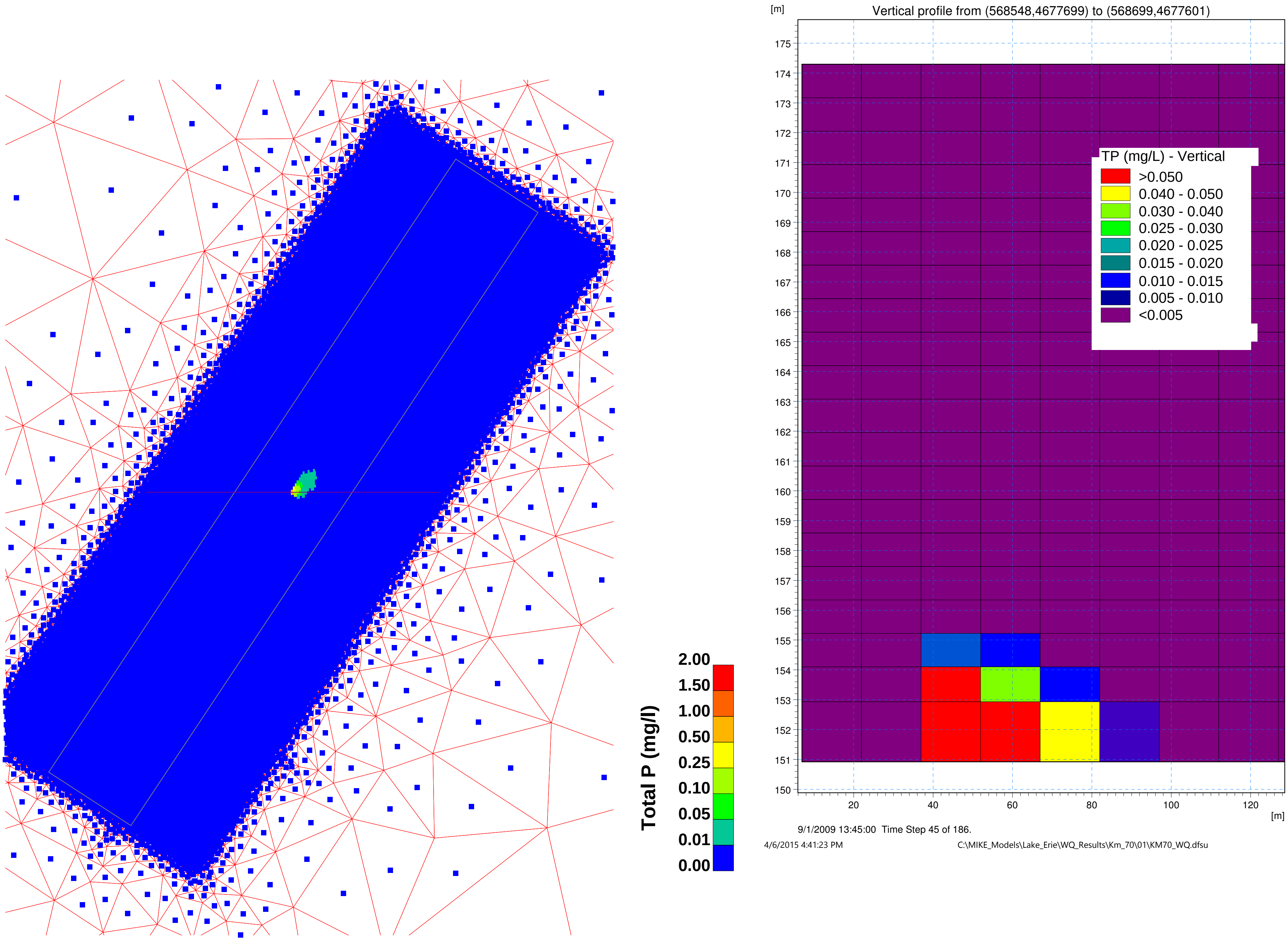
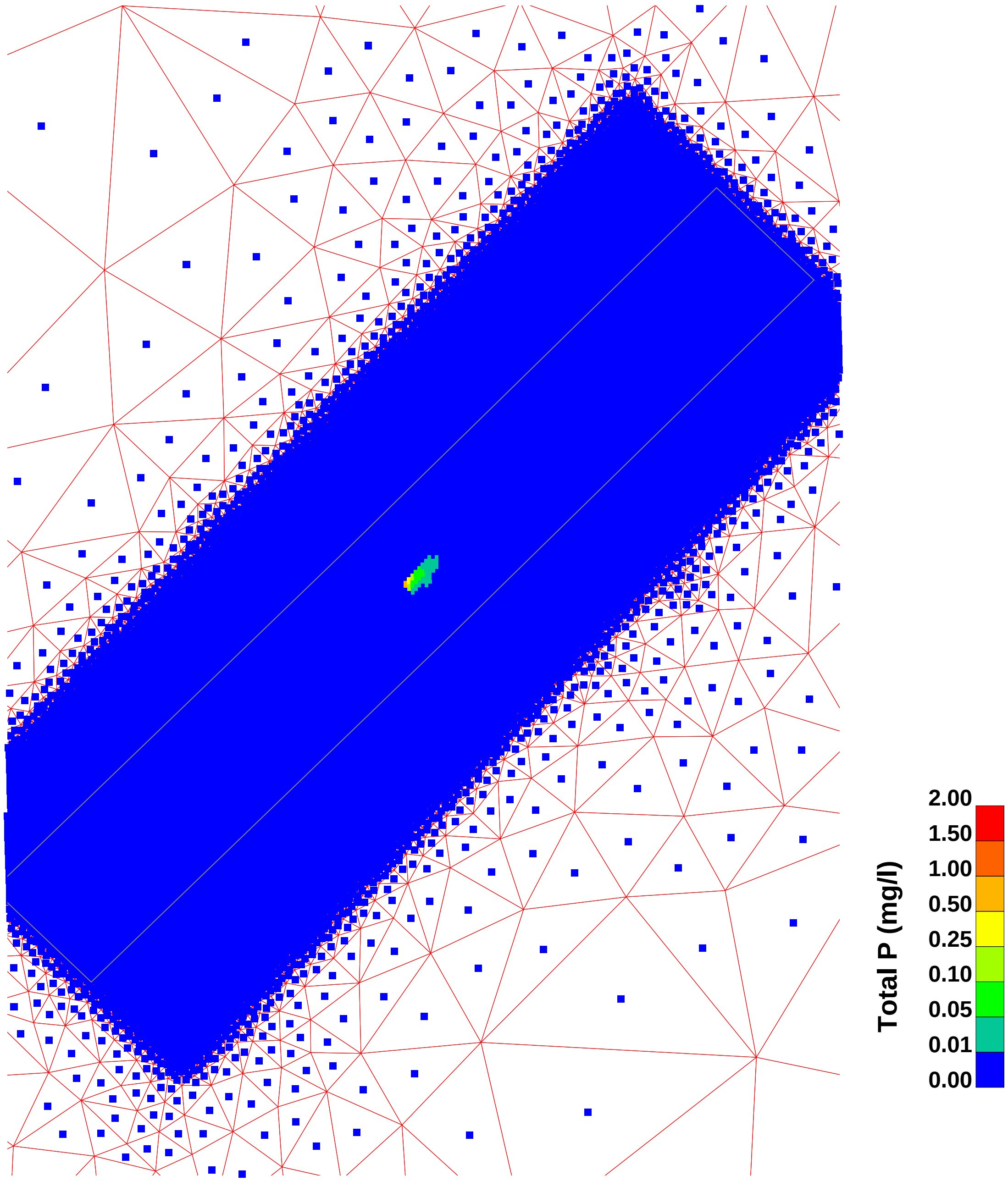


Figure 42. Lake Erie Water Quality Model - Calculated TP at Km 70



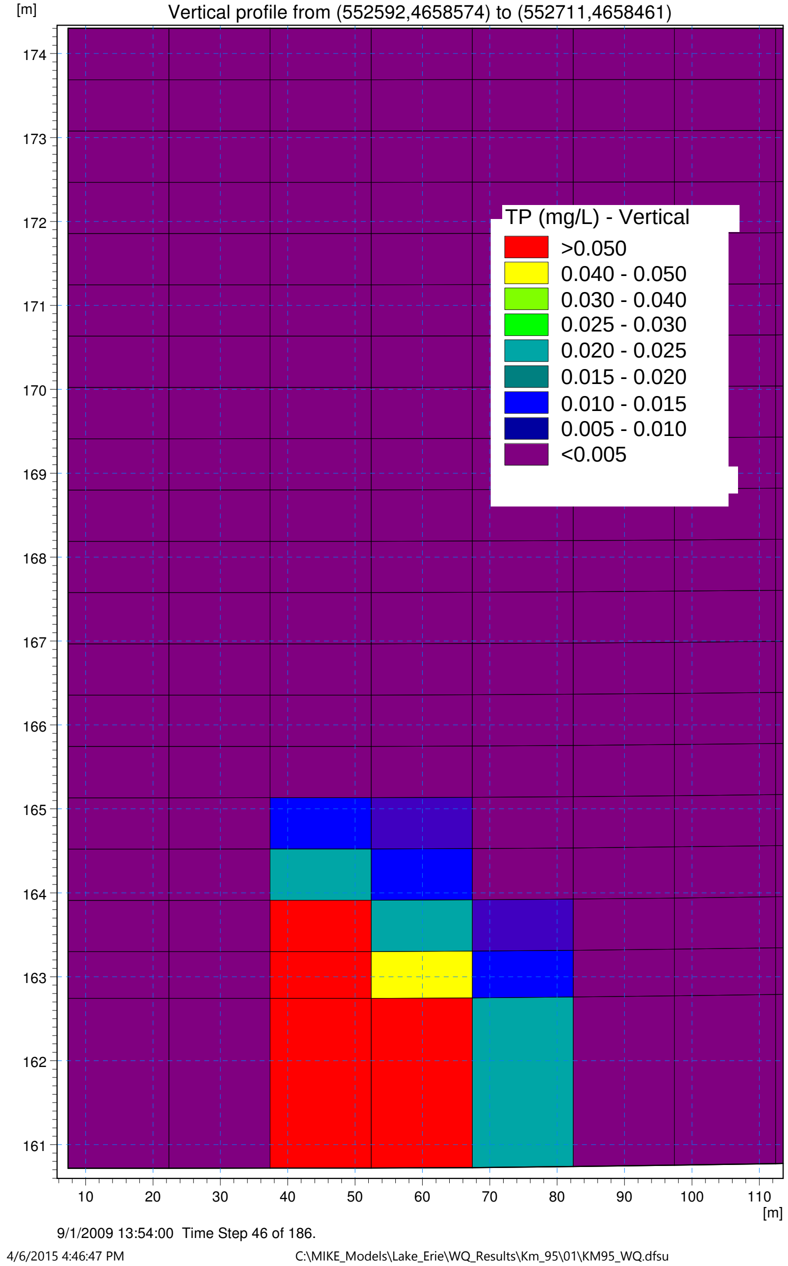


Figure 43. Lake Erie Water Quality Model - Calculated TP at Km 95

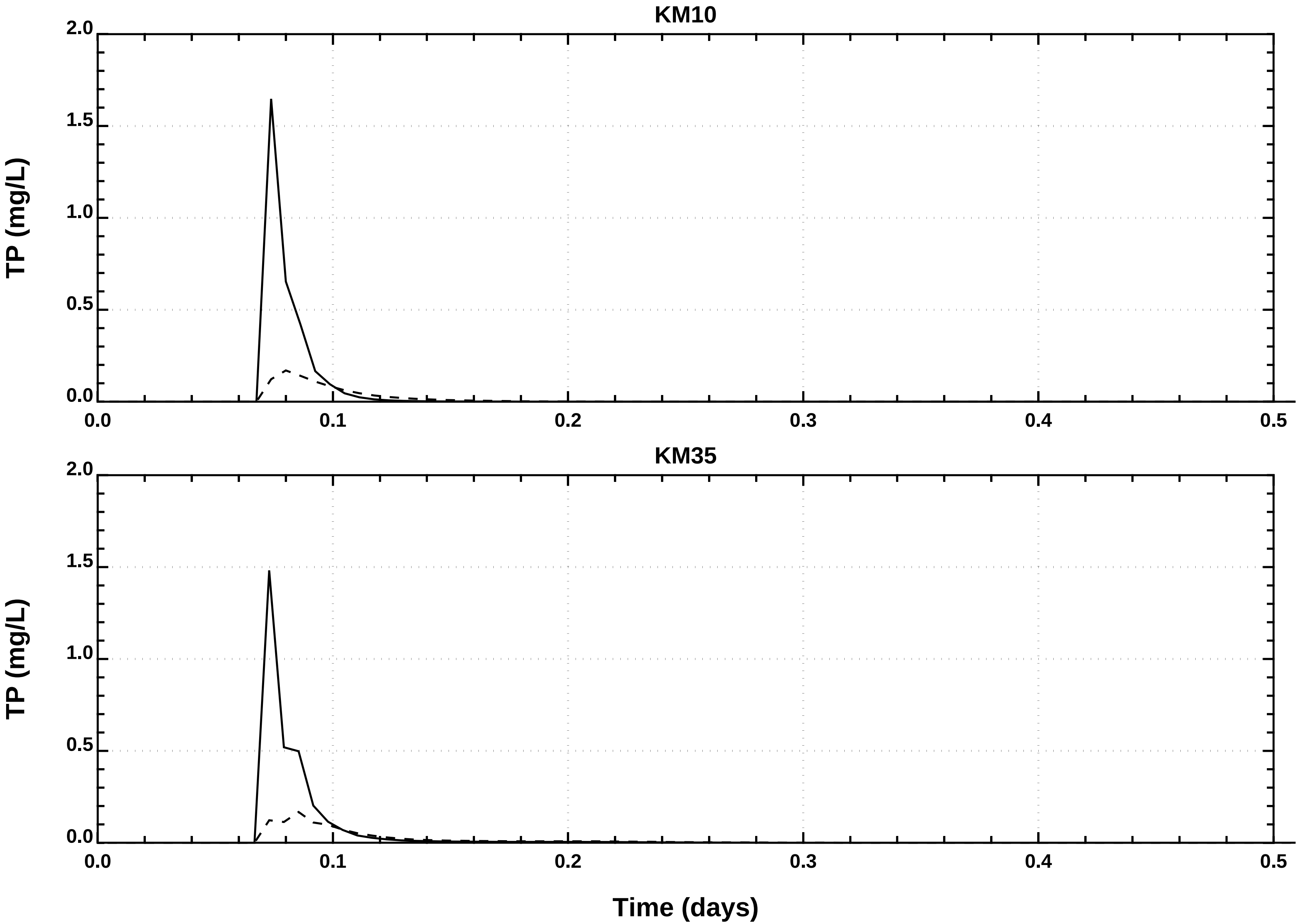


Figure 44. TP Model Projection Results
(Solid Line - Bottom Layer, Dashed Line - One Layer above Bottom: 2-5 meters from bottom)

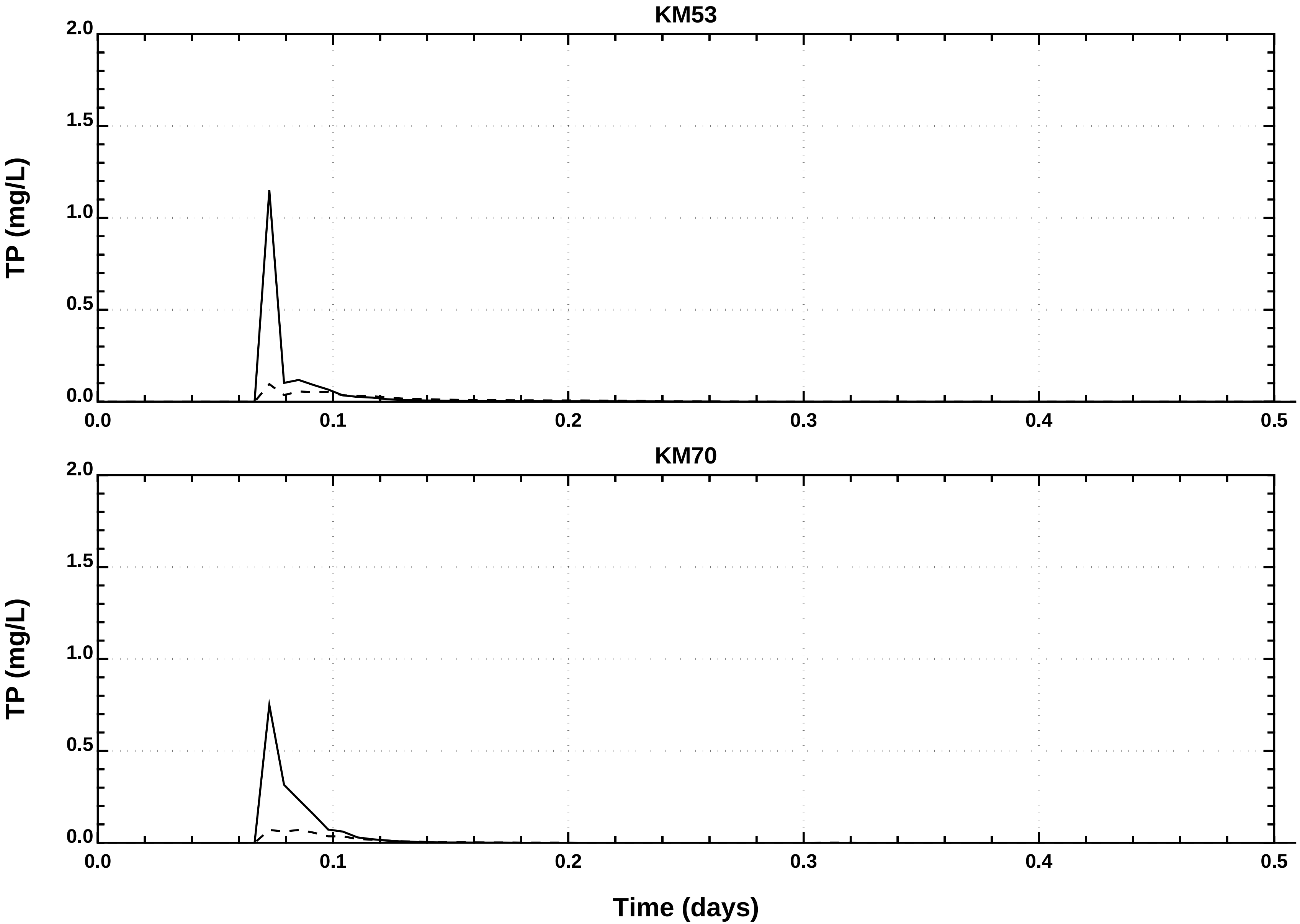


Figure 45. TP Model Projection Results
(Solid Line - Bottom Layer, Dashed Line - One Layer above Bottom: 2-5 meters from bottom)

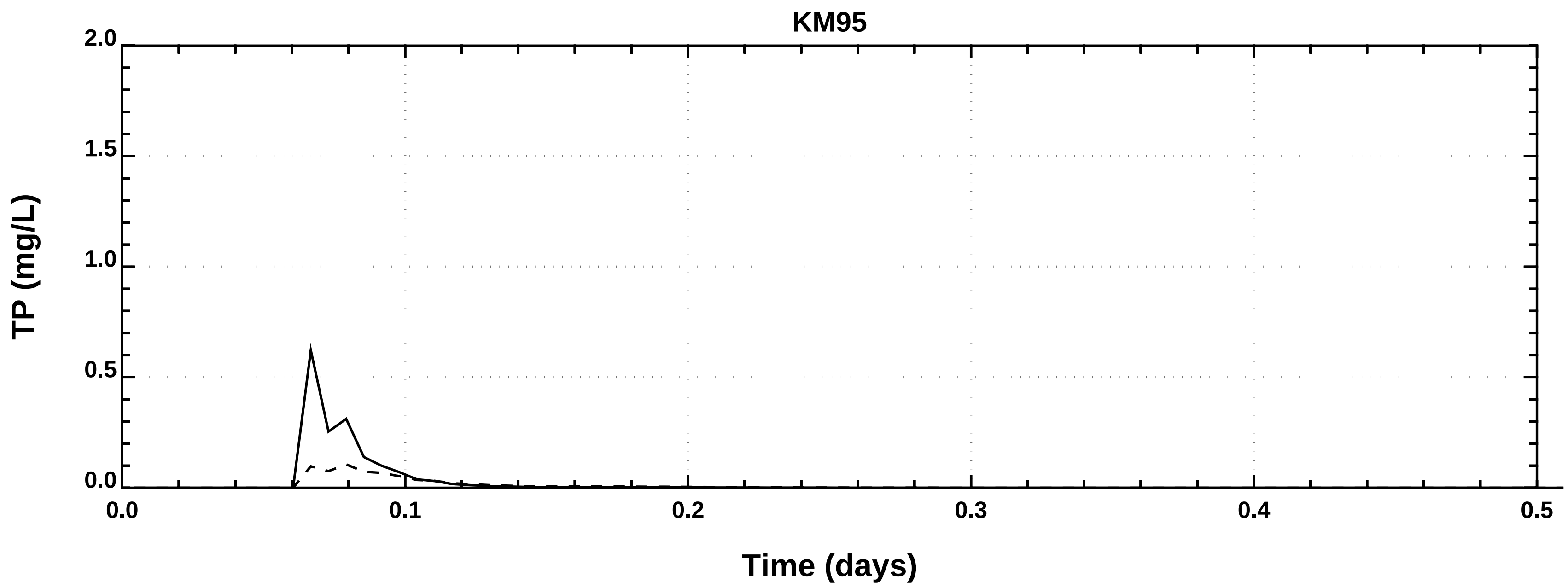


Figure 46. TP Model Projection Results
(Solid Line - Bottom Layer, Dashed Line - One Layer above Bottom: 2-5 meters from bottom)

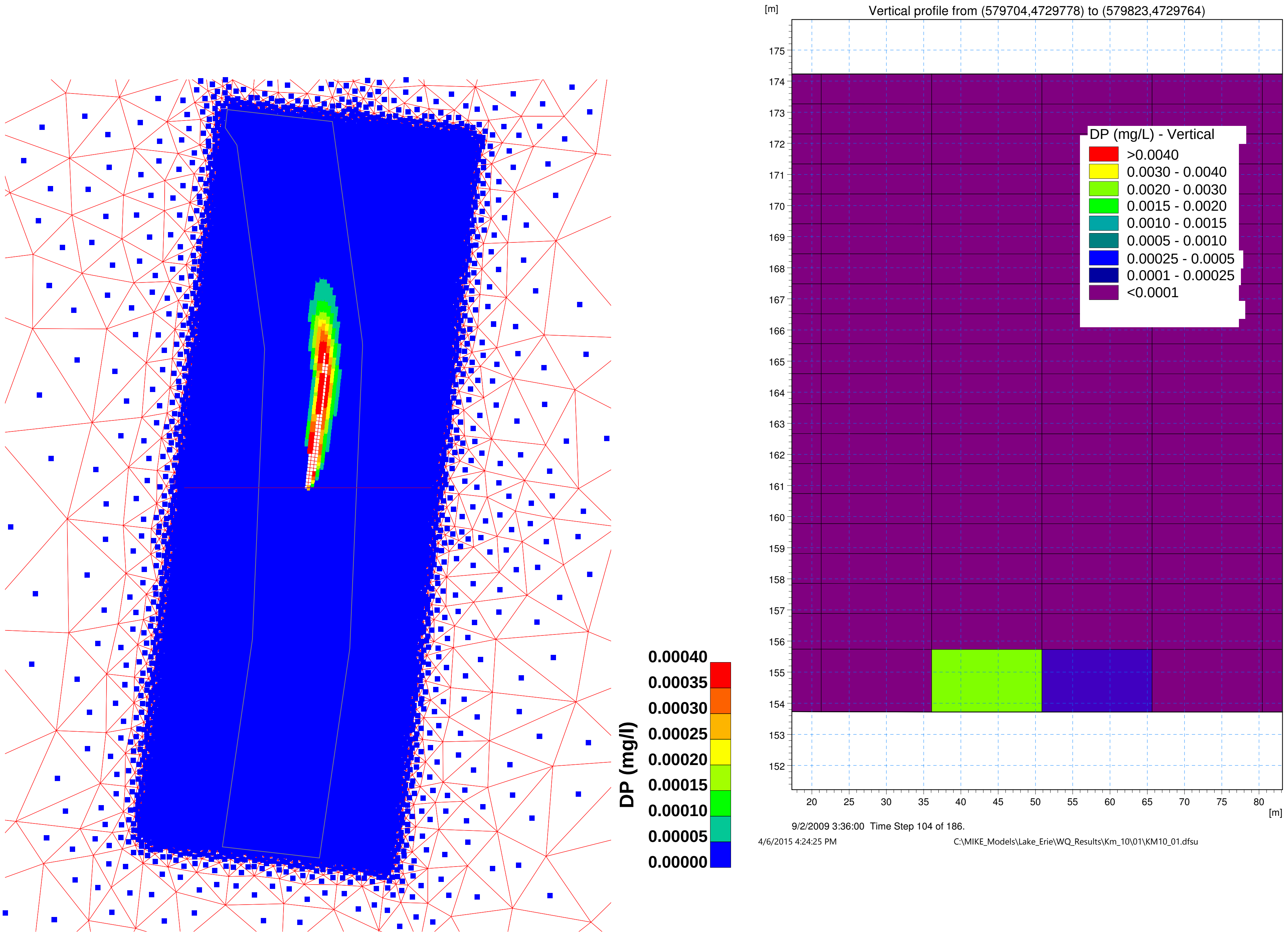


Figure 47. Lake Erie Water Quality Model - Calculated DP at Km 10

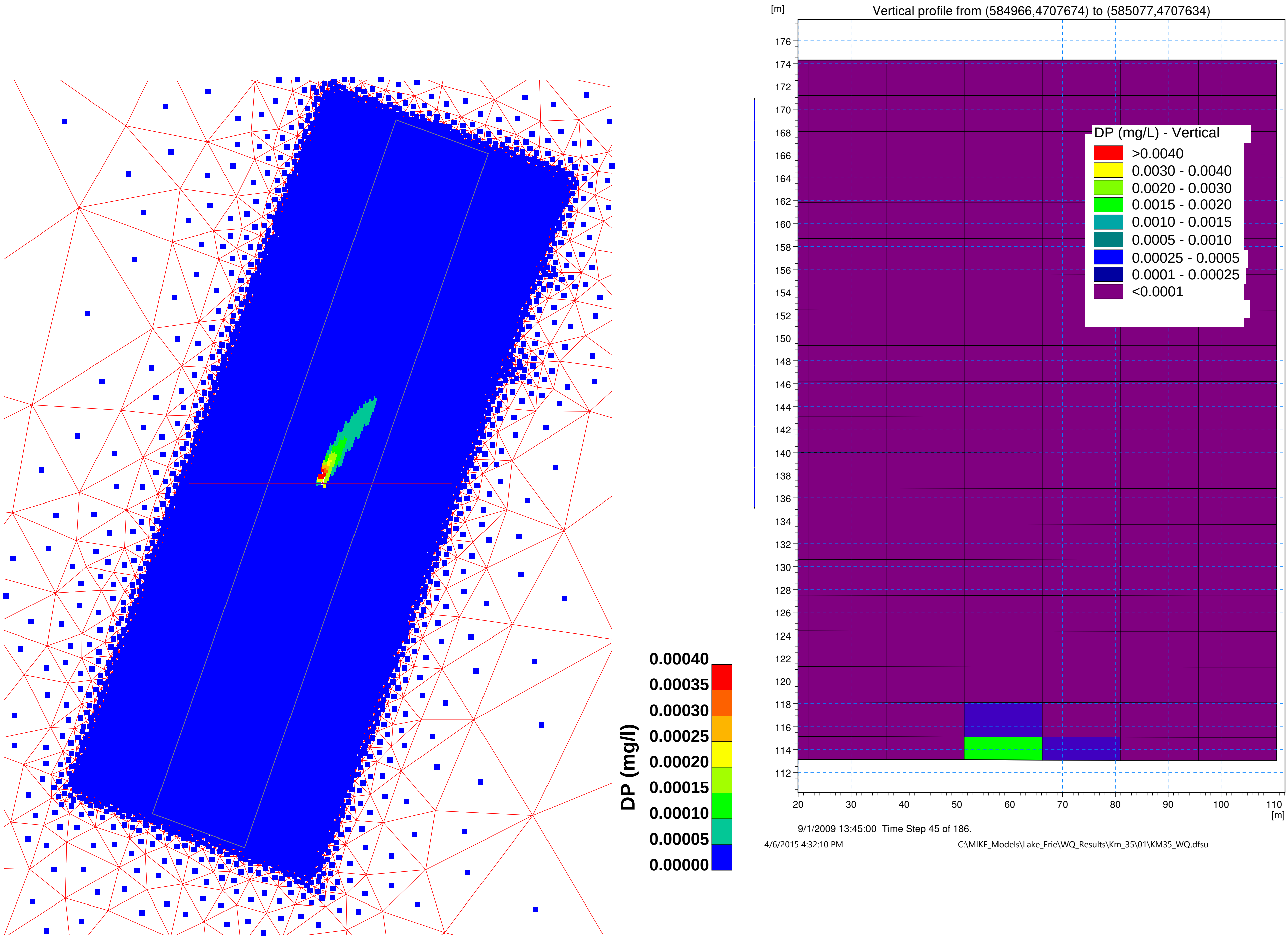


Figure 48. Lake Erie Water Quality Model - Calculated DP at Km 35

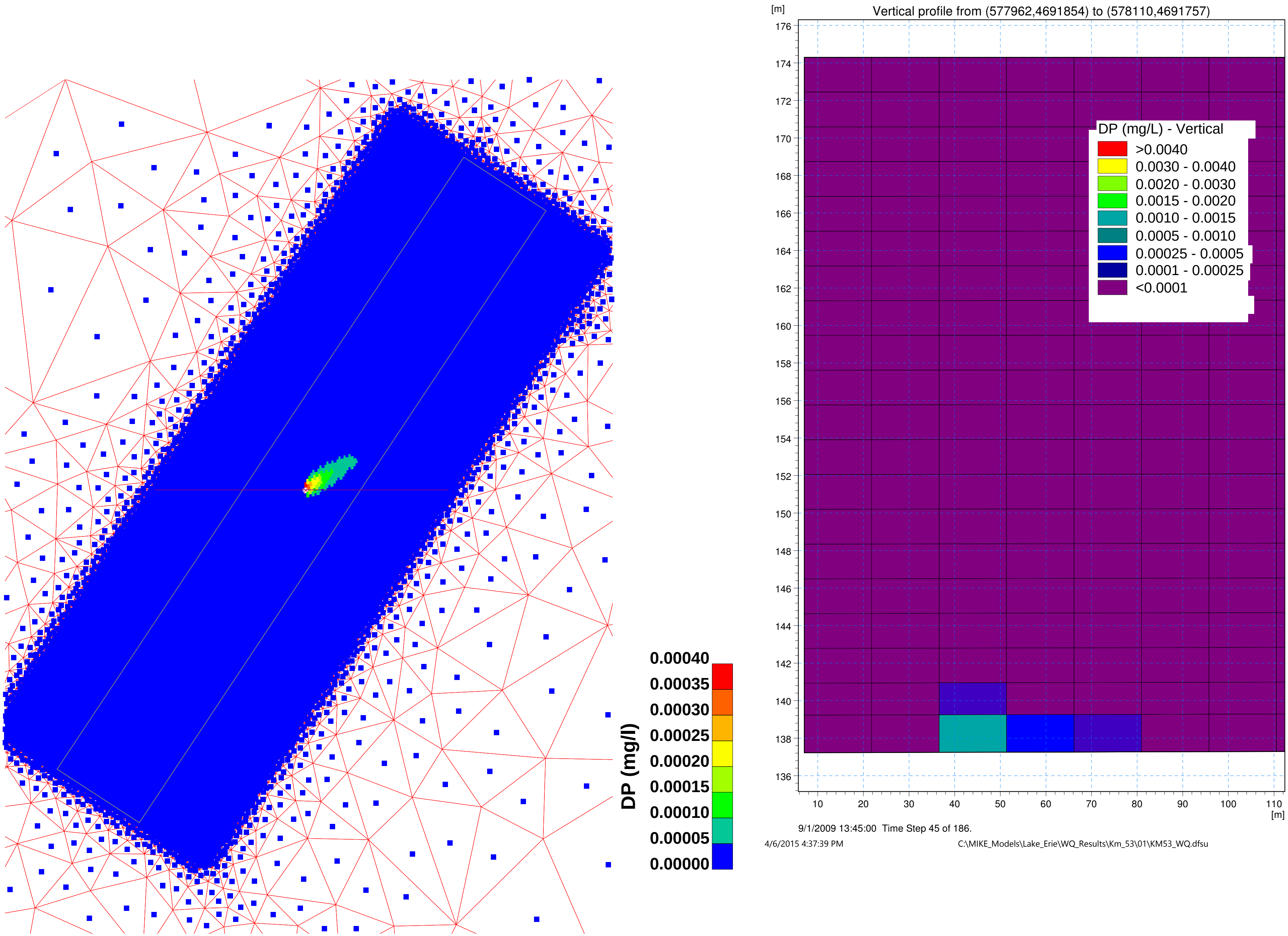


Figure 49. Lake Erie Water Quality Model - Calculated DP at Km 53

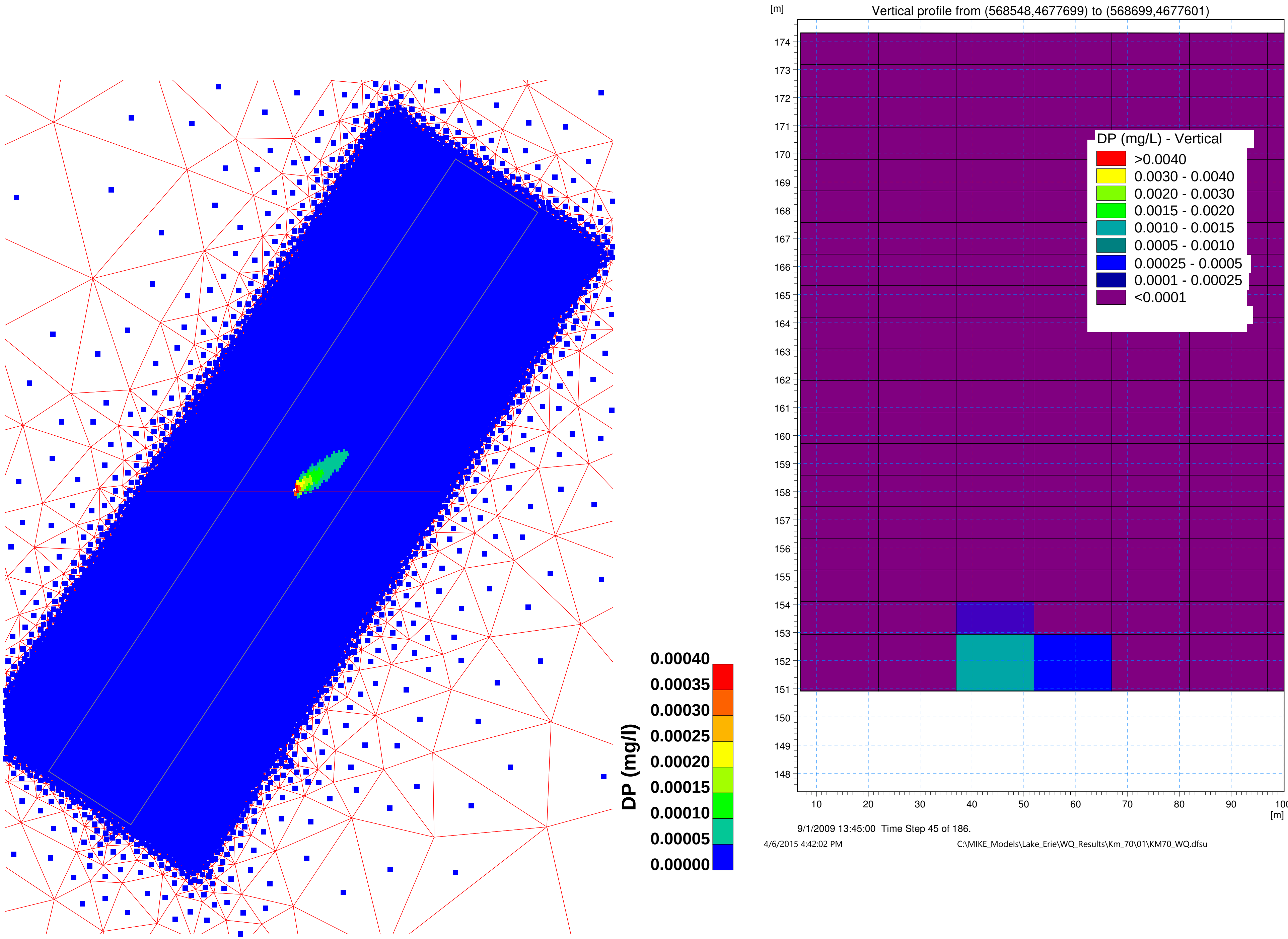


Figure 50. Lake Erie Water Quality Model - Calculated DP at Km 70

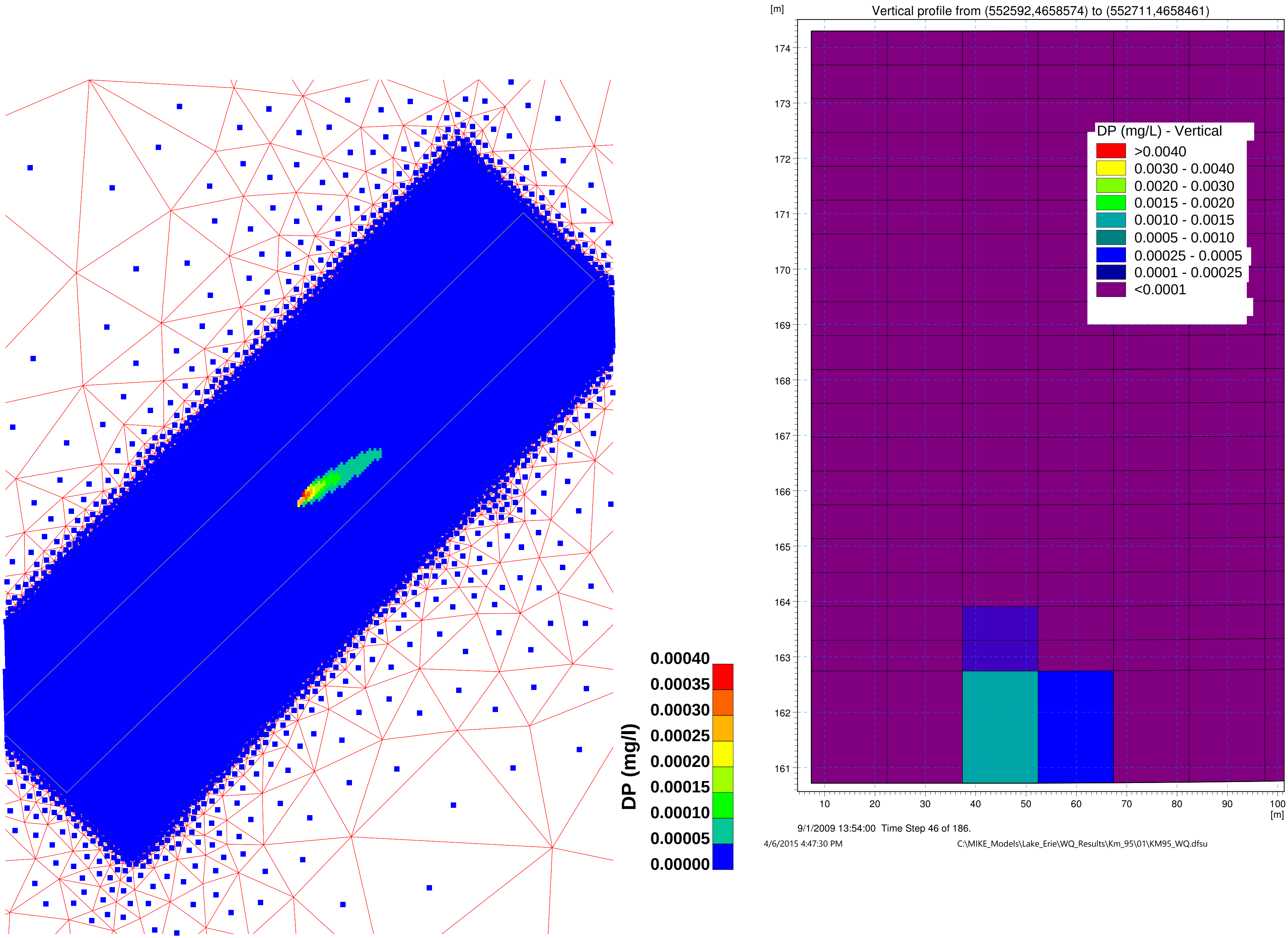


Figure 51. Lake Erie Water Quality Model - Calculated DP at Km 95

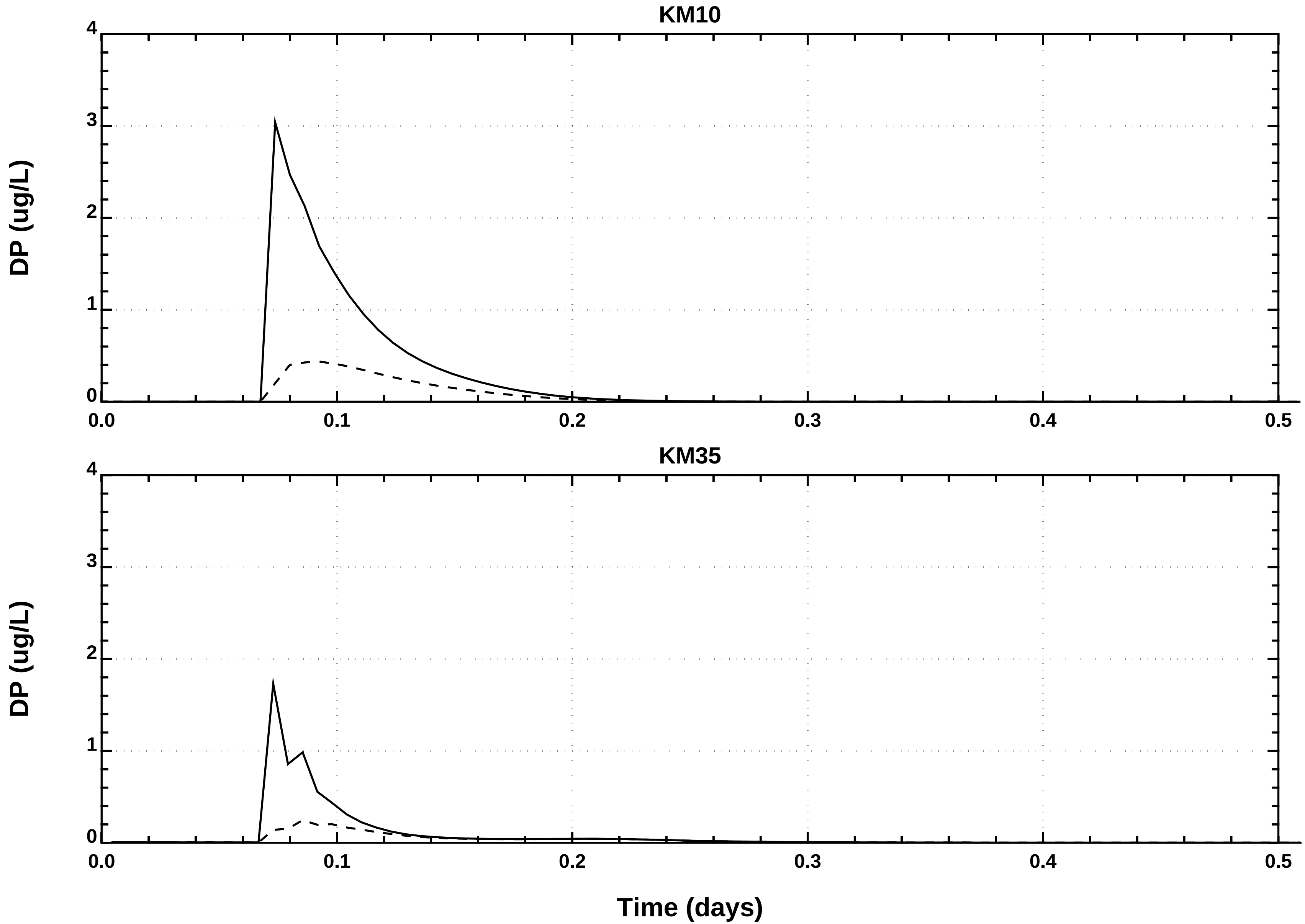


Figure 52. DP Model Projection Results

(Solid Line - Bottom Layer, Dashed Line - One Layer above Bottom: 2-5 meters from bottom)

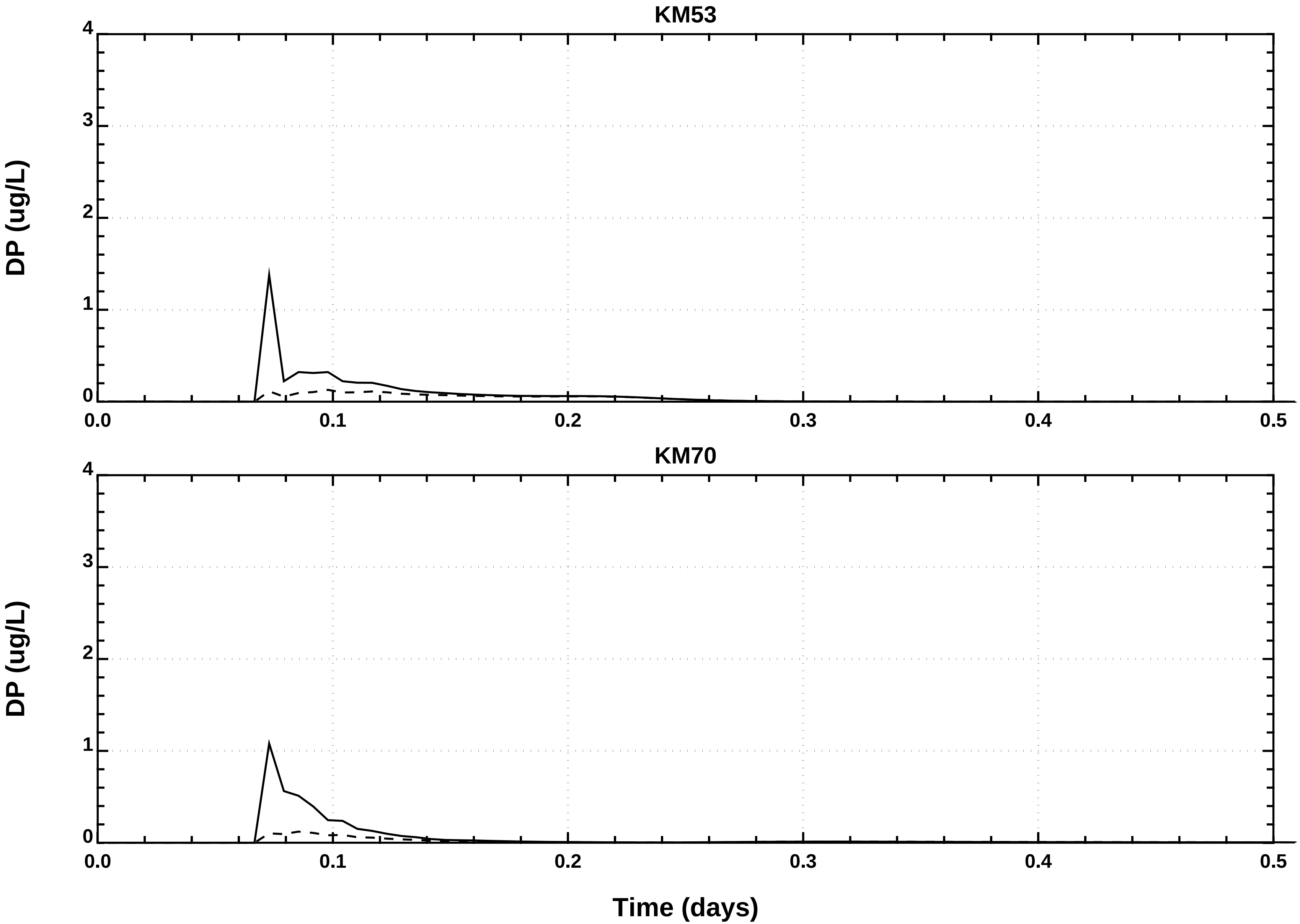


Figure 53. DP Model Projection Results
(Solid Line - Bottom Layer, Dashed Line - One Layer above Bottom: 2-5 meters from bottom)

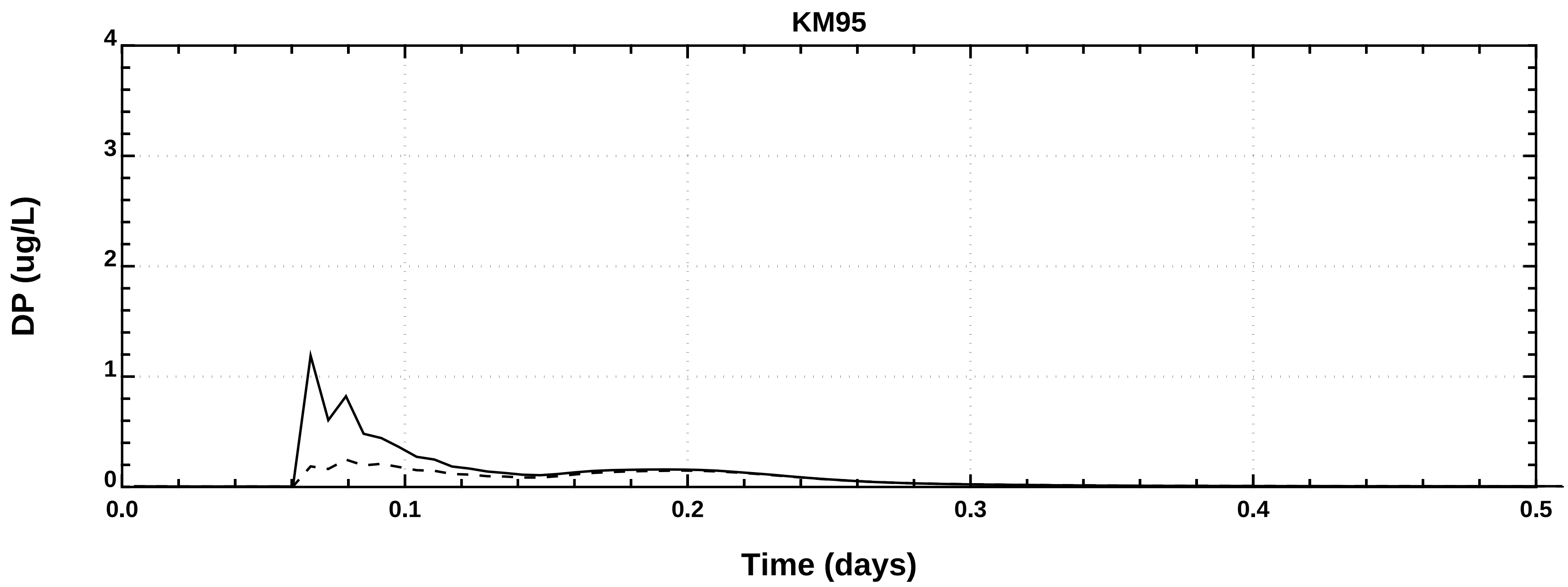


Figure 54. DP Model Projection Results
(Solid Line - Bottom Layer, Dashed Line - One Layer above Bottom: 2-5 meters from bottom)

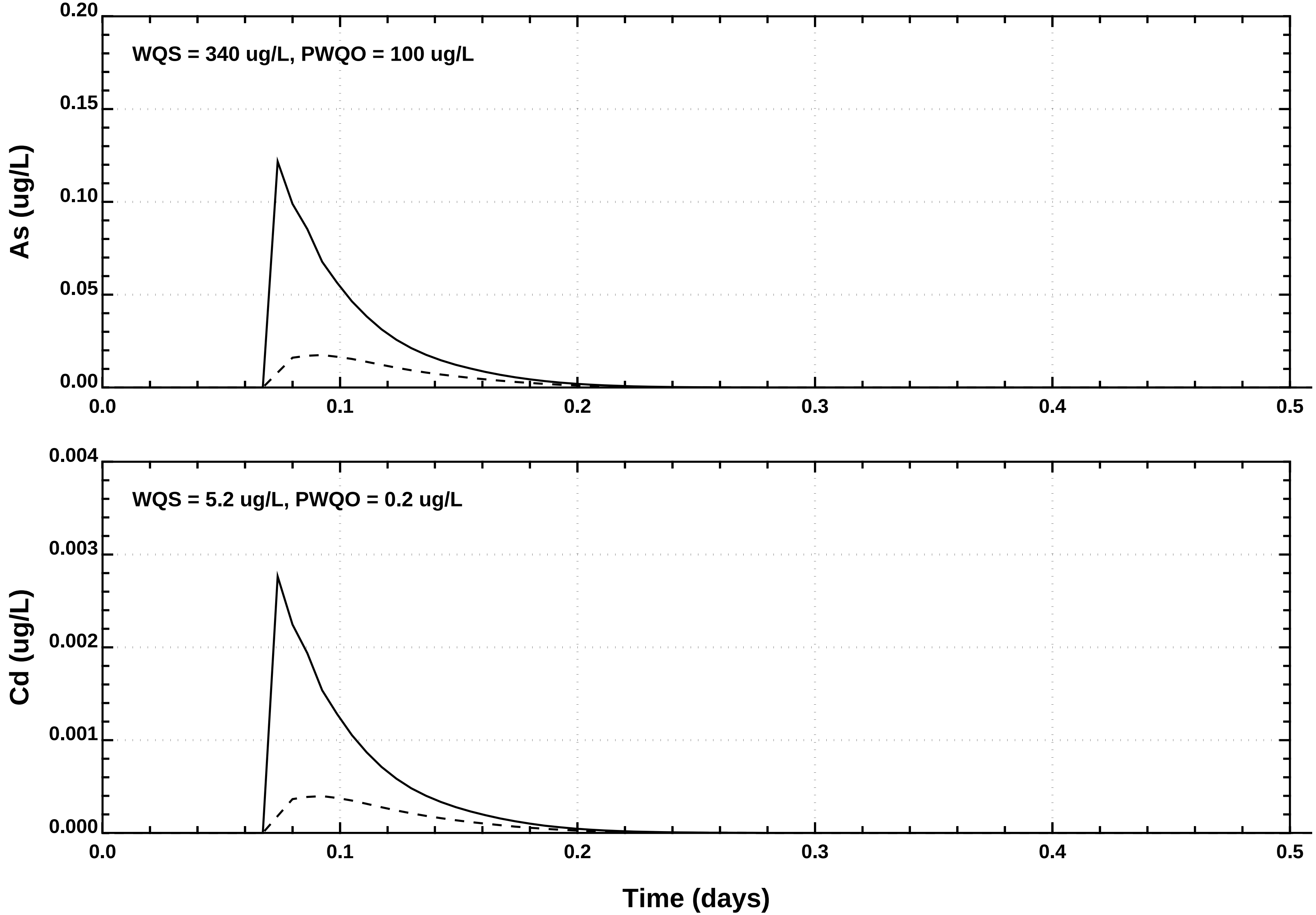


Figure 55. As and Cd Model Projection Results at KM10
(Solid Line - Bottom Layer, Dashed Line - One Layer above Bottom: 2-5 meters from bottom)

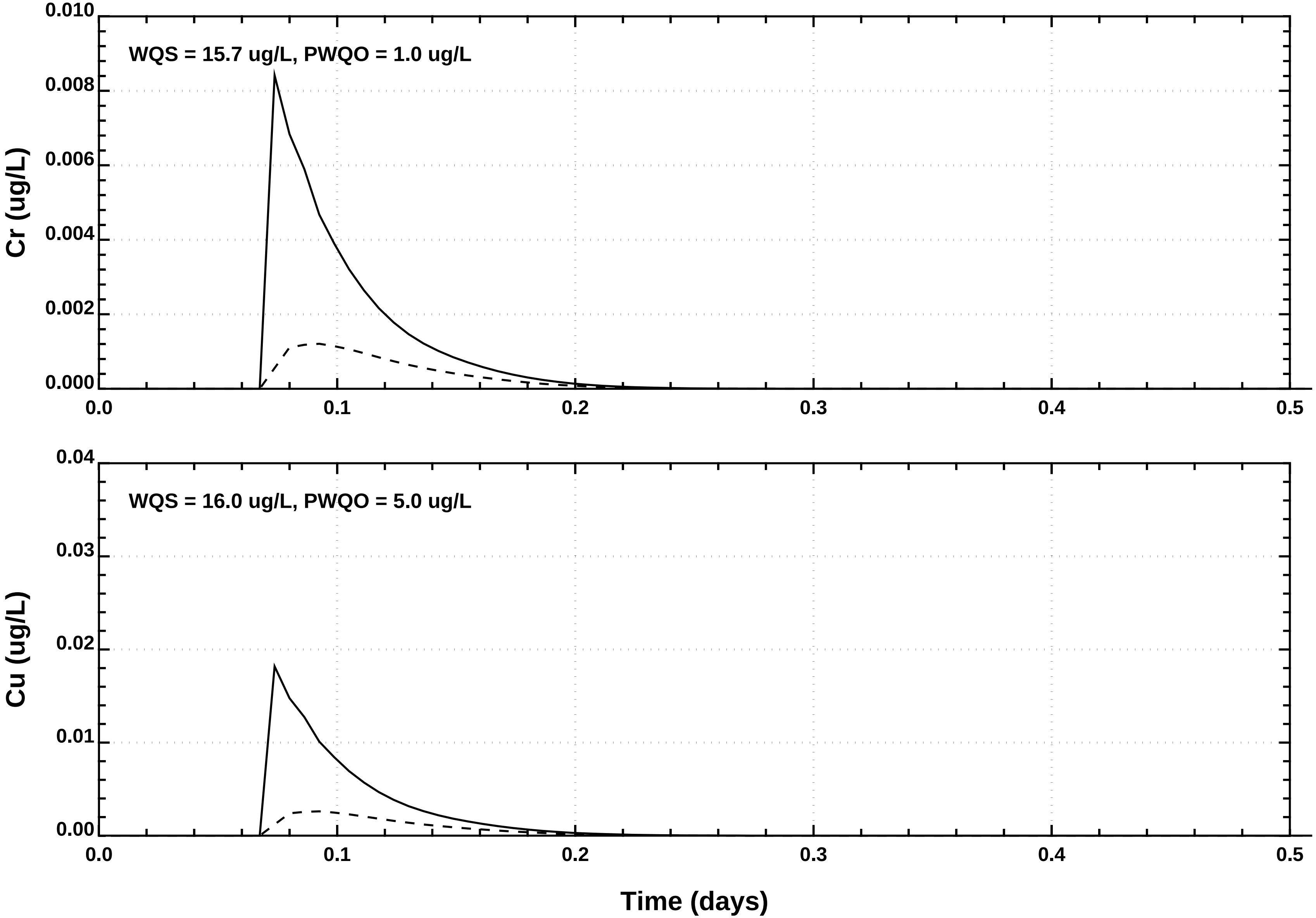


Figure 56. Cr and Cu Model Projection Results at KM10
(Solid Line - Bottom Layer, Dashed Line - One Layer above Bottom: 2-5 meters from bottom)

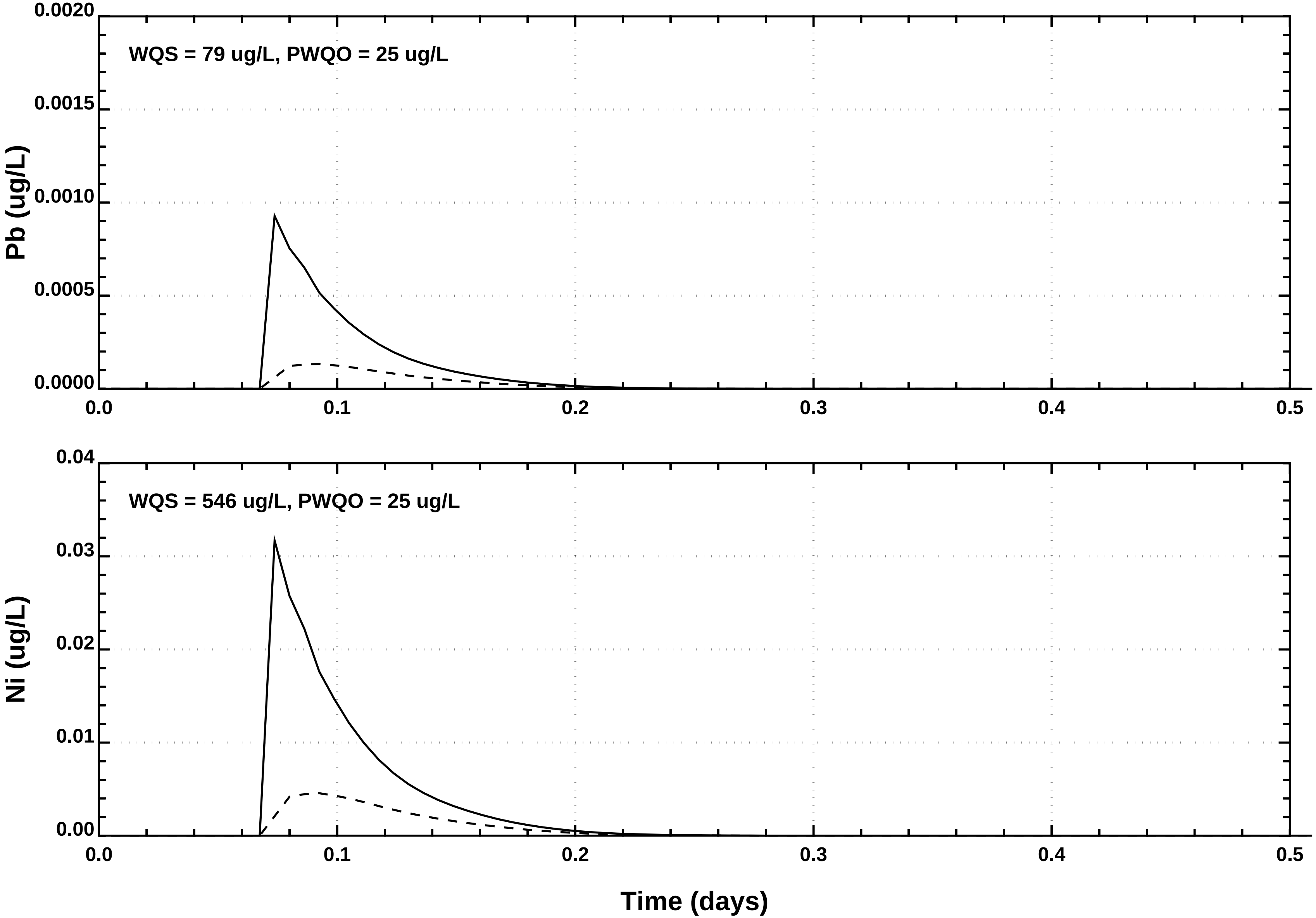


Figure 57. Pb and Ni Model Projection Results at KM10
(Solid Line - Bottom Layer, Dashed Line - One Layer above Bottom: 2-5 meters from bottom)

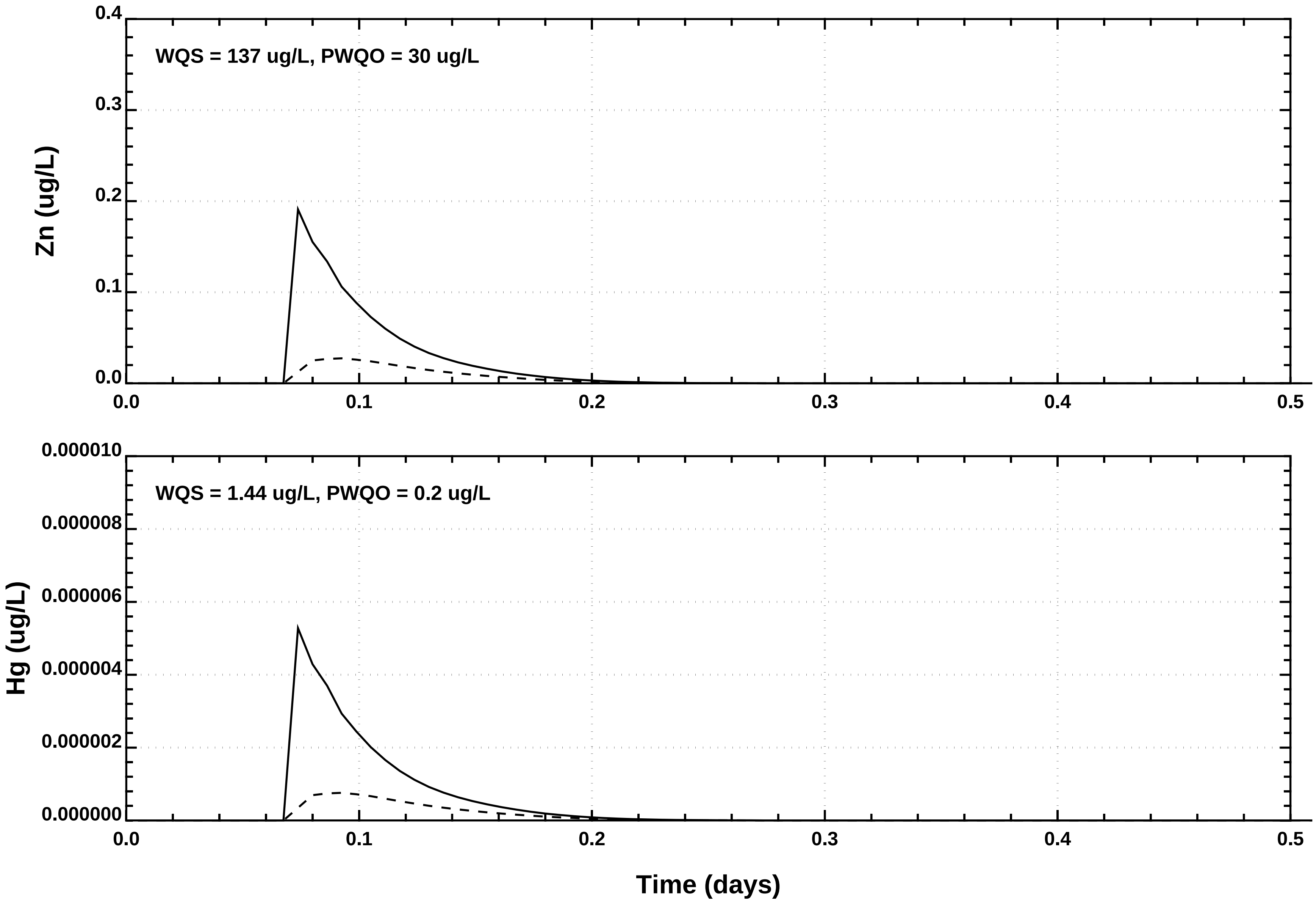


Figure 58. Zn and Hg Model Projection Results at KM10
(Solid Line - Bottom Layer, Dashed Line - One Layer above Bottom: 2-5 meters from bottom)

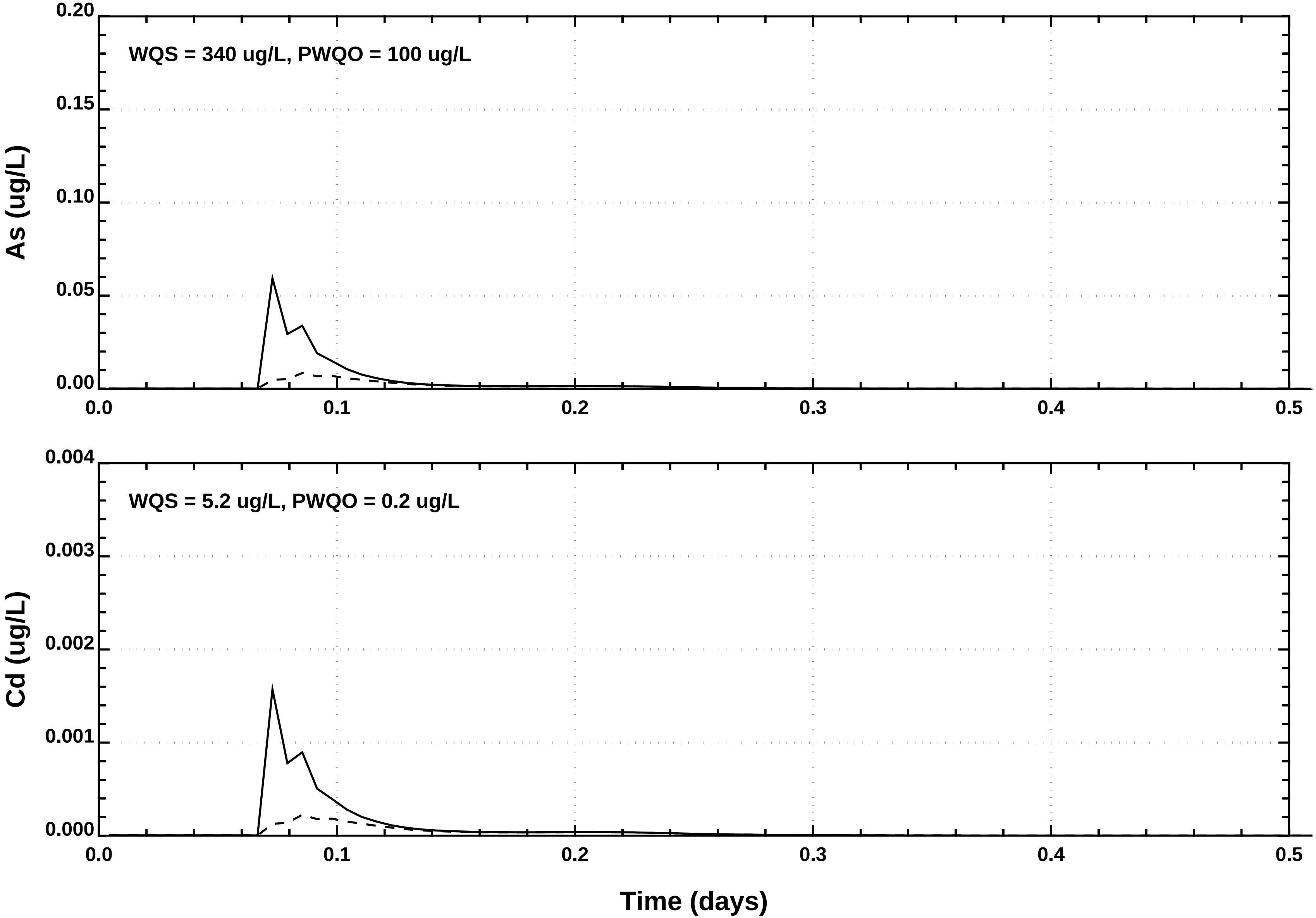


Figure 59. As and Cd Model Projection Results at KM35
(Solid Line - Bottom Layer, Dashed Line - One Layer above Bottom: 2-5 meters from bottom)

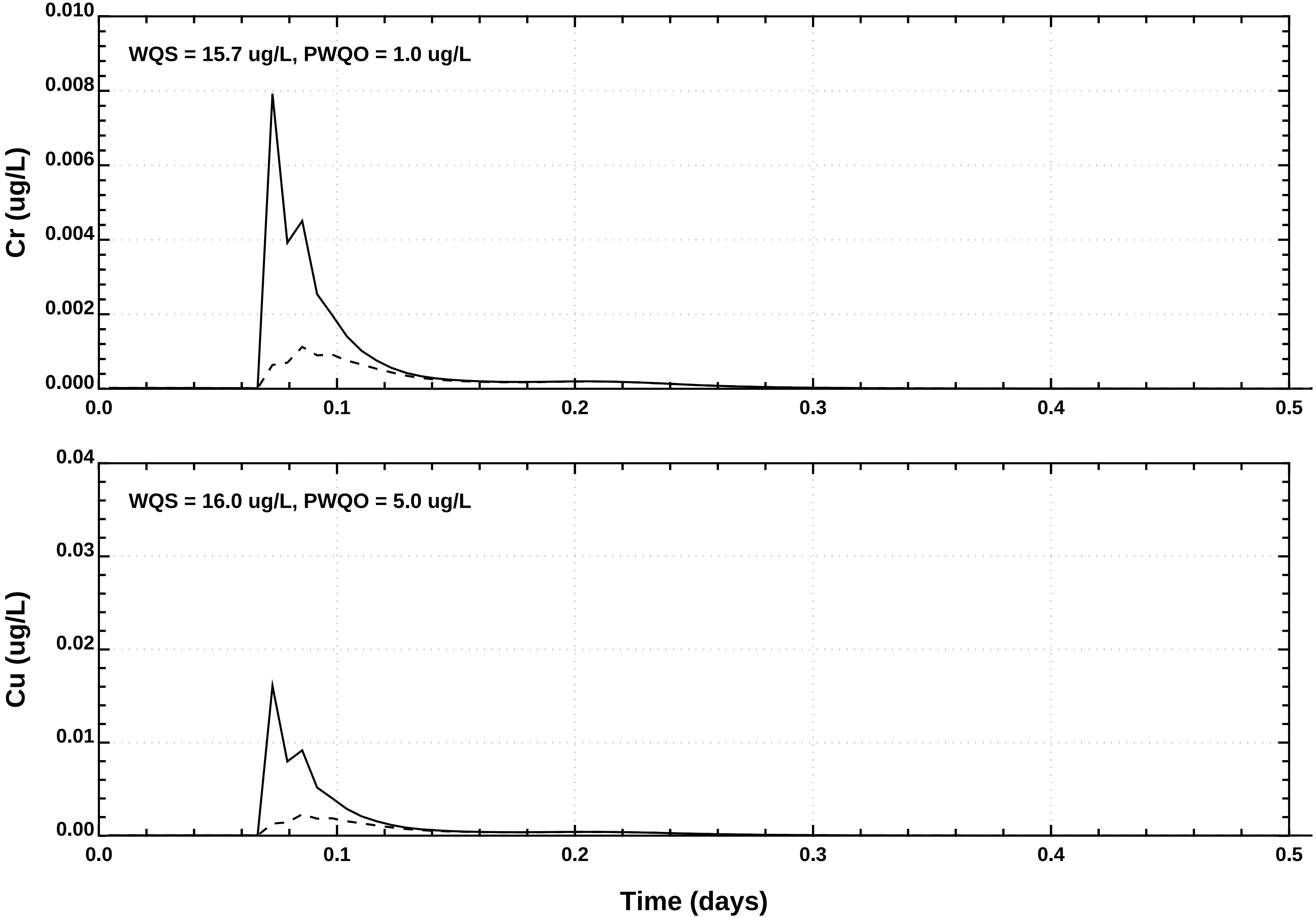


Figure 60. Cr and Cu Model Projection Results at KM35
(Solid Line - Bottom Layer, Dashed Line - One Layer above Bottom: 2-5 meters from bottom)

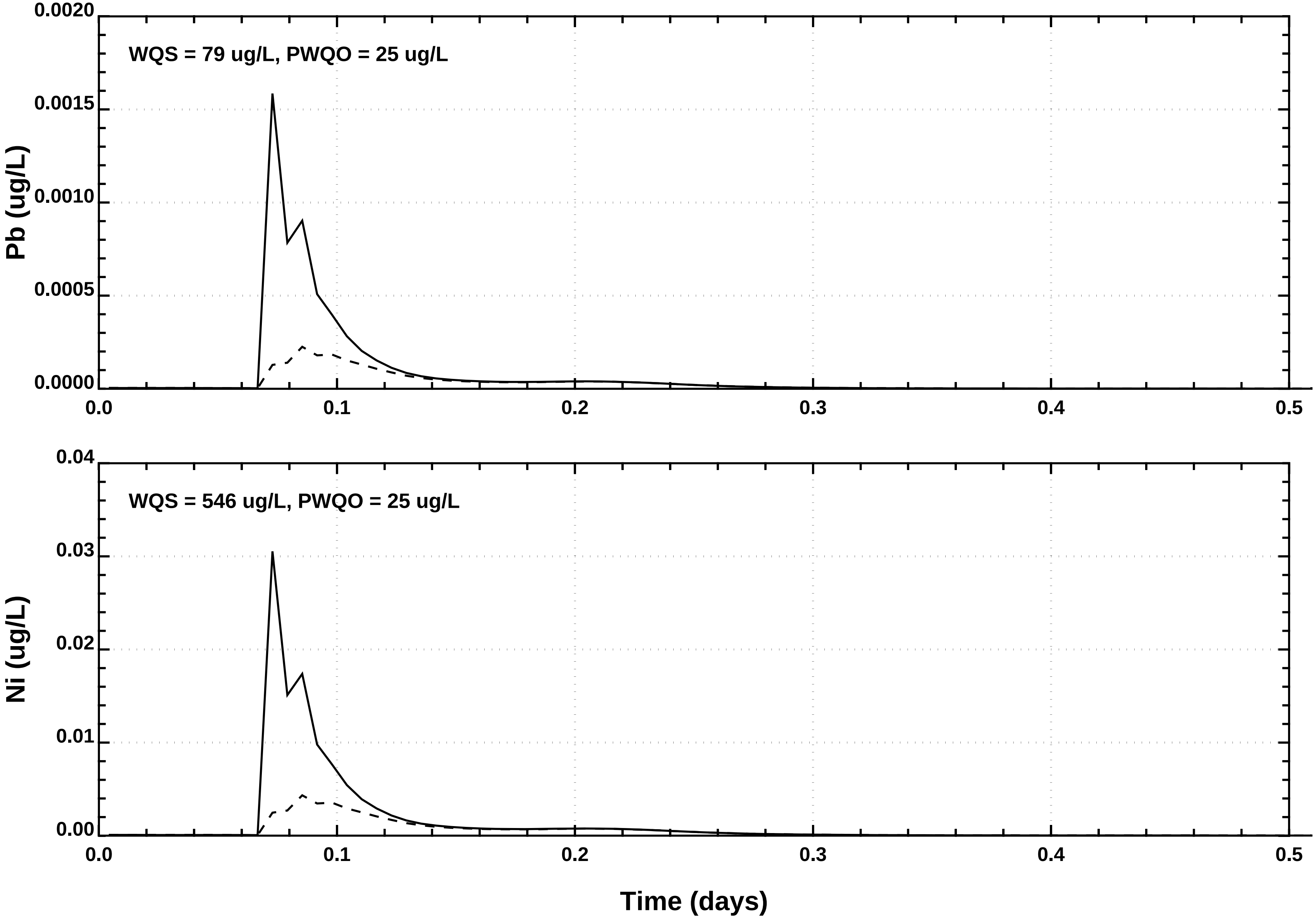


Figure 61. Pb and Ni Model Projection Results at KM35
(Solid Line - Bottom Layer, Dashed Line - One Layer above Bottom: 2-5 meters from bottom)

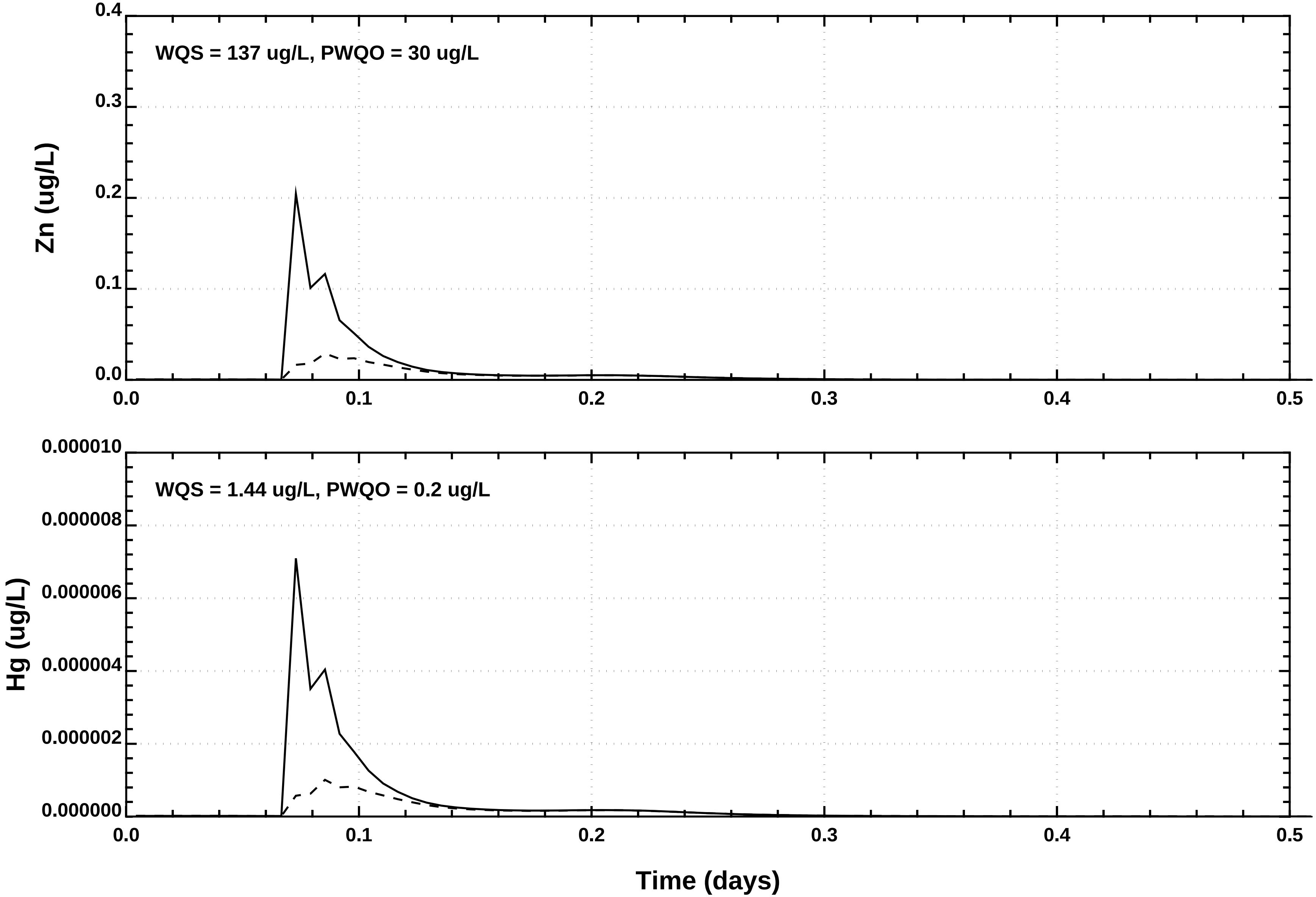


Figure 62. Zn and Hg Model Projection Results at KM35
(Solid Line - Bottom Layer, Dashed Line - One Layer above Bottom: 2-5 meters from bottom)

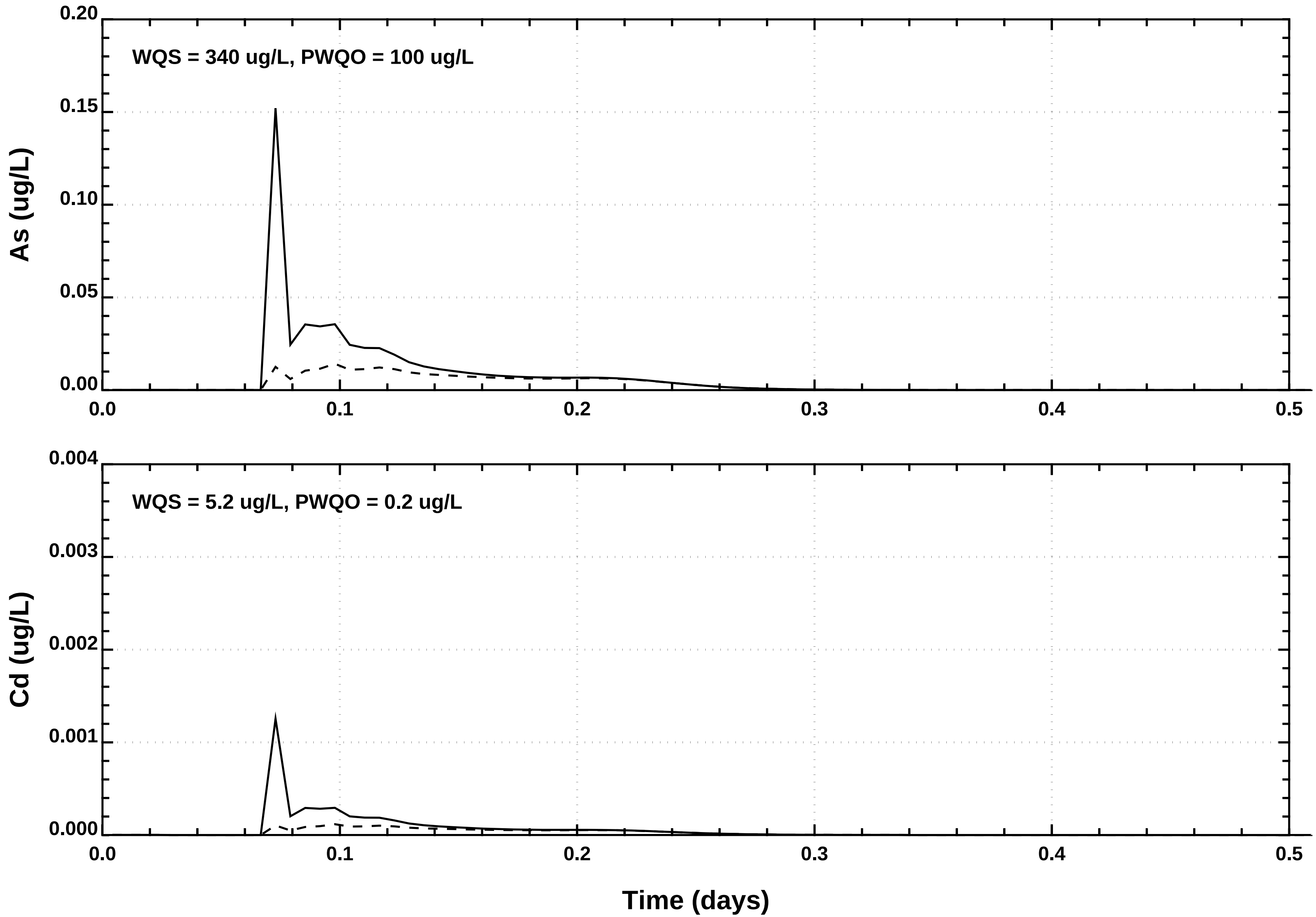


Figure 63. As and Cd Model Projection Results at KM53
(Solid Line - Bottom Layer, Dashed Line - One Layer above Bottom: 2-5 meters from bottom)

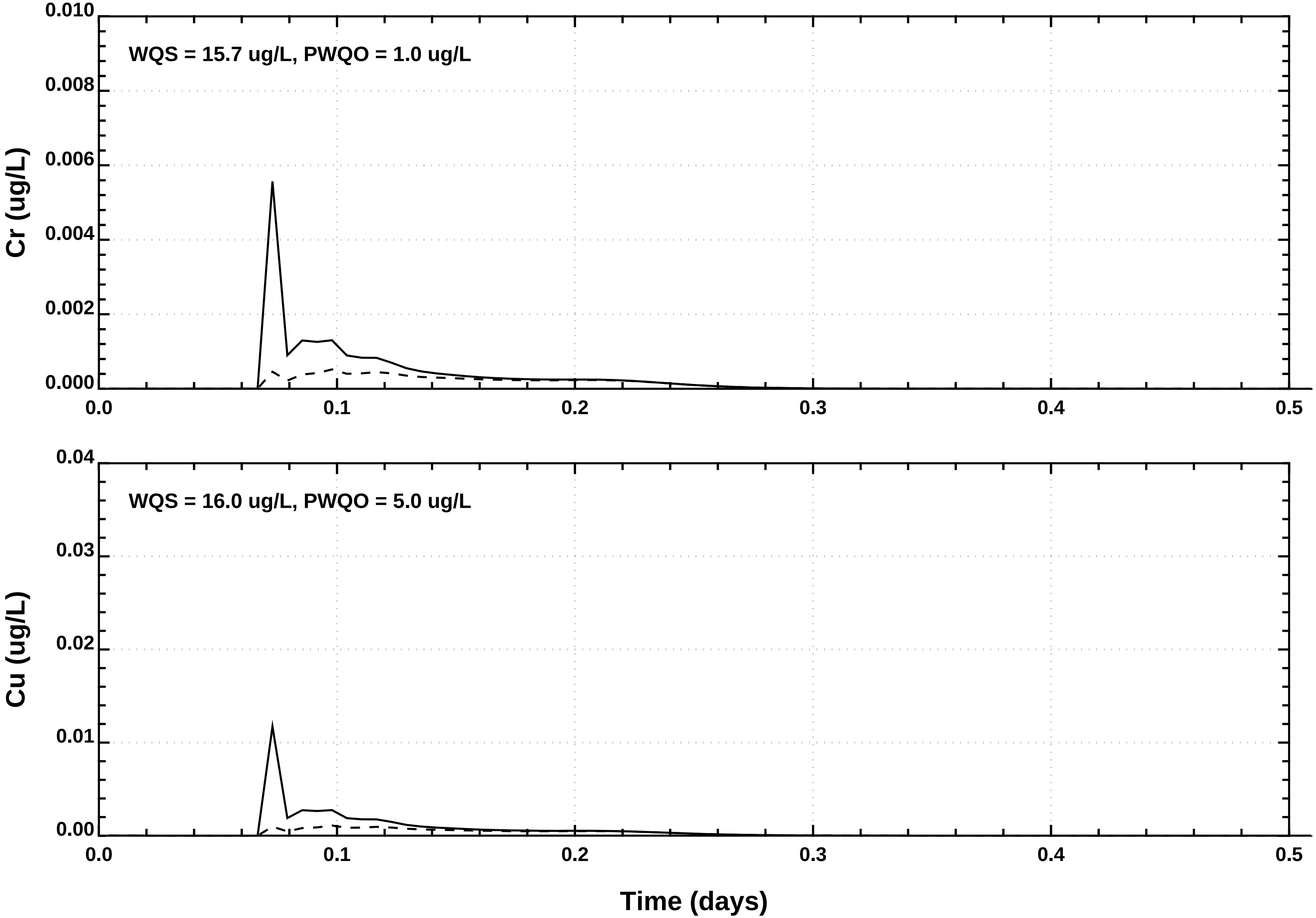


Figure 64. Cr and Cu Model Projection Results at KM53
(Solid Line - Bottom Layer, Dashed Line - One Layer above Bottom: 2-5 meters from bottom)

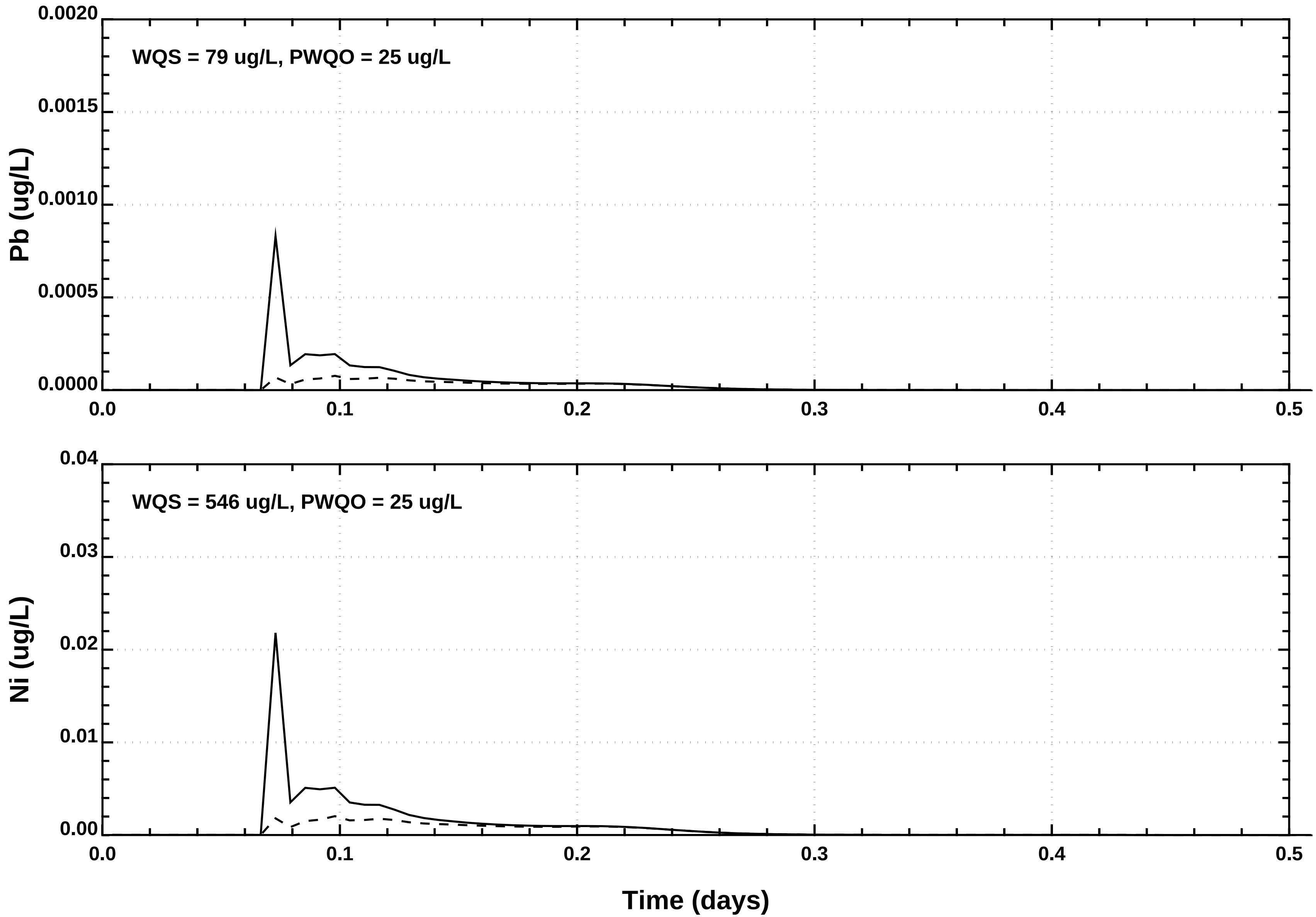


Figure 65. Pb and Ni Model Projection Results at KM53
(Solid Line - Bottom Layer, Dashed Line - One Layer above Bottom: 2-5 meters from bottom)

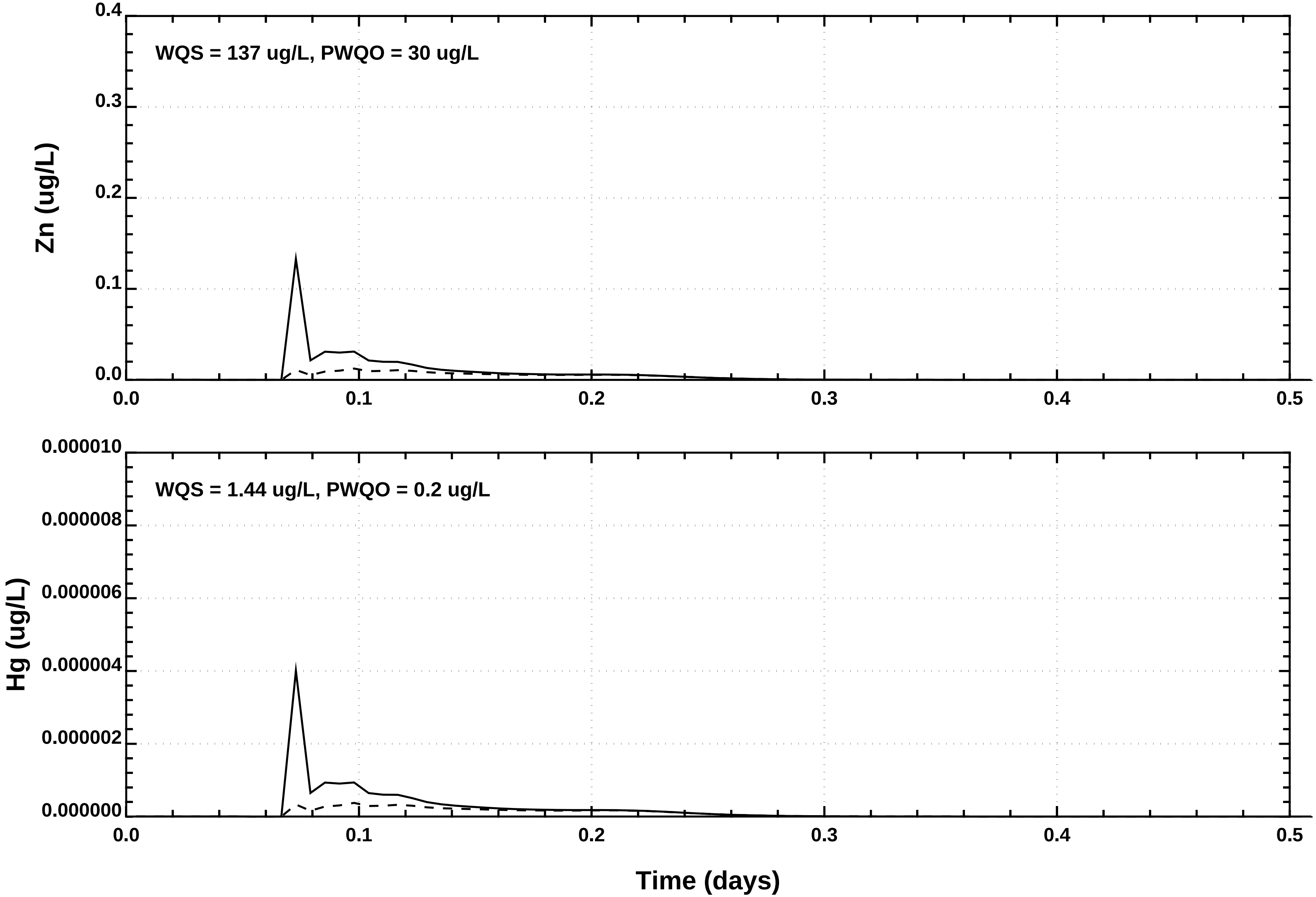


Figure 66. Zn and Hg Model Projection Results at KM53
(Solid Line - Bottom Layer, Dashed Line - One Layer above Bottom: 2-5 meters from bottom)

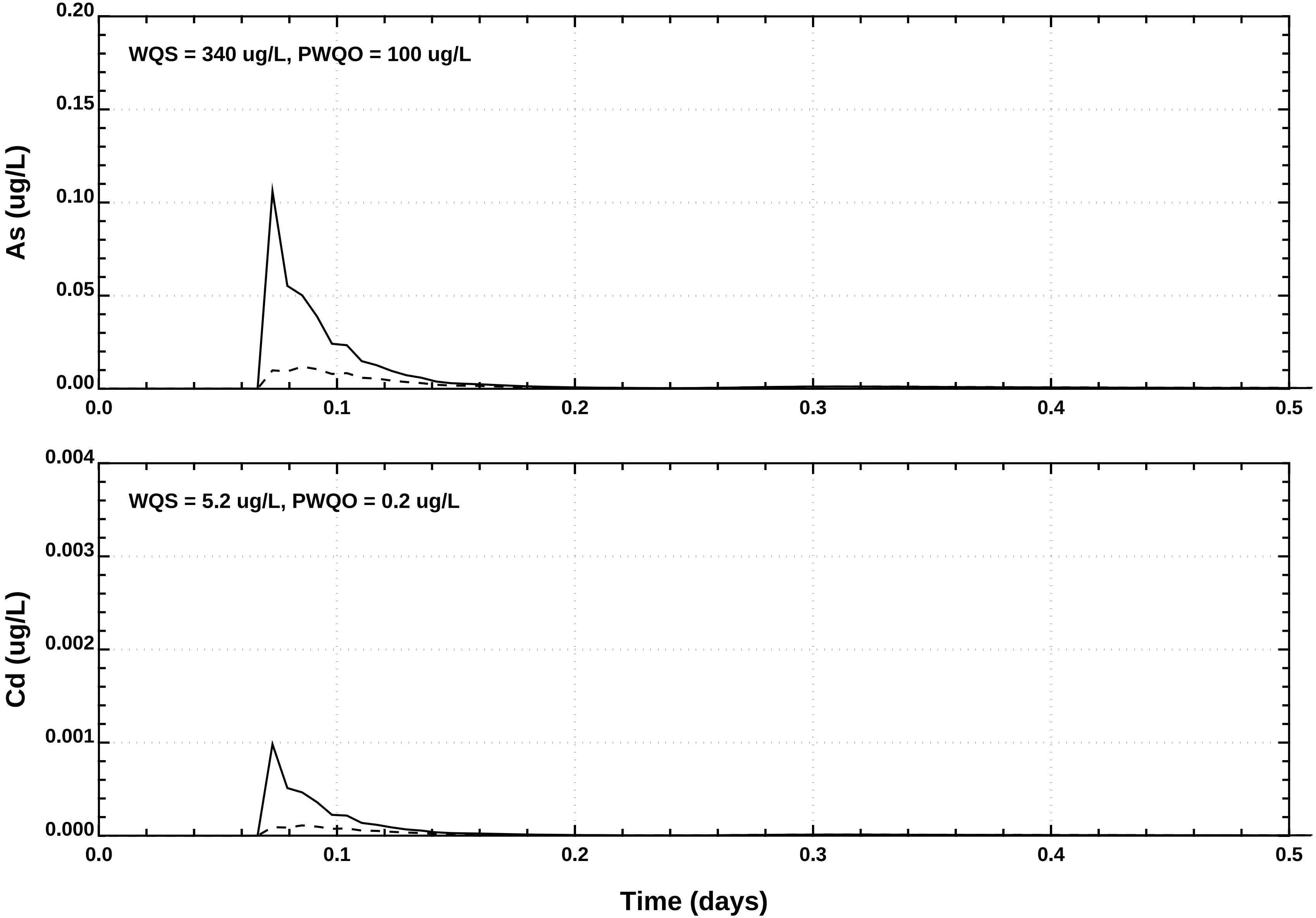


Figure 67. As and Cd Model Projection Results at KM70
(Solid Line - Bottom Layer, Dashed Line - One Layer above Bottom: 2-5 meters from bottom)

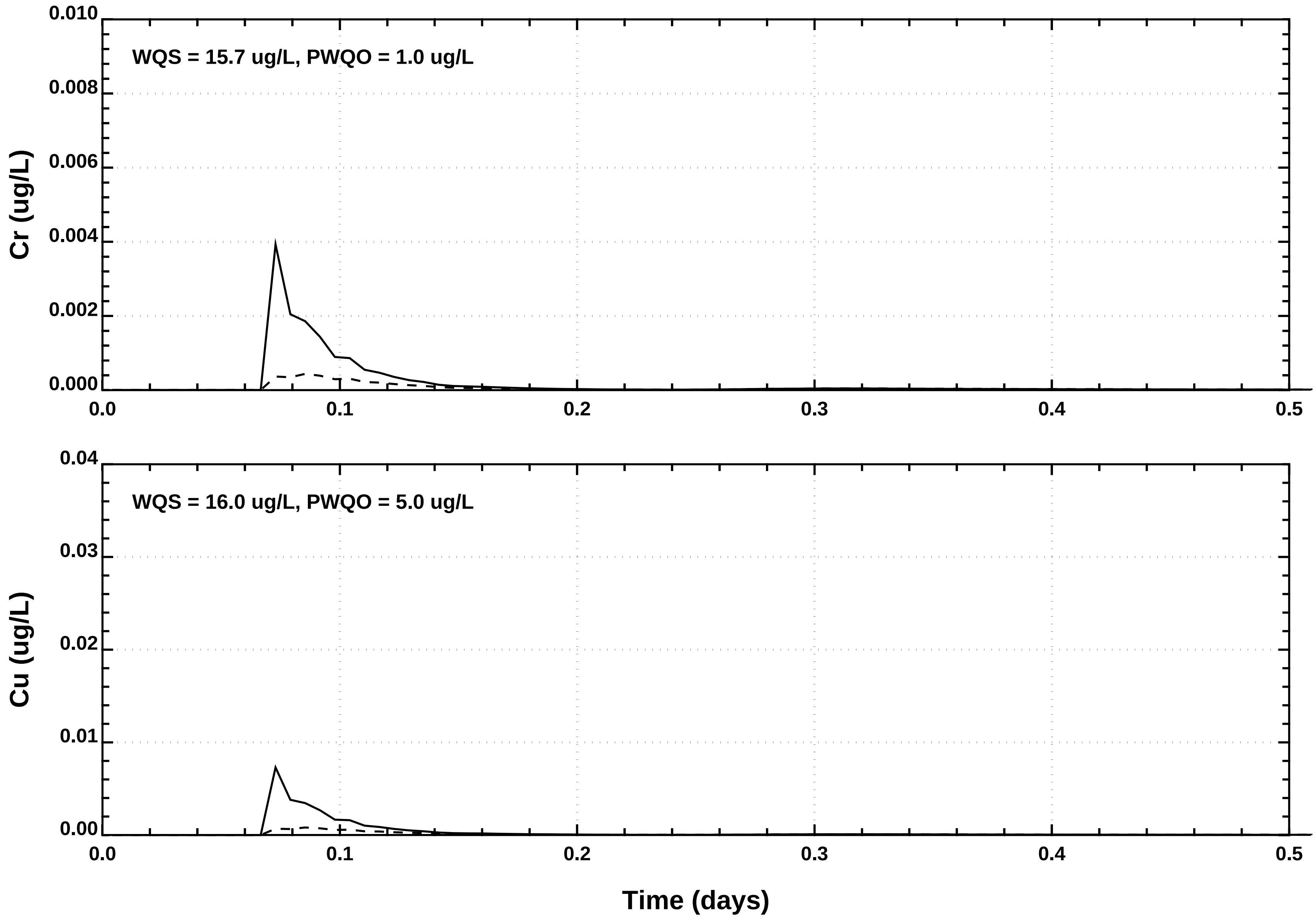


Figure 68. Cr and Cu Model Projection Results at KM70
(Solid Line - Bottom Layer, Dashed Line - One Layer above Bottom: 2-5 meters from bottom)

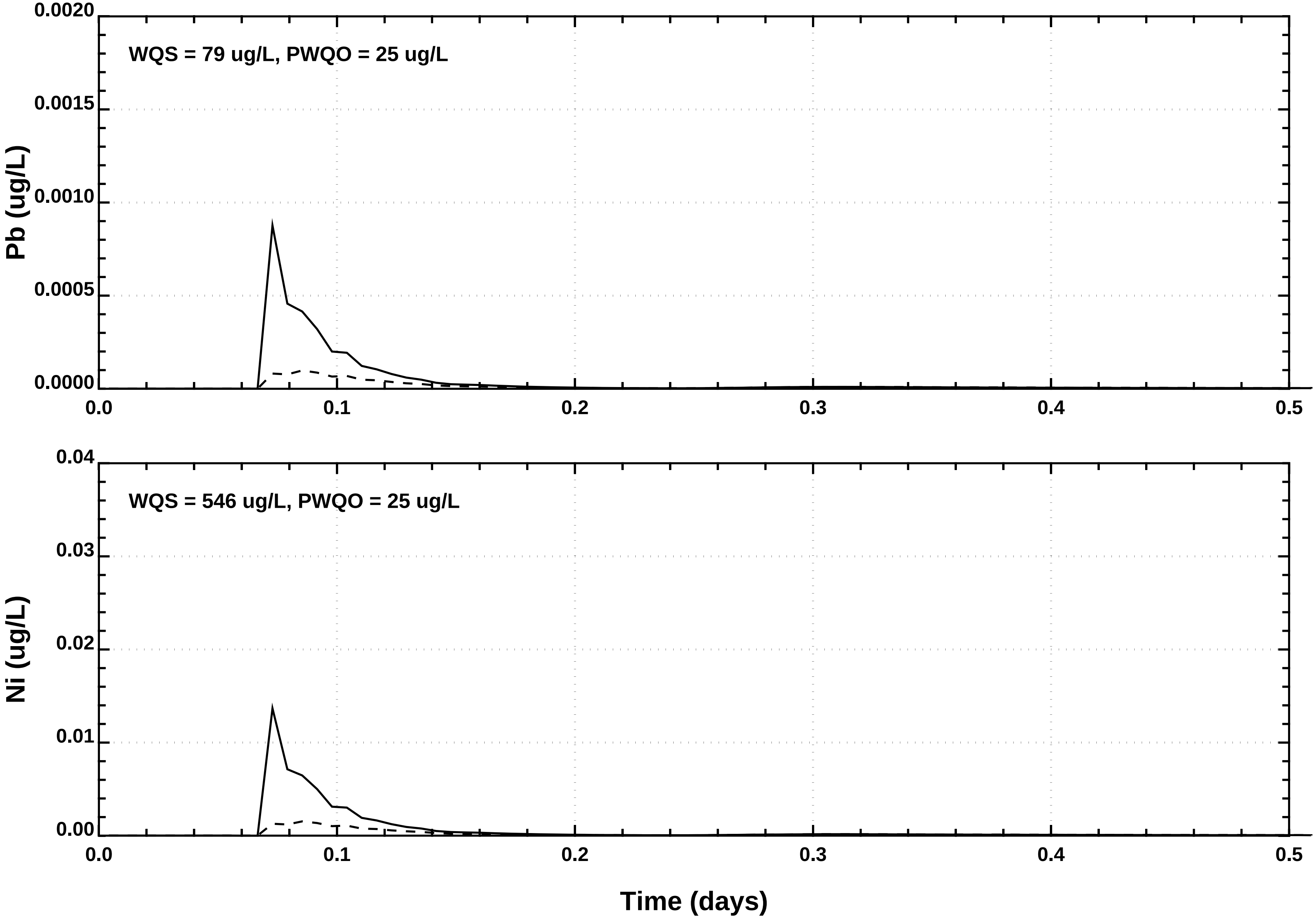


Figure 69. Pb and Ni Model Projection Results at KM70
(Solid Line - Bottom Layer, Dashed Line - One Layer above Bottom: 2-5 meters from bottom)

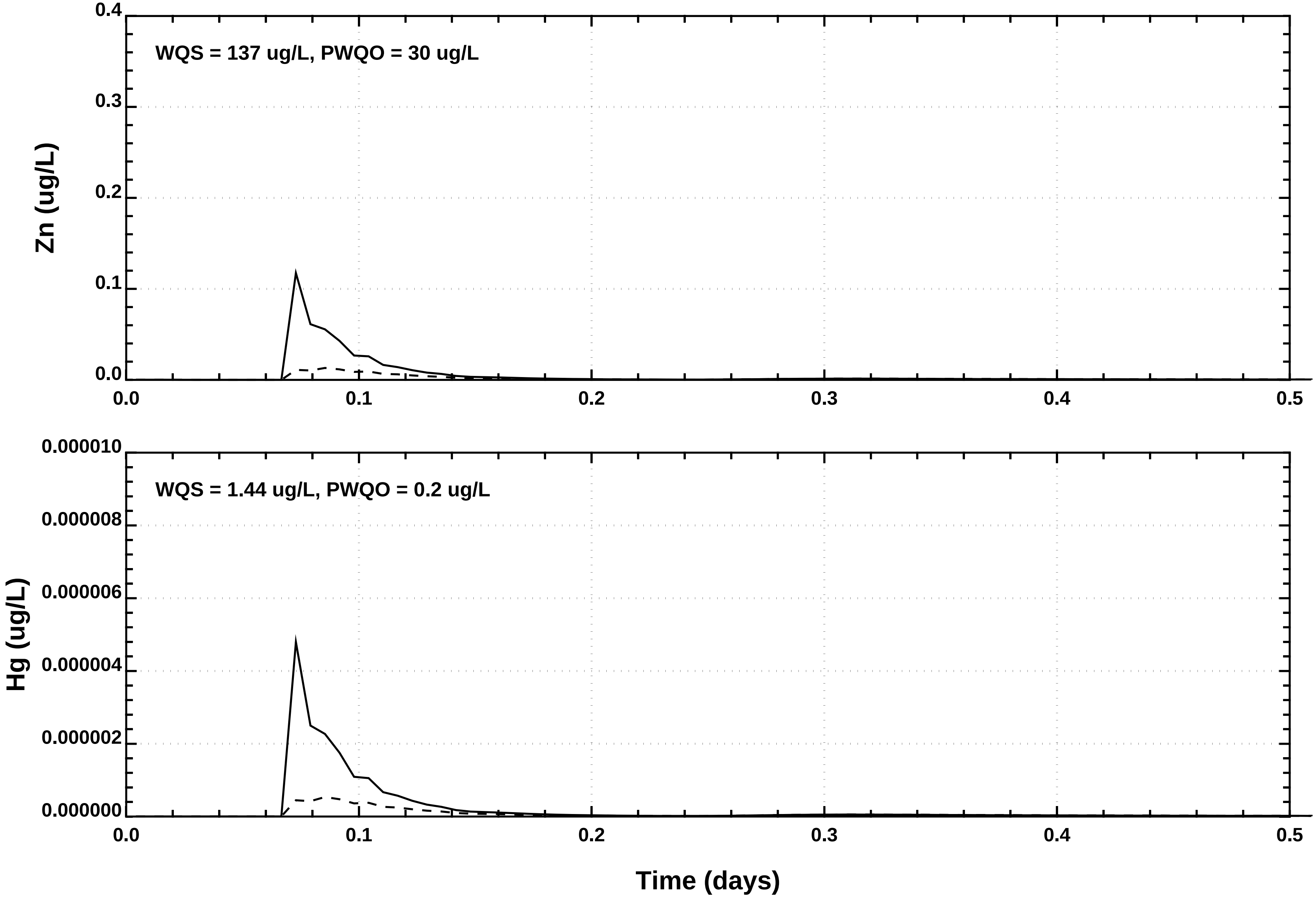


Figure 70. Zn and Hg Model Projection Results at KM70
(Solid Line - Bottom Layer, Dashed Line - One Layer above Bottom: 2-5 meters from bottom)

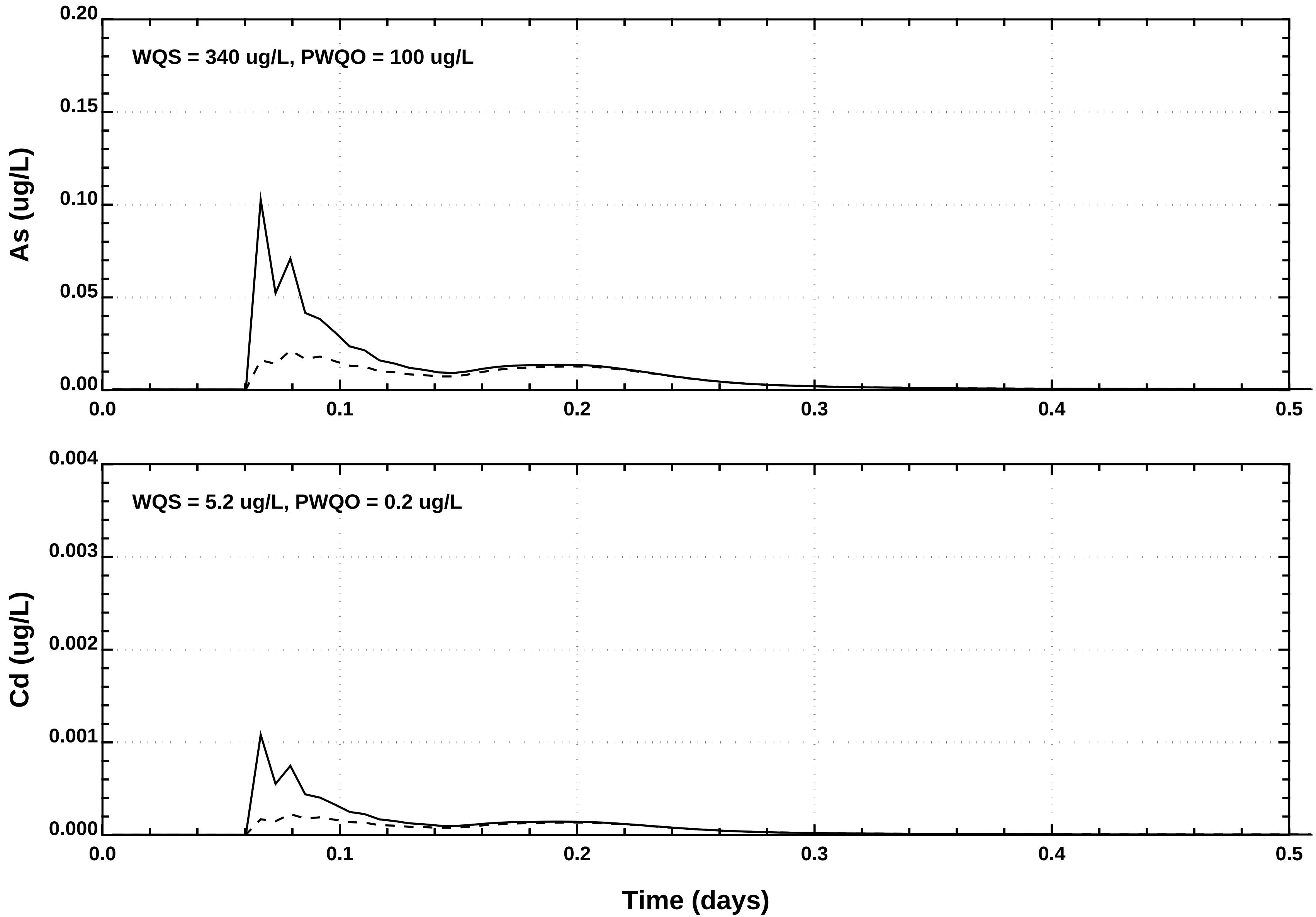


Figure 71. As and Cd Model Projection Results at KM95
(Solid Line - Bottom Layer, Dashed Line - One Layer above Bottom: 2-5 meters from bottom)

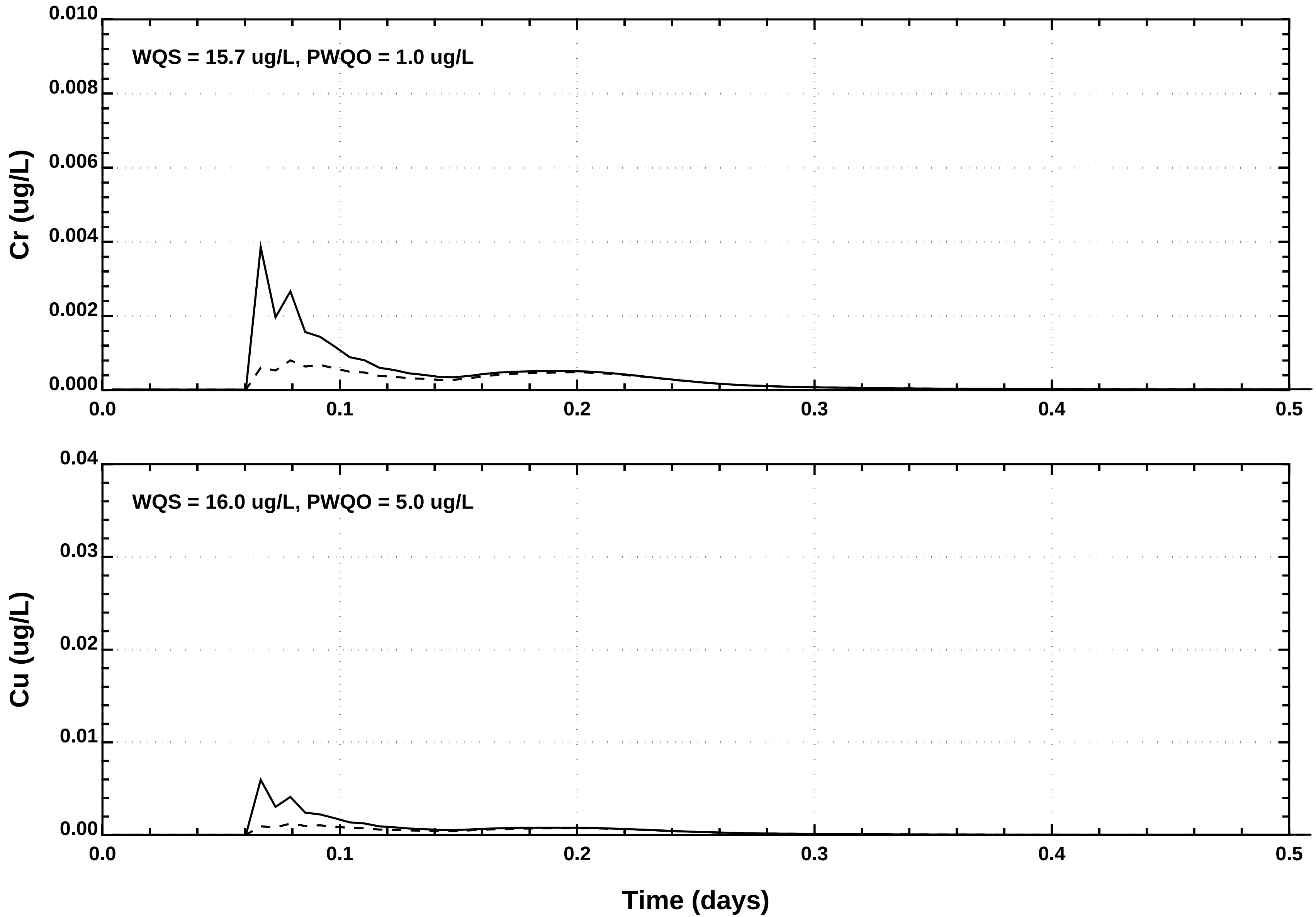


Figure 72. Cr and Cu Model Projection Results at KM95
(Solid Line - Bottom Layer, Dashed Line - One Layer above Bottom: 2-5 meters from bottom)

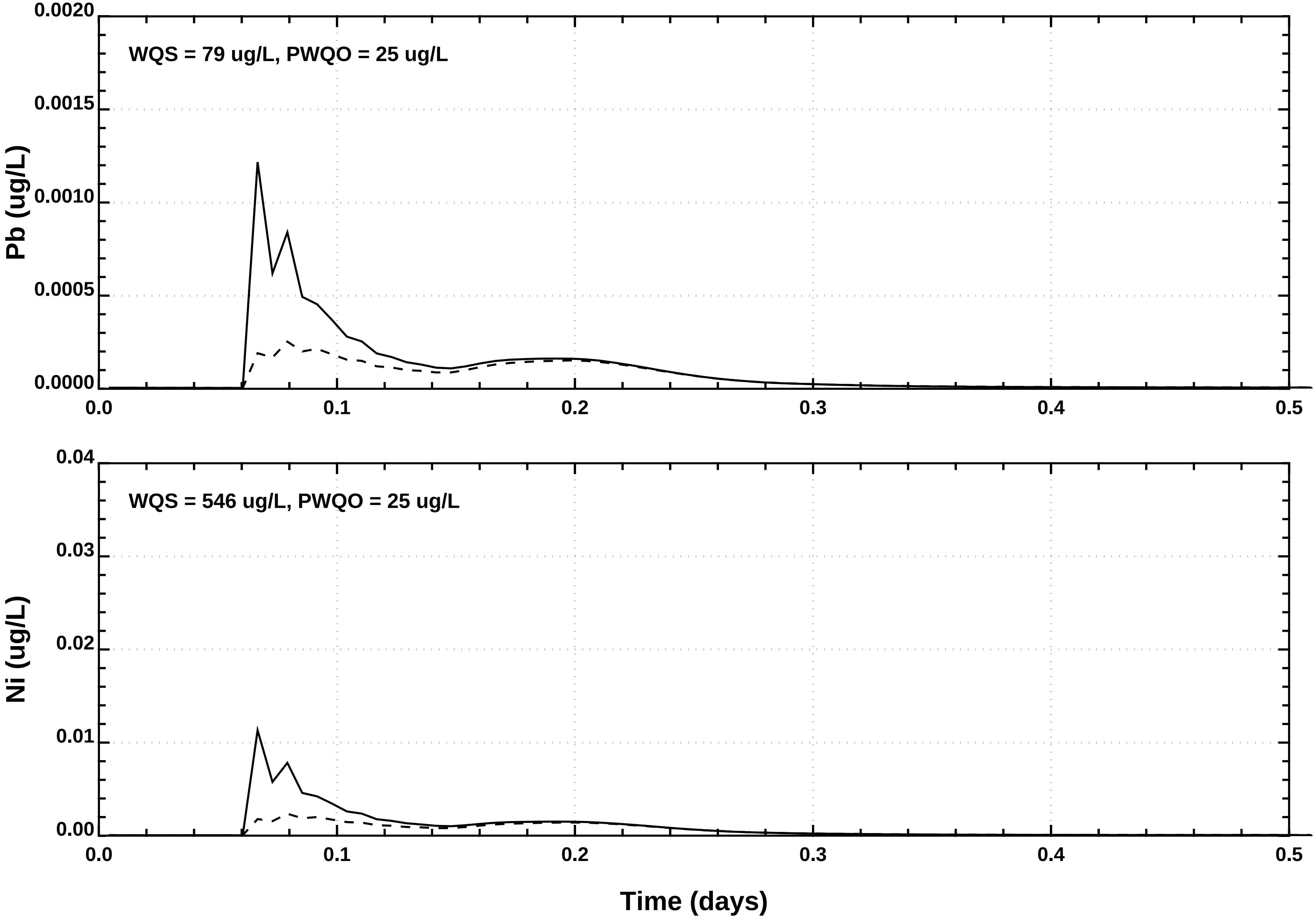


Figure 73. Pb and Ni Model Projection Results at KM95
(Solid Line - Bottom Layer, Dashed Line - One Layer above Bottom: 2-5 meters from bottom)

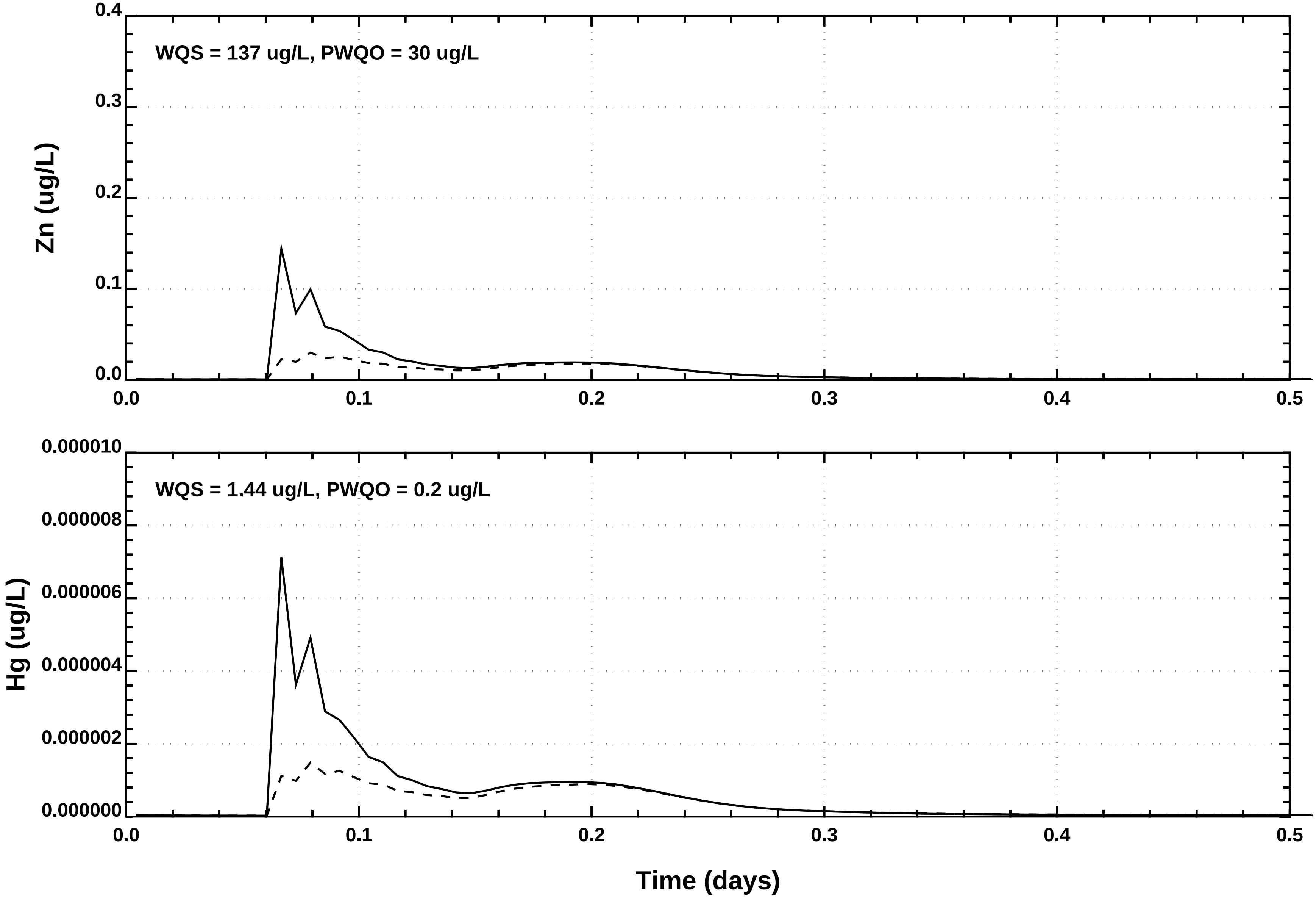


Figure 74. Zn and Hg Model Projection Results at KM95
(Solid Line - Bottom Layer, Dashed Line - One Layer above Bottom: 2-5 meters from bottom)

5 Conclusions

A water quality model of Lake Erie was developed to assess the potential water quality impacts associated with the resuspension of lake sediments during ITC Lake Erie Connector cable installation. These potential water quality impacts are associated with the temporary re-introduction of existing sediments to the water column during cable installation and do not represent a new pollution source to the lake. The water quality modeling was completed to show the concentration increases associated with the cable installation at five representative locations for the following parameters: TSS; TP; DP; arsenic; cadmium; chromium; copper; lead; nickel; zinc; and mercury.

The results from the water quality modeling have shown that minimal water quality impacts are associated with the cable installation in Lake Erie and they are limited to temporary impacts that would occur locally within a four hour timeframe. Specific conclusions reached from the water quality modeling are presented below.

- At all five of the representative locations, the model calculated TSS concentration increases due to the cable installation are <3 mg/L above observed background lake TSS levels at a distance of 100 meters from the point of installation and within five to eleven meters of the lake bottom. The model calculated TSS concentration increases reach a temporary peak concentration at the point of installation and then decrease rapidly. The time to reach a TSS concentration increase of <100 mg/L is on the order of one hour and to reach <3 mg/L above background TSS levels is on the order of one to four hours.

- At all five of the representative locations, the model calculated temporary TP and DP concentration increases due to the cable installation are <0.005 mg/L above observed background lake TP and DP levels at 100 meters from the point of installation and within four to eight meters of the lake bottom. The model calculated temporary TP and DP concentration increases reach a peak concentration at the point of installation and then decrease rapidly. The time to reach <0.005 mg/L above background TP and DP concentrations is on the order of one to four hours.

- The DP mass re-introduced during cable installation represents <0.001% of the total external annual phosphorus inputs to Lake Erie based on loadings rates from 1998-2005. It should be noted that the cable installation does not represent a new source to the lake but rather represents the re-introduction of existing sediment sources into the water column on a short term basis.

- All model calculated dissolved metals concentration increases are less than the associated method detection limits (MDL) and much less than applicable acute and chronic dissolved WQS and PWQO. Therefore, water quality impacts associated with the eight metals (arsenic, cadmium, chromium, copper, lead, nickel, zinc and mercury) due to the installation of the cable in Lake Erie are expected to be in compliance with applicable WQS and PWQO.

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