Water Quality Analysis of Chlorpyrifos in The Patuxent River Lower and Middle Watersheds; Anne Arundel, Calvert, Charles, Prince George's, and St. Mary's Counties, Maryland

FINAL

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List of Abbreviations

10-d	10 day
CBP	Chesapeake Bay Program
CFR	Code of Federal Regulations
COMAR	Code of Maryland Regulations
CWA	Clean Water Act
DNR	Maryland Department of Natural Resources
EPA	U. S. Environmental Protection Agency
km	Kilomters
m	Meters
mg	Milligram
MGS	Maryland Geological Survey
MDE	Maryland Department of the Environment
MDP	Maryland Department of Planning
ND	Non Detect
NRCS	Natural Resources Conservation Service
ppt	Parts per thousand
SD	Standard Deviation
SHA	State Highway Administration
TMDL	Total Maximum Daily Load
USDA	United States Department of Agriculture
WQA	Water Quality Analysis
WQLS	Water Quality Limited Segment
µg/l	Micrograms per Liter

EXECUTIVE SUMMARY

Section 303(d) of the federal Clean Water Act (CWA) and the U.S. Environmental Protection Agency's (EPA) implementing regulations direct each state to identify and list waters, known as water quality limited segments (WQLSs), in which current required controls of a specified substance are inadequate to achieve water quality standards. This list of impaired waters is commonly referred to as the "303(d) List." For each WQLS, the State is to either establish a Total Maximum Daily Load (TMDL) for the specified substance that the waterbody can receive without violating water quality standards, or demonstrate that water quality standards are being met (CFR 2006a).

The Patuxent River Lower (basin code 02131101), located in Anne Arundel, Calvert, Charles, Prince George's, and St. Mary's Counties, Maryland, was identified on the State's list of WQLSs as impaired by fecal coliform (1996, 1998, and 2004), nutrients (1996), sediments (1996), chlorpyrifos in the water column (2002), methylmercury (2002), and impacts to biological communities (2002 and 2004) (MDE 2006a). The Patuxent River Middle (basin code 02131102), located in Anne Arundel, Calvert, and Prince George's Counties, Maryland, was identified on the State's list of WQLSs as impaired by sediments (1996), nutrients (1996), chlorpyrifos in both the water column and underlying sediments (2002), and impacts to biological communities (2002 and 2004) (MDE 2006a). All fecal coliform listings are for tidal shellfish areas, whereas the biological listings are for nontidal waters, except for the 2004 Patuxent River Lower biological listing. All other listings are for the tidal waterbody.

Chlorpyrifos is a pesticide used primarily in agricultural applications, particularly on grain, cotton, field, fruit, nut, and vegetable crops, that has been in production since the 1960s. However, it has also been used for residential applications, such as on lawns and ornamental plants in order to control nonagricultural pests. It is moderately toxic to humans and highly toxic to aquatic organisms, but it does not bioaccumulate (EXTOXNET 2006). Furthermore, it is introduced into a watershed via run off from agricultural or residential uses where the pesticide has been applied. In 2001, the EPA banned the use of chlorpyrifos in residential applications, but it continues to be used in agricultural activities, as the EPA has deemed that its "individual, aggregate risks are within acceptable levels" (US EPA 2002).

The Patuxent River Lower and the Patuxent River Middle were listed on the 2002 303(d) List for chlorpyrifos due to findings reported in the Chesapeake Bay Program's 1999 publication *Targeting Toxics: A Characterization Report - A Tool for Directing Management and Monitoring Actions in the Chesapeake Bay's Tidal Rivers*. The report stated that chlorpyrifos concentrations in both the water column and underlying sediments were at levels that could cause adverse effects to living resources in both the upper and middle tidal portions of the Patuxent River Lower and Middle watersheds. Furthermore, when Chesapeake Bay organisms were exposed to both water column and sediment samples from the two tidal regions in the laboratory, the report states that adverse effects were observed in the organisms. For these reasons, the document listed the upper and middle tidal portions of the Patuxent Lower and Middle watersheds as "Areas of Emphasis." The lower tidal portion of the watersheds was listed as an "Area With Insufficient or Inconclusive Data." Even though water column and sediment

samples were observed to cause adverse effects on Bay organisms in the laboratory, the data was still determined to be inconclusive (CBP 1999).

This report provides an analysis of recent monitoring data showing that the aquatic life criteria for chlorpyrifos are being attained in the Patuxent River Lower and Middle watersheds, and therefore the watersheds are not impaired by chlorpyrifos according to their designated uses and associated aquatic life criteria. The analysis does not support the impairment listing for chlorpyrifos, and a TMDL is not necessary to meet the water quality standards for chlorpyrifos since criteria are currently being attained. Barring the receipt of contradictory data, this report will be used to support a chlorpyrifos listing change for both the Patuxent River Lower and Middle watersheds from Category 5 (waterbodies impaired by one or more pollutants requiring a TMDL) to Category 2 (Surface waters that are meeting some standards and have insufficient information to determine attainment of other standards), when the Maryland Department of the Environment (MDE) proposes the revision of Maryland's 303(d) List for public review in the future. The Patuxent River Middle listings for sediments, nutrients, and impacts to biological communities will be addressed separately at a future date. Two TMDLs to address the bacteria listings for the sub-basins of the Patuxent River Lower watershed were approved by the EPA in 2005, a WQA to address the bacteria listing for the mainstem of the Patuxent River Lower was submitted to the EPA in 2006, and a TMDL to address the 2002 methylmercury listing for the Lake Lariat impoundment was approved in 2004 (MDE 2006a). The Patuxent River Lower listings for nutrients, sediments, and impacts to biological communities will be addressed separately at a future date.

Although the waters of the Patuxent River Lower and Middle watersheds do not display signs of toxic impairments due to chlorpyrifos, the State reserves the right to require additional pollution controls in the watersheds if evidence suggests that chlorpyrifos from the basin is contributing to downstream water quality problems.

1.0 INTRODUCTION

Section 303(d) of the federal Clean Water Act (CWA) and U.S. Environmental Protection Agency's (EPA) implementing regulations direct each state to identify and list waters, known as water quality limited segments (WQLSs), in which current required controls of a specified substance are inadequate to achieve water quality standards. This list of impaired waters is commonly referred to as the "303(d) List." For each WQLS, the State is to either establish a Total Maximum Daily Load (TMDL) for the specified substance that the waterbody can receive without violating water quality standards, or demonstrate that water quality standards are being met (CFR 2006a).

A segment identified as a WQLS may not require the development and implementation of a TMDL if current information contradicts the previous finding of impairment. The most common factual scenarios obviating the need for a TMDL are as follows: 1) more recent data indicating that the impairment no longer exists (i.e., water quality criteria are being met); 2) more recent and updated water quality modeling demonstrates that the segment is now attaining criteria; 3) refinements to water quality criteria or the interpretation of standards, which result in standards being met; or 4) correction to errors made in the initial listing.

The Patuxent River Lower (basin code 02131101) was identified on the State's list of WQLSs as impaired by fecal coliform (1996, 1998, and 2004), nutrients (1996), sediments (1996), chlorpyrifos in the water column (2002), methylmercury (2002), and impacts to biological communities (2002 and 2004) (MDE 2006a). The Patuxent River Middle (basin code 02131102) was identified on the State's list of WQLSs as impaired by sediments (1996), nutrients (1996), chlorpyrifos in both the water column and underlying sediments (2002), and impacts to biological communities (2002 and 2004) (MDE 2006a). All fecal coliform listings are for tidal shellfish areas, whereas the biological listings are for nontidal waters, except for the 2004 Patuxent River Lower biological listing. All remaining listings are for the tidal waterbody

A Water Quality Analysis (WQA) of chlorpyrifos for the Patuxent River Lower and Middle watersheds was conducted by the Maryland Department of the Environment (MDE) using recent water column and porewater data along with sediment toxicity data in order to determine if an impairment currently exists. The Patuxent River Middle listings for sediments, nutrients, and impacts to biological communities will be addressed separately at a future date. Two TMDLs to address the bacteria listings for the sub-basins of the Patuxent River Lower watershed were approved by the EPA in 2005, a WQA to address the bacteria listing for the mainstem of the Patuxent River Lower was submitted to the EPA in 2006, and a TMDL to address the 2002 methylmercury listing for the Lake Lariat impoundment was approved in 2004 (MDE 2006a). The Patuxent River Lower listings for nutrients, sediments, and impacts biological communities will be addressed separately at a future date.

The remainder of this report lays out the general setting of the waterbodies within the Patuxent River Lower and Middle watersheds, presents a discussion of the water quality characterization process, and provides conclusions with regard to the characterization.

2.0 GENERAL SETTING

Location

The Patuxent River is located on Maryland's Western Shore and drains portions of Anne Arundel, Calvert, Charles, Howard, Montgomery, Prince George's, and St. Mary's Counties, Maryland. The river has a length of approximately 71 kilometers (km) and a width ranging from 500 meters (m) upstream to 2.4 km at the mouth. It flows to the south/southeast until it empties into the Chesapeake Bay. The entire watershed covers an area of approximately 930 square miles (DNR 2006b). The Patuxent River Lower watershed is located in Anne Arundel, Calvert, Charles, St. Mary's, and Prince George's Counties, and it drains an area of approximately 207,405 acres. The Patuxent River Middle watershed is located in Anne Arundel, Calvert, and Prince George's Counties, and it drains an area of approximately 66,478 acres (DNR 2006a). The locations of both of these watersheds can be seen in Figure 1.

Geology/Soils

The entire Patuxent River watershed is situated within both the Coastal Plain and Piedmont Plateau Provinces of Maryland along its western shore. The Patuxent River Lower and Middle watersheds, however, are located solely within the Coastal Plain Province of Maryland. The Coastal Plain province is characterized by unconsolidated sediments, which include sand, gravel, silt, and clay. These unconsolidated sediments overlap the rocks of the Piedmont Plateau along the fall line that separates these two geologic provinces. The sediments of the coastal plain dip toward the east at a very low angle of 3 degrees, and some of the younger formations in the province crop out to the surface with increasing frequency in a southeasterly direction. The majority of the province, however, consists of older formations, which are covered by a thin layer of Quaternary Gravel (MGS 2006).

The two predominant soil types in the Patuxent River Lower and Middle watersheds are the Sassafras and Westphalia soil associations. The Sassafras association makes up the majority of the southeastern portion of the Patuxent River Lower watershed, while the Westphalia association makes up the majority of the western and northeastern portions of both the Lower and Middle watersheds. The Westphalia soil association is characterized by rolling to steep, moderate to well-drained, severely eroded soils, consisting of either a sandy clay loam or fine sandy loam. The Sassafras soil association is characterized by gently sloping to steep, well-drained, moderately to severely eroded soils, consisting of either a sandy clay loam or a silt loam. The remaining watershed area is made up of the Beltsville soil association, which is found predominantly on the western edge of the watersheds in St. Mary's, Charles, and Prince George's Counties, along with the Galestown, Othello, and Bibb soil associations, which are predominantly found around the mainstem of the Patuxent River itself (USDA 1967, 1971, 1973, 1974, and 1978). The soil type distribution is displayed in Figure 2.

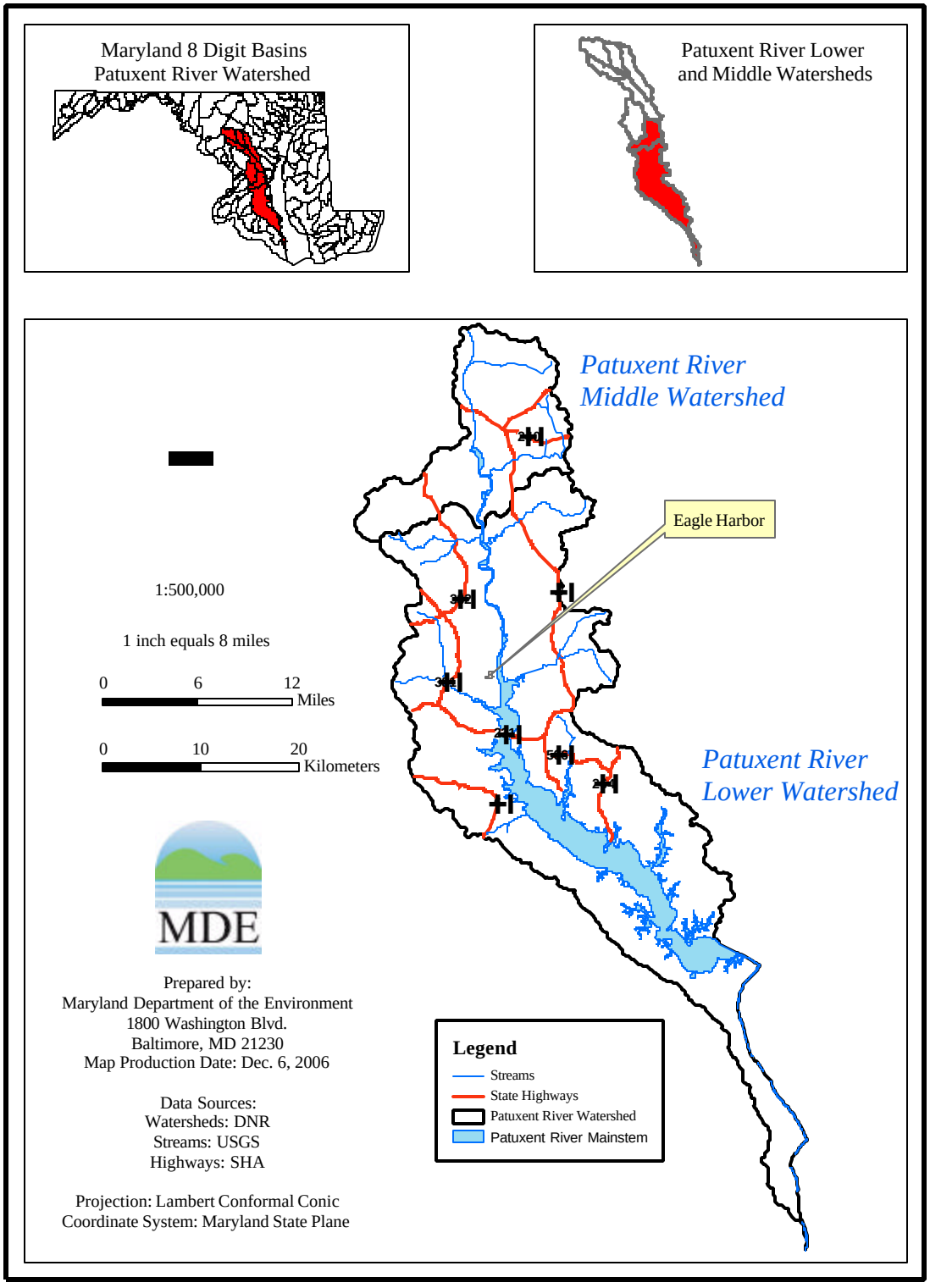


Figure 1: Location Map of the Patuxent River Lower and Middle Watersheds

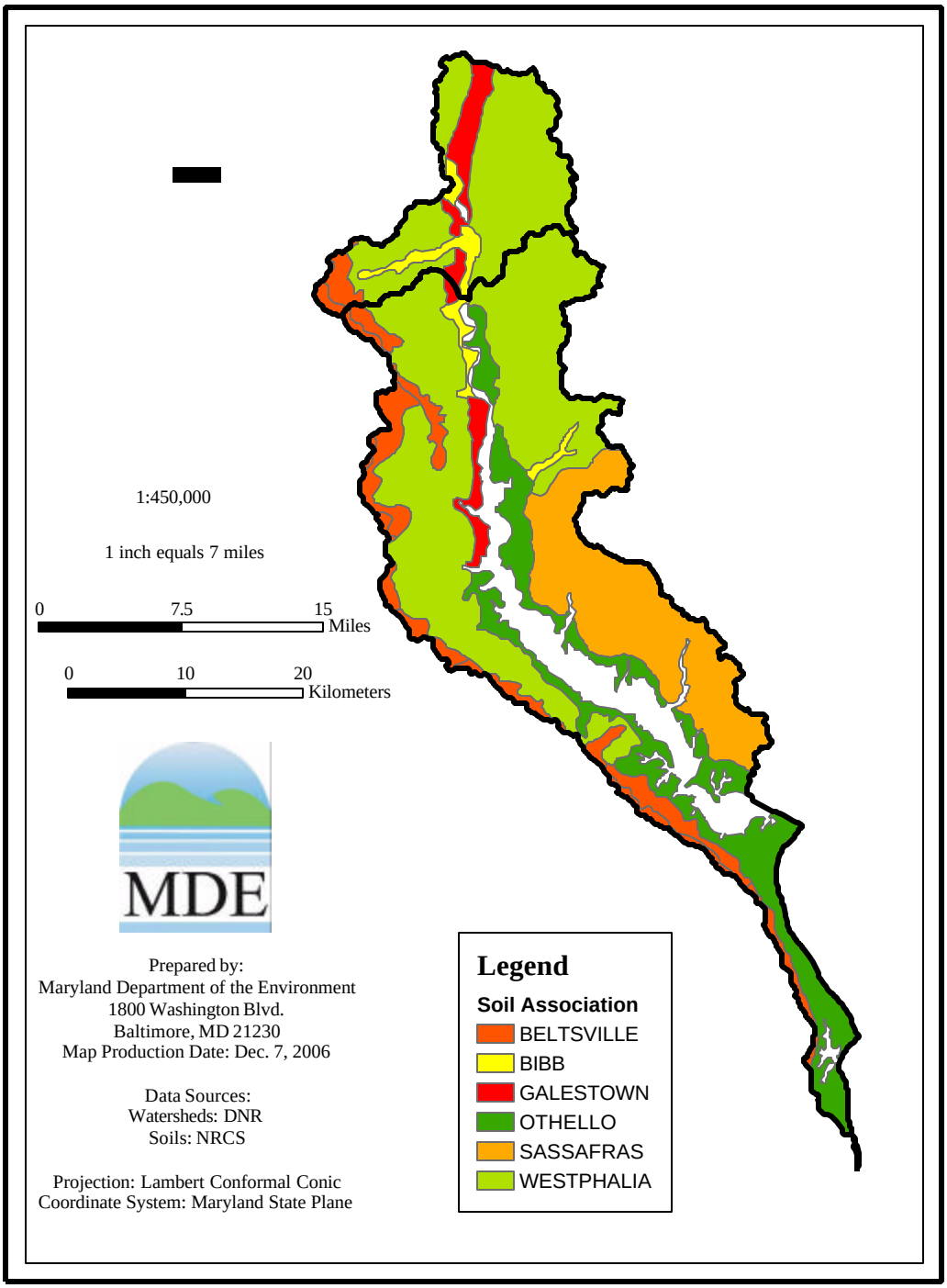


Figure 2: Soils Map of the Patuxent River Lower and Middle Watersheds

Land use

The Patuxent River Lower watershed is predominantly forested, with forest comprising 124,077 acres of the 207,405 total acres (59.82%) in the watershed. Agricultural and residential land uses make up the majority of the remaining 40.18% of the watershed, consisting of 43,717 acres (21.08%) and 35,606 acres (17.17%) respectively. Commercial/industrial land use makes up 3,035 acres (1.46%) of the watershed, while barren and open urban land comprise 262 acres (0.13%) and 705 acres (0.34%) of the watershed respectively (MDP 1997, 2002). Figure 3 depicts the land use distribution in the Patuxent River Lower watershed.

The Patuxent River Middle watershed is also primarily forested, with forest comprising 42,838 acres of the total 66,478 acres (64.44%) in the watershed. Once again, residential and agricultural land uses make up the majority of the remaining land area in the Patuxent River Middle watershed. Agricultural land use comprises 14,984 acres (22.54%) and residential land use comprises 7,196 acres (10.83%) of the watershed. Commercial/industrial land use, barren land, and open urban land make up the remaining 2.19% of the watershed's land area with 505 acres (0.76%), 59 acres (.09%), and 884 acres (1.33%) respectively (MDP 1997, 2002). Figure 4 depicts the land use distribution in the Patuxent River Middle watershed.

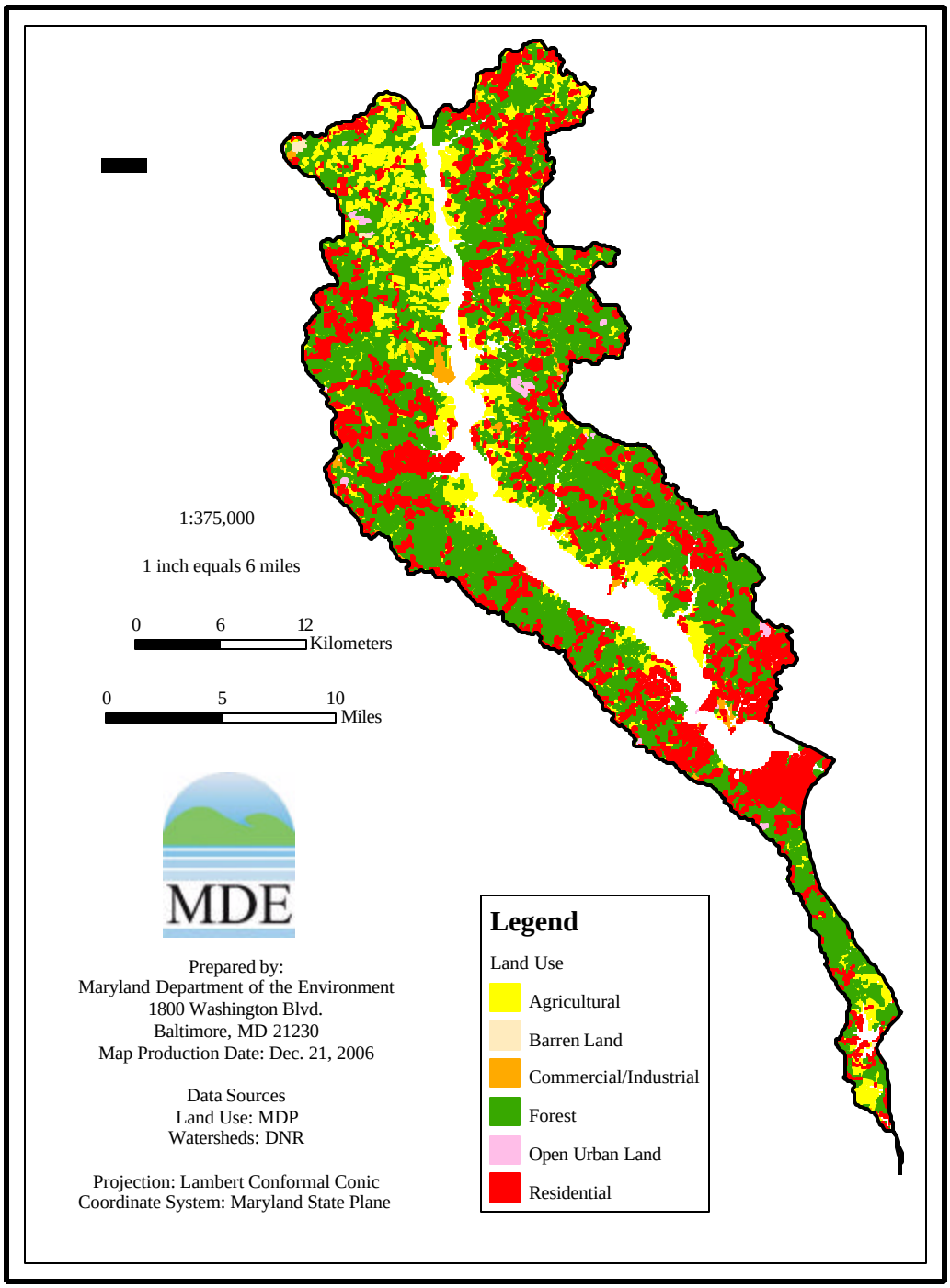


Figure 3: Patuxent River Lower Land Use Map

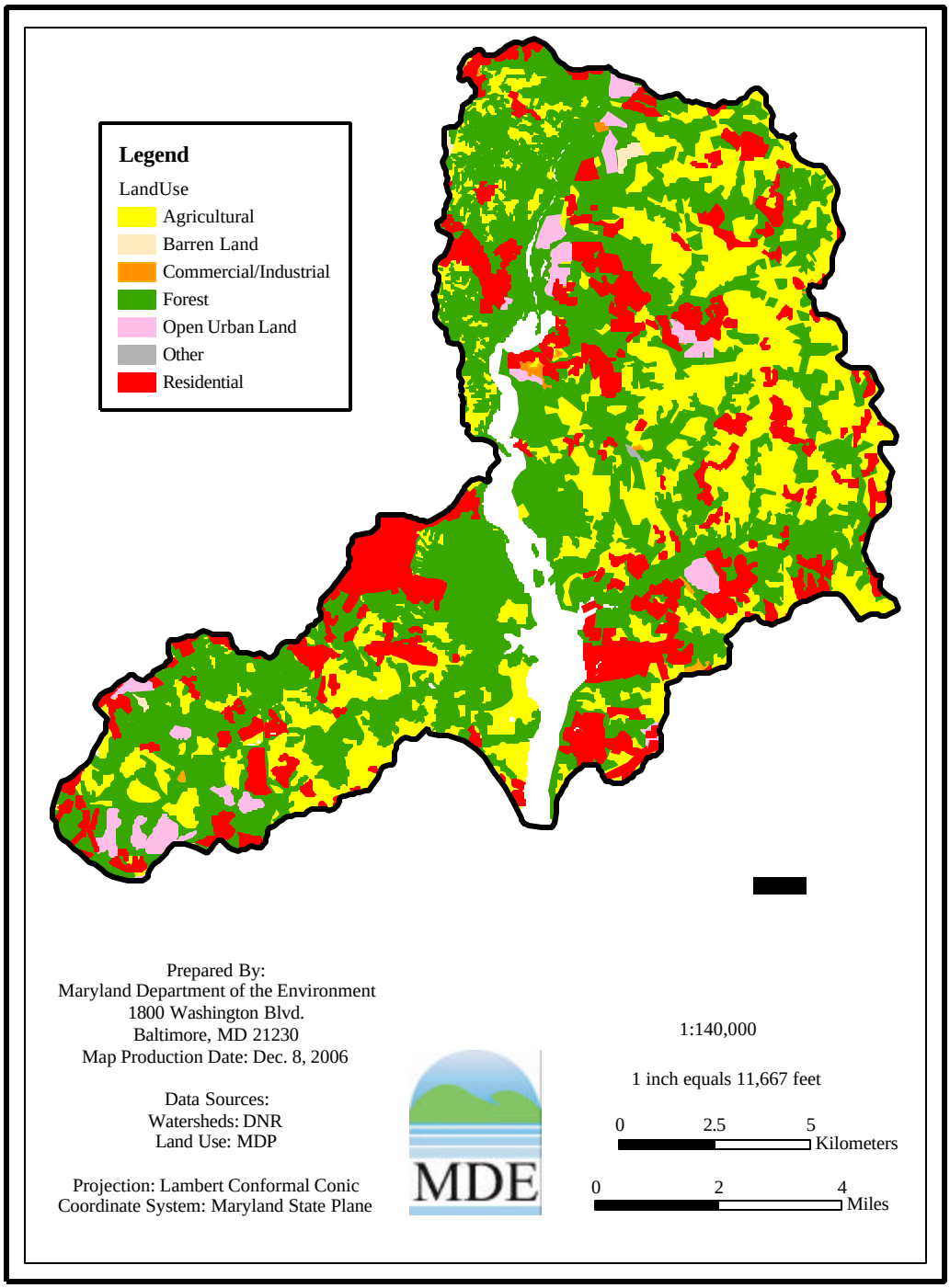


Figure 4: Patuxent River Middle Land Use Map

3.0 WATER QUALITY CHARACTERIZATION

A water quality standard is the combination of a designated use for a particular body of water and the water quality criteria designed to protect that use. Designated uses include support of aquatic life, primary or secondary contact recreation, drinking water supply, and shellfish propagation and harvest. Water quality criteria consist of narrative statements and numeric values designed to protect the designated uses. The criteria developed to protect different designated uses may differ and are dependent on the specific designated use(s) of a waterbody. Maryland's water quality standards presently include numeric criteria for metals and other toxic substances based on the need to protect aquatic life, wildlife, and human health.

The Maryland Surface Water Use Designation for both the Patuxent River Lower and Patuxent River Middle is Use II, *Support of Estuarine and Marine Aquatic Life and Shellfish Harvesting* (COMAR 2006d). Furthermore, COMAR (Code of Maryland Regulations) defines the Patuxent River Middle as a freshwater river segment, while the southern half of the Patuxent River Lower is designated as saltwater and the northern half as freshwater, even though salinity concentrations are found to exceed one ppt (parts per thousand) (COMAR 2006b; USDA 2006). Based on EPA guidance, when salinity concentrations are between one and ten ppt the more stringent of the freshwater and saltwater criteria are applied (US EPA 2006). Thus, the saltwater criteria for chlorpyrifos, which is more stringent than the freshwater criteria, will be applied to the Patuxent River Lower, and the freshwater criteria for chlorpyrifos will be applied to the Patuxent River Middle, as it is not only designated as a freshwater river segment, but also salinity concentrations are not found to exceed one ppt (USDA 2006).

The State of Maryland has not established saltwater acute or chronic criteria for chlorpyrifos under COMAR, nor has it established any freshwater chronic criteria for chlorpyrifos (COMAR 2006c). However, the State's General Water Quality Criteria provide a basis for applying an appropriate numeric chronic threshold for determining a chlorpyrifos impairment in both saltwater and freshwater environments. Specifically, COMAR section 26.08.02.03 (B)(5) states that the waters of Maryland may not be polluted under the following condition:

> (5) Toxic Substances attributable to sewage, industrial wastes, or other wastes in concentrations outside designated mixing zones, which:
>
> (a) Interfere directly or indirectly with designated uses, or
>
> (b) Are harmful to human, plant, or aquatic life (COMAR 2006a)

Elevated levels of chlorpyrifos are proven to cause toxicity in aquatic life, therefore condition 5(b) of the State's General Water Quality Criteria is applicable to this analysis (MDE 2006b). In order to evaluate whether a chlorpyrifos impairment exists in the Patuxent Lower and Middle watersheds, MDE will apply numeric criteria developed under EPA's National Recommended Water Quality Criteria. The criteria recommended by the EPA and subsequently used in this analysis are shown below in Table 1.

Table 1: Numeric Water Quality Criteria

Criteria	Freshwater Aquatic Life Acute (µg/l)	Freshwater Aquatic Life Chronic (µg/l)	Saltwater Aquatic Life Acute (µg/l)	Saltwater Aquatic Life Chronic (µg/l)
Chlorpyrifos	0.083	0.041	0.011	0.0056

* Criteria Taken from EPA's National Recommended Water Quality Standards (US EPA 2006)

Water column surveys used to support this WQA were conducted by the United States Department of Agriculture's (USDA) Environmental Management and Byproduct Utilization Laboratory at nine stations, three in the Patuxent River Middle (Stations TF1.3, WXT0001, and TF1.4) and six in the Patuxent River Lower (Stations LE1.1, TF1.5, TF1.6, TF1.7, RET1.1, and LE1.2), in December 2005 and May 2006. Also, sediment bulk samples were collected at two stations for porewater extraction, one in each watershed (Stations WXT0001 and RET1.1). This sampling allowed for an analysis of surface water and porewater chlorpyrifos concentrations in both the Patuxent River Middle and Patuxent River Lower. Furthermore, the University of Maryland Wye Research and Education Center performed a sediment toxicity test on sediments from the two stations listed above using a standard EPA 10-day amphipod test. Table 2 shows the list of stations with their geographical coordinates, and Figure 5 displays the locations of these stations in the watersheds.

For both the surface water and porewater evaluations, a comparison is made between chlorpyrifos dissolved concentrations and the associated chronic criterion (saltwater for the Patuxent River Lower and freshwater for the Patuxent River Middle) for chlorpyrifos. The water column evaluation and sediment quality evaluation are presented in Sections 3.1 and 3.2 respectively.

Table 2: Sample Stations for the Patuxent River Lower and Middle Watersheds

Station	Latitude	Longitude	Watershed	Station Description
TF1.3	38.8109	-76.7123	Patuxent Middle	Mid-channel from MD Route 4 bridge near Wayson's Corner
WXT0001	38.7835	-76.7133	Patuxent Middle	Midstream at Mt. Calvert House in Upper Marlboro
TF1.4	38.7750	-76.7127	Patuxent Middle	West Shore from Main Pier at Jackson Landing
TF1.5	38.7010	-76.6950	Patuxent Lower	Mid-channel at Nottingham
TF1.6	38.6585	-77.6838	Patuxent Lower	Mid-channel off wharf at Lower Marlboro
TF1.7	38.6033	-76.6736	Patuxent Lower	Mid-channel on a transect of approximate 115 degrees from Jack's Creek
RET1.1	38.5261	-76.6700	Patuxent Lower	Mid-channel 5000 meters ENE of Long Point
LE1.1	38.4300	-76.6089	Patuxent Lower	Mid-channel SSW of Jack Bay Sandpit and Northeast of Sandgates
LE1.2	38.3789	-76.5113	Patuxent Lower	Mid-channel 1600 meters; southwest of Paterson's Point

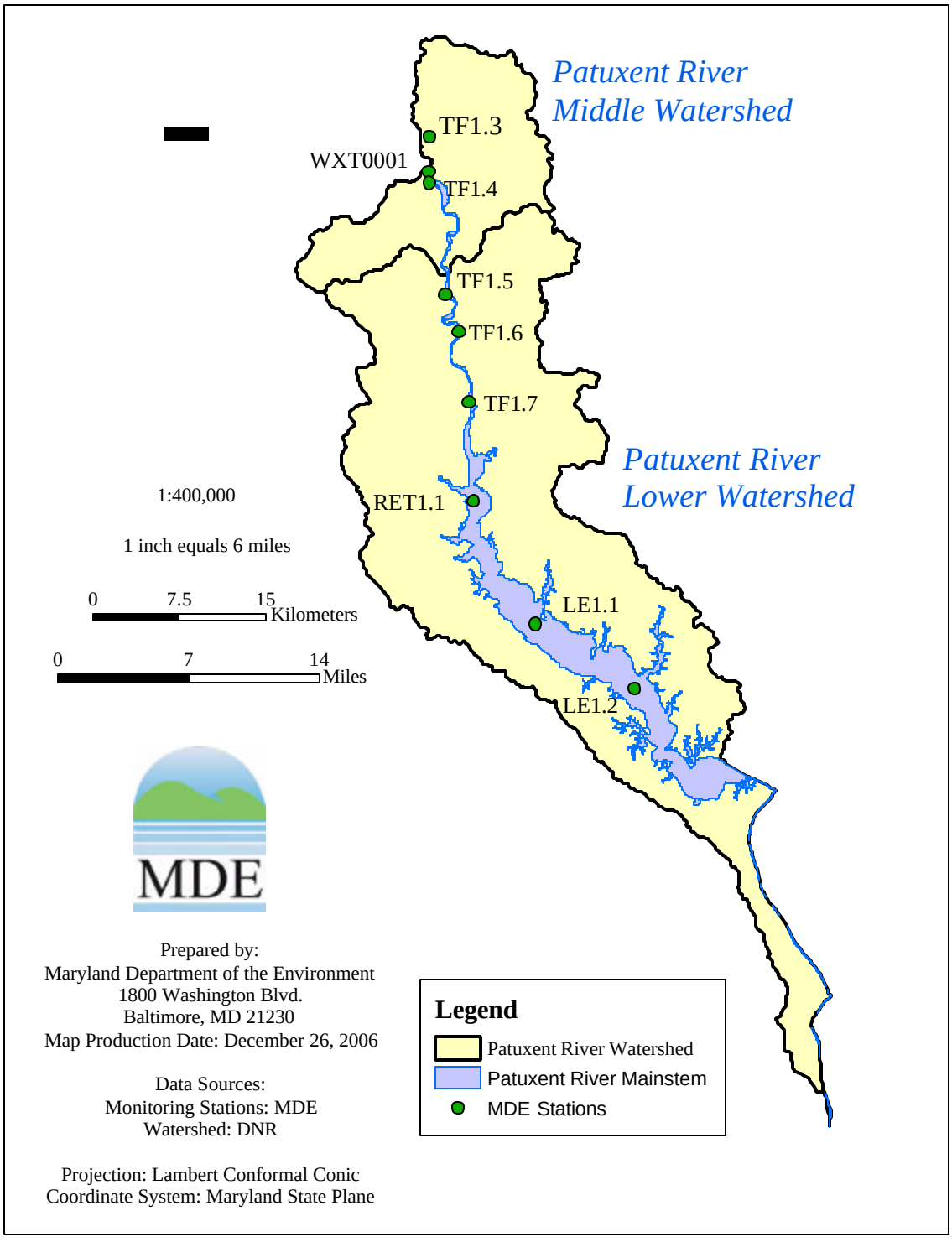


Figure 5: MDE Monitoring Stations in the Patuxent River Lower and Patuxent River Middle

3.1 Water Column Evaluation

MDE conducted a data solicitation for chlorpyrifos and considered all readily available data from the past five years in the WQA. The surface water and porewater data for the Patuxent River Lower and the Patuxent River Middle are presented in Tables 3 and 4 for each station and evaluated using the associated aquatic life freshwater or saltwater chronic criteria, depending on which watershed the station is located in. The surface water and porewater data are also displayed in Figures 6 and 7.

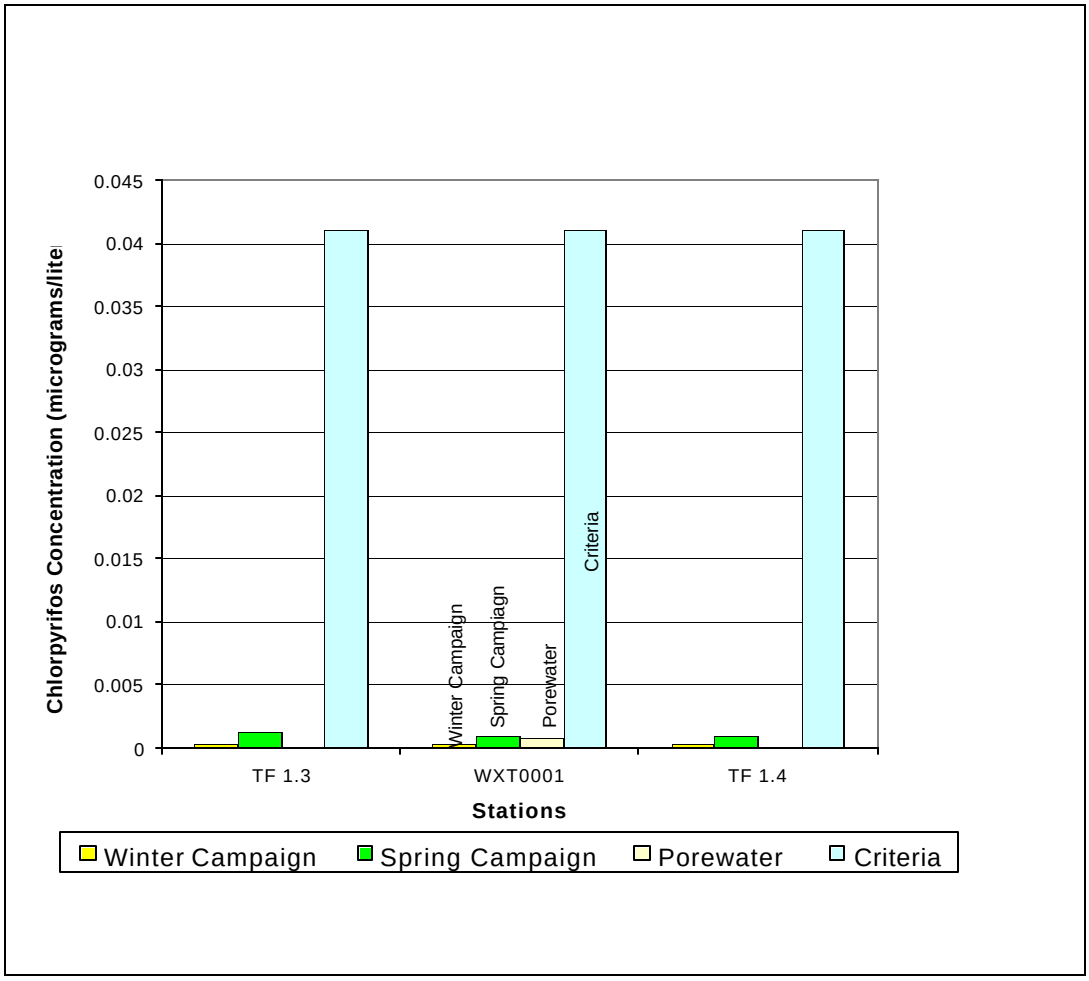
Table 3: Patuxent River Lower and Middle Surface Water Chlorpyrifos Data

Station	Date	Watershed	Chlorpyrifos Concentration (µg/l)*	Chlorpyrifos Criteria (µg/l)	Chronic Criteria Applied
TF1.3	12/15/05	Patuxent Middle	ND**	0.041	Freshwater
	5/15/06	Patuxent Middle	0.0013	0.041	Freshwater
WXT0001	12/15/05	Patuxent Middle	ND	0.041	Freshwater
	5/15/06	Patuxent Middle	0.001	0.041	Freshwater
TF1.4	12/15/05	Patuxent Middle	ND	0.041	Freshwater
	5/15/06	Patuxent Middle	0.00095	0.041	Freshwater
LE1.1	12/15/05	Patuxent Lower	ND	0.0056	Saltwater
	5/15/06	Patuxent Lower	ND	0.0056	Saltwater
TF1.5	12/15/05	Patuxent Lower	ND	0.0056	Saltwater
	5/15/06	Patuxent Lower	ND	0.0056	Saltwater
TF1.6	12/15/05	Patuxent Lower	ND	0.0056	Saltwater
	5/15/06	Patuxent Lower	0.0013	0.0056	Saltwater
TF1.7	12/15/05	Patuxent Lower	ND	0.0056	Saltwater
	5/15/06	Patuxent Lower	0.00084	0.0056	Saltwater
RET1.1	12/15/05	Patuxent Lower	ND	0.0056	Saltwater
	5/15/06	Patuxent Lower	ND	0.0056	Saltwater
LE1.2	12/15/05	Patuxent Lower	ND	0.0056	Saltwater
	5/15/06	Patuxent Lower	ND	0.0056	Saltwater

* Method Detection Limit = 0.00022 µg/l ** ND = Non-detect

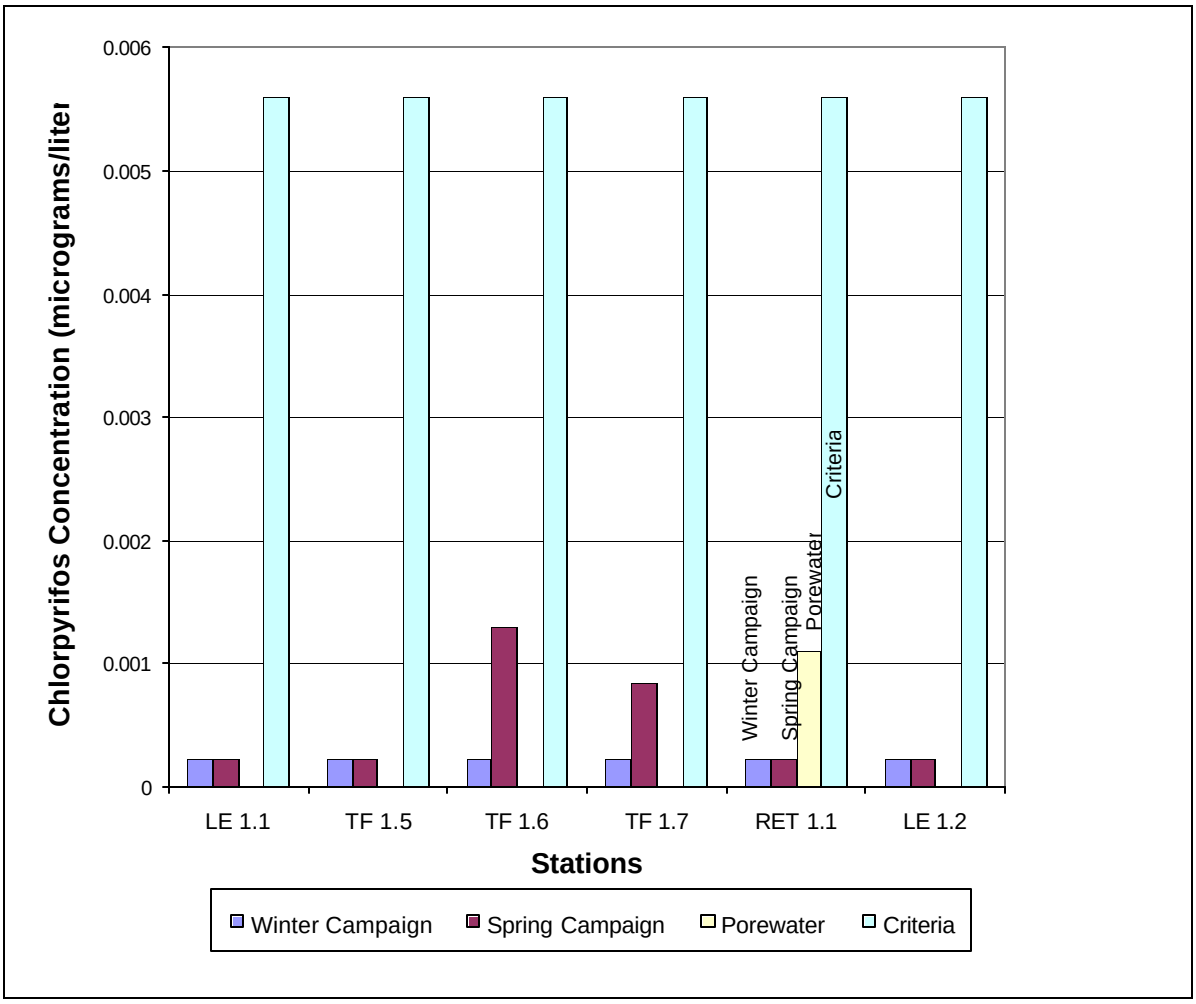
Table 4: Patuxent River Lower and Middle Porewater Chlorpyrifos Data

Station	Date	Watershed	Chlorpyrifos Concentration (µg/l)	Chlorpyrifos Criteria (µg/l)	Chronic Criteria Applied
WXT0001	5/1/06	Patuxent Middle	0.0008	0.041	Freshwater
RET1.1	5/1/06	Patuxent Lower	0.0011	0.0056	Saltwater



* Non detect values displayed as the value of the method detection limit

Figure 6: Patuxent River Middle Surface Water and Porewater Chlorpyrifos Data



* Non detect values displayed as the value of the method detection limit

Figure 7: Patuxent River Lower Surface Water and Porewater Chlorpyrifos Data

The detection limit for both the surface water and porewater chlorpyrifos analysis was 0.00022 µg/l. No sample concentrations of chlorpyrifos in the water column exceed 0.0013 µg/l, and thirteen of the eighteen samples are below the detection limit of 0.00022 µg/l. All concentrations are well below the aquatic life saltwater chronic criteria for chlorpyrifos of 0.0056 µg/l, which also indicates that the samples from the Patuxent River Middle are also below the aquatic life freshwater criteria of 0.041 µg/l. Furthermore, the porewater chlorpyrifos sample concentrations of 0.0008 µg/l for station WXT0001 and 0.0011 µg/l for station RET1.1 are well below their respective criteria (USDA 2006).

3.2 Sediment Quality Evaluation

Sediment quality in the Patuxent River Lower and Middle watersheds was evaluated using two 10-day whole sediment tests. The first of these tests was conducted with the amphipod *Hyalella azteca*, and the second was performed with the amphipod *Leptocheirus plumulosus*. Surficial sediment samples were collected at two stations (RET1.1 and WXT0001) in May 2006 using a stainless steel petite ponar grab ($0.023 m^2$). Refer to Figure 5 for the station locations. Eight replicates containing ten amphipods each were exposed to the contaminated sediment samples, as well as a control sediment sample, for testing (Fisher, Ziegler, and Osborn 2006). The results of the tests are presented in Table 5. The table displays average amphipod survival (%) and average amphipod growth (mg dry weight) for both tests along with the controls for each test. To see the complete results of the sediment toxicity test, see Appendix A.

Table 5: Patuxent River Lower and Middle Sediment Toxicity Test Results

	H. azteca 10-d*			*L. plumulosus* 10-d		
Sample	**Average Survival (%)**	**Initial Weight (mg)**	**Average Growth (mg)**	**Average Survival (%)**	**Initial Weight (mg)**	**Average Growth (mg)**
Control	95.0	0.05	0.19	80.0	0.04	0.22
RET1.1**	97.5	0.05	0.20	86.3	0.04	0.27
WXT0001**	96.3	0.05	0.22	85.0	0.04	0.26

* 10-d = 10 day ** RET 1.1 is in Patuent Lower and WXT0001 is in Patuxent Middle

The tests consider two performance criteria: survival and growth. For the tests to be valid the average survival of control sediment samples must be greater than or equal to 80% and there must be measurable growth (Fisher, Ziegler, and Osborn 2006).

Survival of amphipods in the field sediment samples was actually greater than the average survival demonstrated in the control sediment samples in both tests. The average survival for the control sediment sample in the *H. azteca* 10-d (10-day) test was 95.0% and 80.0% in the 10-d test using *L. plumulosus*. The average survival for the field sediment samples was 97.5% and 96.3% for *H. azteca*, which is higher than the 95.0% control survival rate. *L. plumulosus* had a survival rate of 86.3% and 85.0% at stations RET1.1 and WXT0001 respectively, which is once again higher than the control survival rate of 80.0% (Fisher, Ziegler, and Osborn 2006). No sediment samples in the Patuxent River Lower or Middle exhibited toxicity contributing to mortality.

Average amphipod growth for all field sediment samples was greater than the control sediment samples as well. The control sediment samples exhibited average final dry weights of 0.19 mg in the *H. azteca* test and 0.22 mg in the *L. plumulosus* test. The field sediment for the *H. azteca* 10-d test exhibited 0.20 mg and 0.22 mg final dry weights in both test station sediments, while the field samples for the *L. plumulosus* test exhibited 0.27 mg and 0.26 mg final dry weights (Fisher, Ziegler, and Osborn 2006). In both tests, the field sediment samples had higher average amphipod growths than in the control sediments. Thus, no samples exhibited toxicity contributing to growth inhibition.

4.0 CONCLUSION

The WQA establishes that the water quality standard for chlorpyrifos is being met in both the Patuxent River Lower and Middle watersheds. The surface water and porewater data collected in December 2005 and May 2006 at nine monitoring stations (presented in Table 3 and Table 4) show that concentrations of chlorpyrifos in the water column and sediment do not exceed the water quality criterion recommended by the EPA for chlorpyrifos. An ambient sediment bioassay conducted in both the Patuxent River Lower and Patuxent River Middle established that there is no toxicity in the sediment as a result of chlorpyrifos or other toxics contamination. Therefore, the water column and sediment in the Patuxent River Lower and Middle are not impaired by chlorpyrifos. Thus, the designated uses are supported and the water quality standard is being met.

Barring the receipt of contradictory data, this report will be used to support a chlorpyrifos listing change for both the Patuxent River Lower and Patuxent River Middle from Category 5 (waterbodies impaired by one or more pollutants requiring a TMDL) to Category 2 (Surface waters that are meeting some standards and have insufficient information to determine attainment of other standards), when MDE proposes the revision of Maryland's 303(d) List for public review in the future. Although the waters of the Patuxent River Lower and Middle watersheds do not display signs of toxic impairments due to chlorpyrifos, the State reserves the right to require additional pollution controls in the Patuxent River Lower and Middle watersheds if evidence suggests that chlorpyrifos from the basin is contributing to downstream water quality problems.

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CBP (Chesapeake Bay Program). 1999. *Targeting Toxics: A Characterization Report - A Tool for Directing Management and Monitoring Actions in the Chesapeake Bay's Tidal Rivers*. Annapolis, MD: U.S. Environmental Protection Agency. Also Available at http://www.chesapeakebay.net/pubs/792.pdf.

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Appendix A

Table A-1: Patuxent River Lower and Middle 10-d *Hyallela azteca* Amphipod Sediment Toxicity Test

Sample	Surviving Amphipods (#)	Amphipod Growth (mg)	Average Amphipod Survival (%) (SD)*	Average Amphipod Growth (mg) (SD)*
Control A	10	0.18	95.0 (7.56)	0.19 (0.012)
Control B	10	0.17		
Control C	9	0.17		
Control D	10	0.19		
Control E	8	0.18		
Control F	10	0.20		
Control G	9	0.19		
Control H	10	0.20		
RET1.1 A	9	0.19	97.5 (4.63)	0.20 (0.017)
RET1.1 B	10	0.18		
RET1.1 C	10	0.20		
RET1.1 D	9	0.21		
RET1.1 E	10	0.19		
RET1.1 F	10	0.23		
RET1.1 G	10	0.22		
RET1.1 H	10	0.21		
WXT0001 A	9	0.22	96.3 (5.18)	0.22 (0.019)
WXT0001 B	10	0.20		
WXT0001 C	10	0.23		
WXT0001 D	9	0.25		
WXT0001 E	10	0.24		
WXT0001 F	10	0.20		
WXT0001 G	10	0.20		
WXT0001 H	9	0.22		

* SD = Standard Deviation

Table A-2: Patuxent River Lower and Middle 10-d *Leptocheirus plumulosus* Amphipod Sediment Toxicity Test

Sample	Surviving Amphipods (#)	Amphipod Growth (mg)	Average Amphipod Survival (%) (SD)*	Average Amphipod Growth (mg) (SD)*
Control A	9	0.28	80.0 (14.14)	0.22 (0.053)
Control B	9	0.22		
Control C	7	0.23		
Control D	10	0.15		
Control E	7	0.14		
Control F	9	0.24		
Control G	6	0.19		
Control H	7	0.28		
RET1.1 A	10	0.31	86.3 (19.23)	0.27 (0.056)
RET1.1 B	9	0.36		
RET1.1 C	10	0.22		
RET1.1 D	4	0.22		
RET1.1 E	9	0.26		
RET1.1 F	9	0.20		
RET1.1 G	9	0.25		
RET1.1 H	9	0.31		
WXT0001 A	8	0.24	85.0 (17.73)	0.26 (0.057)
WXT0001 B	5	0.31		
WXT0001 C	9	0.22		
WXT0001 D	9	0.28		
WXT0001 E	10	0.24		
WXT0001 F	7	0.16		
WXT0001 G	10	0.31		
WXT0001 H	10	0.33		

* SD = Standard Deviation