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# **Water Quality Analysis of Lead in Northeast River, Cecil County, Maryland**

**Final**



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**List of Abbreviations**

COMAR	Code of Maryland Regulations
CWA	Clean Water Act
DNR	Maryland Department of Natural Resources
EPA	Environmental Protection Agency
HAC	Hardness Adjusted Criteria
MDE	Maryland Department of the Environment
MDP	Maryland Department of Planning
mg/l	Milligrams per Liter
NPDES	National Pollution Discharge Elimination System
NRCS	National Resource Conservation Service
Pb	Lead
SCS	Soil Conservation Service
SD	Significant Difference
SHA	State Highway Administration
STATSGO	State Soil Geographic
TMDL	Total Maximum Daily Load
UMCES	University of Maryland Center for Environmental Sciences
USGS	United States Geological Survey
WQA	Water Quality Analysis
WQLS	Water Quality Limited Segment
µg/l	Micrograms per Liter
Zn	Zinc

## **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.

Northeast River (basin code 02130608), located in Cecil County, was identified on the State's list of WQLSs as impaired by nutrients (1996 listing), suspended sediments (1996 listing), zinc (Zn) (1996 listing), lead (Pb) (1996 listing), polychlorinated biphenyls (PCBs) (2002 listing), and impacts to biological communities (2002 listing). All impairments were listed for the tidal waters except for impacts to biological communities, which are listed for the non-tidal region. Code of Maryland Regulations (COMAR) 26.08.02.03-1-B(3)(g) defines the Elk River area, which includes the Northeast River, as a fresh waterbody. This report provides an analysis of recent monitoring data, including hardness data, which shows that the aquatic life criteria and designated uses associated with Pb are being met in the Northeast River. The information (P. Jiapizian, personal communication 2001) used for listing Pb is suspect due in part to sampling and analysis methods available at the time, and assessment inconsistencies that led to the listing in 1996.

This report provides an analysis of recent monitoring data, including hardness data, which shows that the aquatic life uses and criteria are being met in the Northeast River watershed, and 303(d) impairment listings associated with Pb are not supported by the analyses contained herein. The analyses support the conclusion that a TMDL for Pb is not necessary to achieve water quality standards. Barring the receipt of contradictory data, this report will be used to support a Pb listing change for the Northeast River 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 listings for PCBs, suspended sediments, and impacts to biological communities will be addressed separately at a future date. A TMDL for nutrients was completed in 2004 and a WQA for Zn was completed in 2005.

Although the waters of the Northeast River watershed do not display signs of toxic impairments due to Pb, the State reserves the right to require additional pollution controls in the Northeast River watershed if evidence suggests that Pb from the basin is contributing to downstream water quality problems.

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## 1.0 INTRODUCTION

Section 303(d) of the federal Clean Water Act (CWA) and U.S. Environmental Protection Agency (EPA)'s 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.

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 those standards, which result in standards being met; or 4) correction to errors made in the initial listing.

Northeast River (basin code 02130608) was identified on the State's 1996 303(d) list as impaired by nutrients, suspended sediments, lead (Pb) and zinc (Zn) with additional listings for polychlorinated biphenyls (PCBs) and impacts to biological communities in 2002. All impairments were listed for the tidal waters except for the impacts to biological communities, which are listed for the non-tidal region. Code of Maryland Regulations (COMAR) defines the Elk River area, which includes the Northeast River, as a fresh waterbody.

The informational basis (P. Jiapizian, personal communication, 2001) for this listing contended that mean levels of Pb exceeded the EPA chronic aquatic life criteria for Pb, and both the acute and chronic criteria for Pb at the time of listing (1996). Although criteria were "exceeded", several methodological flaws in the monitoring and listing assessment used in 1996 exist. First, unfiltered (total metals) samples were compared to dissolved criteria. Second, current criteria for Pb rely on a hardness correction – since no hardness data existed, criteria thresholds using a 100 mg/L "default" hardness value were used for the assessment. Finally, station means for each analyte were calculated setting non-detects at ½ the detection limit. While this procedure may have been appropriately conservative at the time, the sensitivity of analytical instrumentation has improved dramatically, and samples taken currently for Pb have appropriate detection limits that are well below their respective criteria values.

A Water Quality Analysis (WQA) of Pb for the tidal waters of Northeast River was conducted by the Maryland Department of the Environment (MDE) using recent water column chemistry data and sediment toxicity data. A data solicitation was conducted by MDE and all readily available data from the past five years was considered. Accordingly, a TMDL for Pb is not required for Northeast River. The listings for suspended sediments and impacts to biological communities will be addressed separately at a future date. A TMDL for nutrients was completed in 2004 and a WQA for Zn was completed in 2005.

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The remainder of this report lays out the general setting of the waterbody within the Northeast River watershed, presents a discussion of the water quality characterization process, and provides conclusions with regard to the characterization.

### 2.0 GENERAL SETTING

The Northeast River watershed is located in the extreme reaches of the Maryland Portion of the upper Chesapeake Bay watershed (Figure 1). It is located in Cecil County and bounded by the Principio Creek watershed to the west and by the Elk River to the east. Northeast River is tidal (fresh) as far north as the Town of North East, where the head of tide intersects the fall line at the confluence of two major streams, the Northeast Creek and the Little Northeast Creek. The fall line intersects most of the central watershed, traversing both the Northeast Creek to the west, and Little Northeast Creek just to the east. The tidal segment of the Northeast River differs from a true estuary in that there is little intrusion of salt from the lower Chesapeake for the majority of the year; thus, there is neither longitudinal nor lateral distribution of salinity. This atypical tidal exchange produces unusual salinity distributions within the Northeast River. The watershed zone is predominately rural in nature (Figure 2), consisting mainly of animal operations (dairy cows and beef cattle farms) with fields dedicated to feed production. Farms are generally quite large in the region. Limited rural residential uses are present, and the communities of North East and Charlestown, where some impervious surfaces and the Northeast River WWTP are located, are the major urban areas.

The geology and topography, specifically the presence of steep slopes, makes the area very different from that seen throughout the nearby upper Eastern Shore. The steep slope topography and hard rock streambed strata, combined with an abrupt drop to the head of tide, augment the depositional character of Northeast River's tidal zone. Limited commercial fishing is conducted in the tidal zone of the Northeast River. Recreational fishing and general water contact recreation can be found most of the year.

The tidal portion of the river is approximately 5.9 miles (9.4 km) in length, from its confluence with Chesapeake Bay. The depths of the river range from about 6 inches (0.15 m) in the headwaters to greater than 13-15 feet (3.9-4.5 m) at the middle of the river. At the mouth of the river, the depth ranges from 6-7 feet (1.8-2.1 m). The Northeast River watershed has an area of approximately 45,557 acres or 184.4 square kilometers. The land uses in the watershed consist of forest and other herbaceous (18,709 acres or 41.1 %), mixed agriculture (18,680 acres or 41.0%), water (132.5 acres or 0.3%), and urban (8,035 acres or 17.6%) (see Figure 2). These land uses are based on 2000 Maryland Department of Planning (MDP) land use/land cover data and 2000 Pennsylvania Multi Resolution Land Cover (MRLC) Data. Figure 3 shows the relative amounts of the different land uses for the entire watershed including the portion of Pennsylvania.

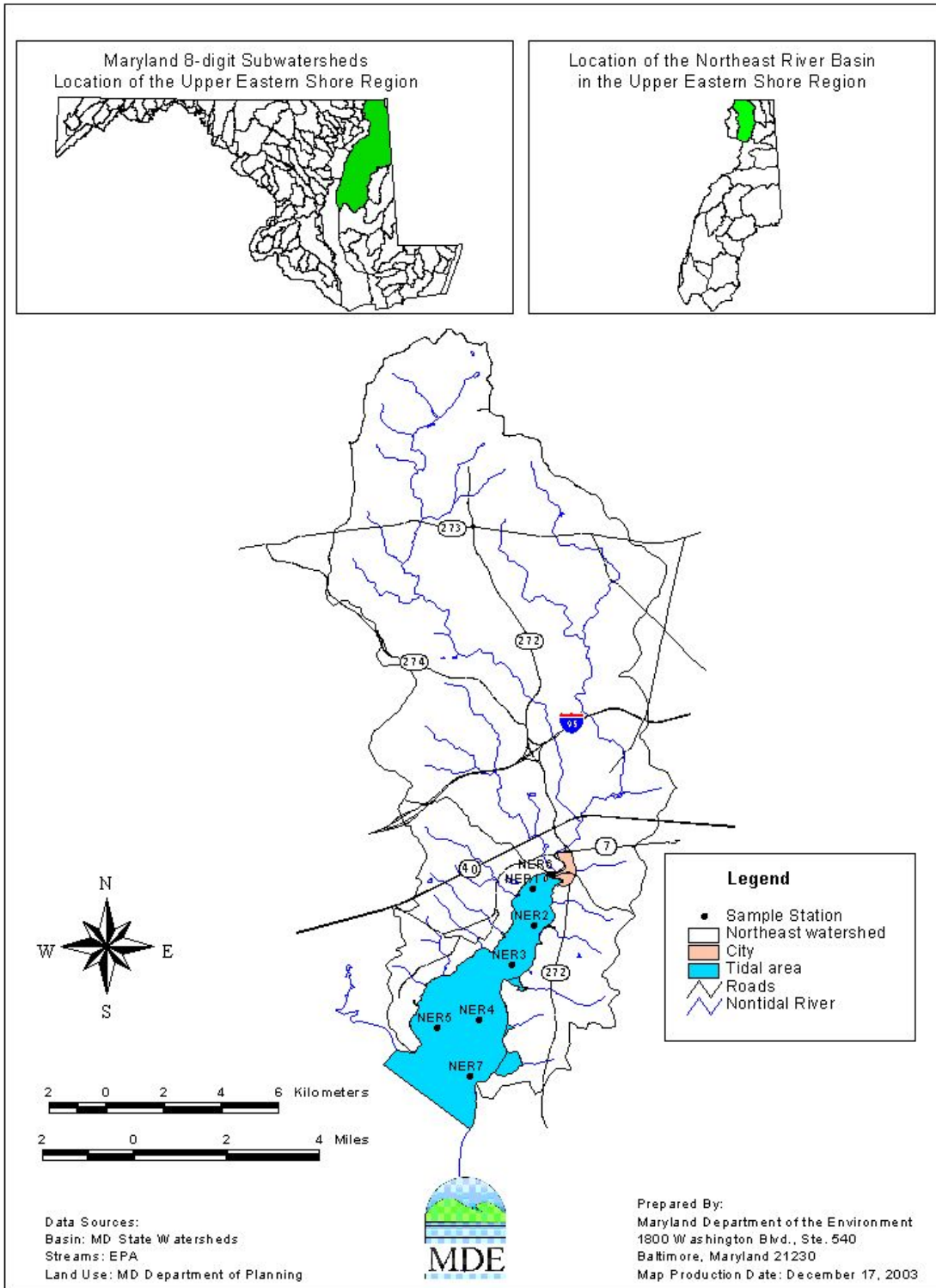
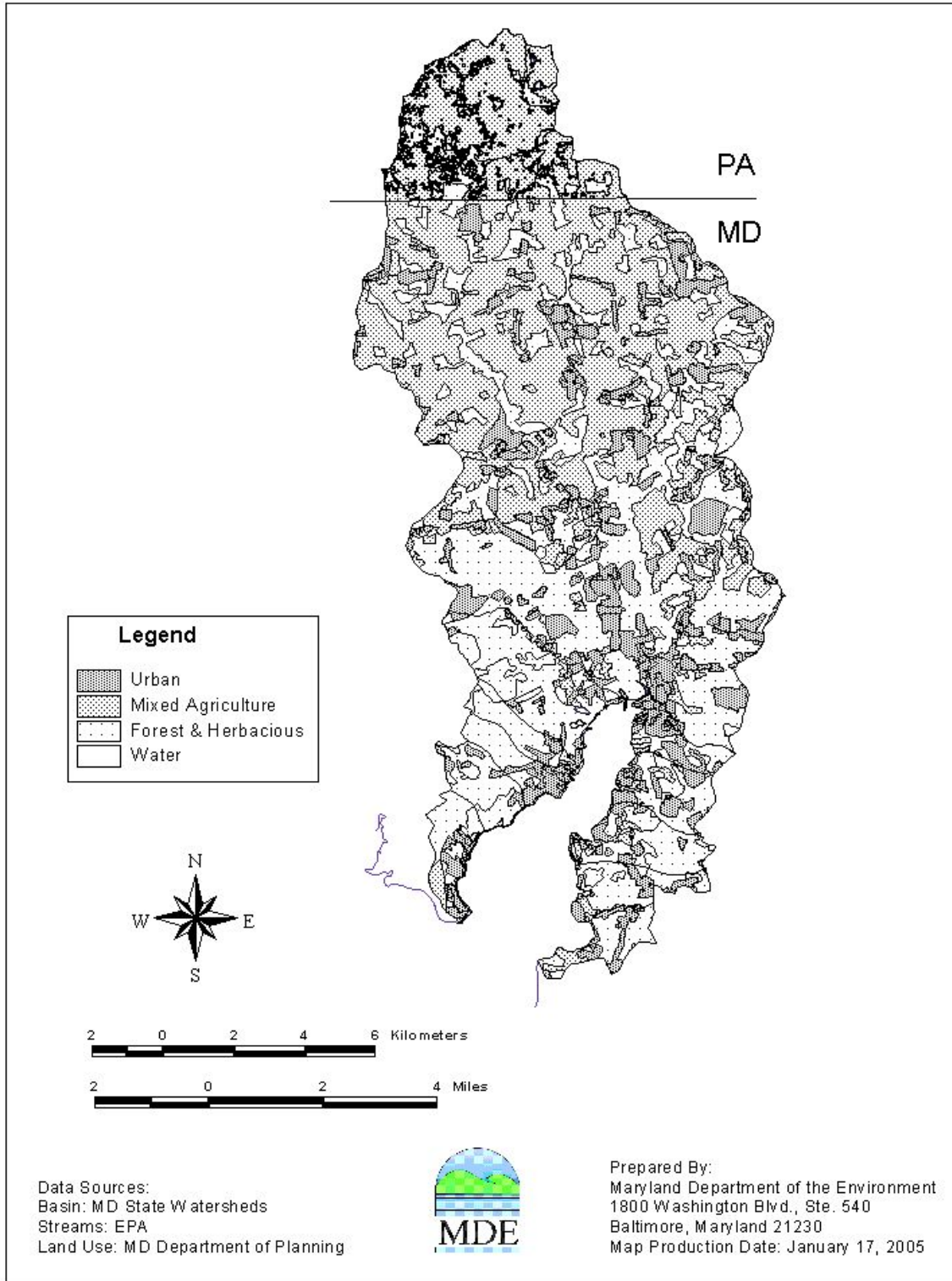
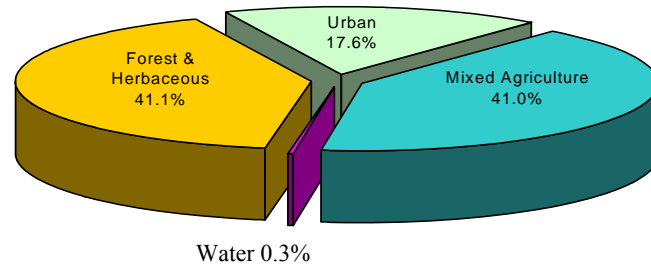


Figure 1: Location Map of the Northeast River Drainage Basin





**Figure 2: Land Use Map of the Northeast River Drainage Basin**



**Figure 3: Proportions of Land Use in the Northeast River Drainage Basin**

### 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. Water quality standards for toxic substances also address sediment quality to ensure the bottom sediment of a waterbody is capable of supporting aquatic life, thus protecting the designated uses.

The Maryland Surface Water Use Designation (COMAR 26.08.02.08H(2)(a)) for the tidal portion of the Northeast River is Use II – shellfish harvesting, water contact recreation, fishing, and protection of aquatic life and wildlife. COMAR 26.08.02.03-1(B)(3)(g) defines the tidal region of the Northeast River basin considered in this WQA as being freshwater. Salinity concentrations for the Northeast River are below 1ppt, thus it is a freshwater body and freshwater criterion may be applied. The freshwater aquatic life criteria (default hardness = 100 mg/L) for Pb are displayed below in Table 1 (COMAR 26.08.02.03-2G).

**Table 1: Numeric Water Quality Criteria\***

Metal	Fresh Water Aquatic Life Acute Criteria (µg/l)	Fresh Water Aquatic Life Chronic Criteria (µg/l)
Pb	65	2.5

\*Criteria based on default hardness of 100 mg/L

Water column surveys, used to support this WQA, were conducted by UMCES at seven stations throughout the Northeast River estuary from March 2003 to September 2003. The sampling dates were as follows: 3/11/03 (winter dry weather); 4/15/03 (spring wet weather); 7/15/03

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(summer dry weather); 9/15/03 (summer wet weather). Additional samples were collected by UMCES in November 2005 to analyze for hardness due to errors in the original dataset.

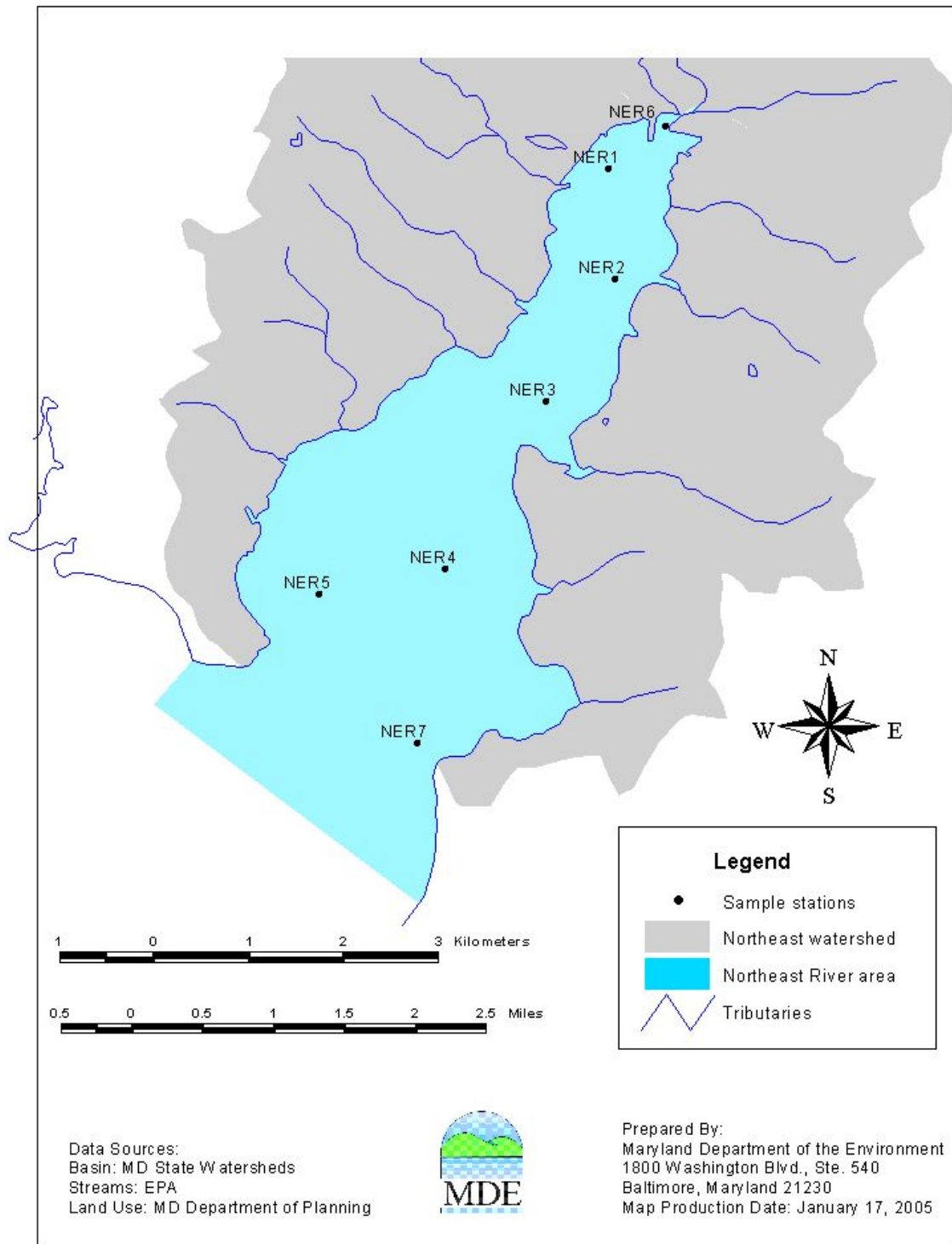
Sediment bulk samples were also collected on 7/15/03 and 9/15/03 at each station. These samples were evaluated for toxicity using a 10-day sediment bioassay. Table 2 shows the list of stations with their geographical coordinates. The station locations are presented in Figure 4.

**Table 2: Sample Stations for Northeast River**

Station	Latitude	Longitude	Description
NER-1	39.589	-75.957	West side of river below headwaters of Northeast River
NER-2	39.578	-75.956	East side of river near Northeast Heights
NER-3	39.565	-75.966	East side of river near Hance Point
NER-4	39.548	-75.979	East side of river near Sandy Cove
NER-5	39.546	-75.996	West side of river near Carpenter Point
NER-6	39.593	-75.950	Headwaters of Northeast River near town of Northeast
NER-7	39.531	-75.983	East side of river near Red Point

For the water quality evaluation, a comparison is made between Pb dissolved water column concentrations and fresh water aquatic life chronic criterion, the most stringent of the numeric water quality criterion for Pb. Water hardness concentrations were obtained for each station to adjust the fresh water aquatic life criteria that water were established at a default hardness of 100 mg/l for Pb (COMAR 26.08.02.03-1-B(3)(g)).

The State uses water hardness adjustment to calculate fresh water aquatic life chronic criteria for those metals (Pb) whose toxicity is a function of total hardness. According to EPA's National Recommended Water Quality Criteria (EPA, November 2002), allowable hardness values must fall within the range of 25 - 400 mg/l. MDE uses an upper limit of 400 mg/l in calculating the hardness adjusted criteria (HAC) when the measured hardness exceeds this value. Based on



**Figure 4: Northeast River Sample Station Location Map**

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technical information, EPA's Office of Research and Development does not recommend a lower limit on hardness for adjusting criterion (EPA, July 2002). A lower limit may result in a criterion that is less protective of the water quality standard. In analyses where available hardness data indicates a value below 25 mg/L, the Department may perform additional analyses to insure data quality objectives for the assessments were met. When data is of questionable quality, the Department will take additional samples to establish the validity of the initial assessment.

Under circumstances where a water quality criterion exceedance is the result of a hardness adjustment below 25 mg/l, the State will perform a scientific review of the following conditions to determine if the exceedance is valid:

- A. Presence/absence of sensitive species in the waterbody of concern.
- B. Existence of other environmental conditions (e.g. high Dissolved Organic Carbon (DOC)), which might mitigate the toxicity of metals due to competitive binding/complexation of metals.

This review is necessary because of the scientific uncertainty existing for hardness-toxicity relationships below 25 mg/l due to limited toxicity test data used to develop the relationship.

The HAC equation for Pb is as follows (EPA, 2002):

$$HAC = e^{(m[\ln(\text{Hardness}(\text{mg/l}))]+b)} * CF$$

Where,

HAC = Hardness Adjusted Criteria ( $\mu\text{g/l}$ )

m = slope

b = y intercept

CF = Conversion Factor (conversion from totals to dissolved numeric criteria)

The HAC parameters for Pb are presented in Table 3 (EPA, 2002).

**Table 3: HAC Parameters (Fresh Water Aquatic Life Chronic Criteria)**

Chemical	Slope (m)	y Intercept (b)	Conversion Factor (CF)
Pb	1.2730	-4.705	$1.462 - \ln(\text{hardness}) * 0.146$

The water column evaluation and sediment quality evaluation are presented in Section 3.1 and 3.2, respectively.

### 3.1 Water Column Evaluation

MDE conducted a data solicitation for metals and considered all readily available data from the past five years in the WQA. The water column data is presented in Table 4 for each station and

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is evaluated against the fresh water hardness adjusted chronic criteria (Baker, 2004 & Heyes, 2007). Table 4 displays hardness (mg/l), detection limit (µg/l), sample concentration (µg/l) and criteria (µg/l) by sampling date. The Pb water column data is also presented in Figure 5.

Concentrations of Pb in the water column are no greater than 0.31 and several samples fall below the detection limit of 0.003. All concentrations are well below their associated freshwater aquatic life hardness adjusted chronic criterion.

**Table 4: Northeast River Water Column Data (Pb)**

Station	Hardness <sup>1</sup> (mg/l)	Date	Detection Limit (µg/l)	Sample (µg/l)	Criteria <sup>2</sup> (µg/l)
NER1	233.75	3/11/03	0.003	0.18	6.257
	233.75	4/15/03		0.16	6.257
	233.75	7/15/03		0.11	6.257
	233.75	9/15/03		BDL	6.257
NER2	327.25	3/11/03	0.003	0.17	6.961
	327.25	4/15/03		0.11	6.961
	327.25	7/15/03		0.07	6.961
NER3	258.68	3/11/03	0.003	0.16	8.897
	258.68	4/15/03		0.09	8.897
	258.68	7/15/03		BDL	8.897
	258.68	9/15/03		BDL	8.897
NER4	215.05	3/11/03	0.003	0.10	5.729
	215.05	4/15/03		0.08	5.729
	215.05	7/15/03		BDL	5.729
NER5	140.25	3/11/03	0.003	0.10	3.630
	140.25	4/15/03		0.06	3.630
	140.25	7/15/03		BDL	3.630
NER6	196.35	3/11/03	0.003	0.11	5.202
	196.35	4/15/03		0.31	5.202
	196.35	7/15/03		0.08	5.202
	196.35	9/15/03		BDL	5.202
NER7	439.45	3/11/03	0.003	0.11	10.944
	439.45	4/15/03		0.05	10.944
	439.45	7/15/03		BDL	10.944
	439.45	9/15/03		0.16	10.944

<sup>1</sup> Hardness data collected in November 2005 due to error in the original dataset

<sup>2</sup> Freshwater Aquatic Life Hardness Adjusted Chronic Criterion

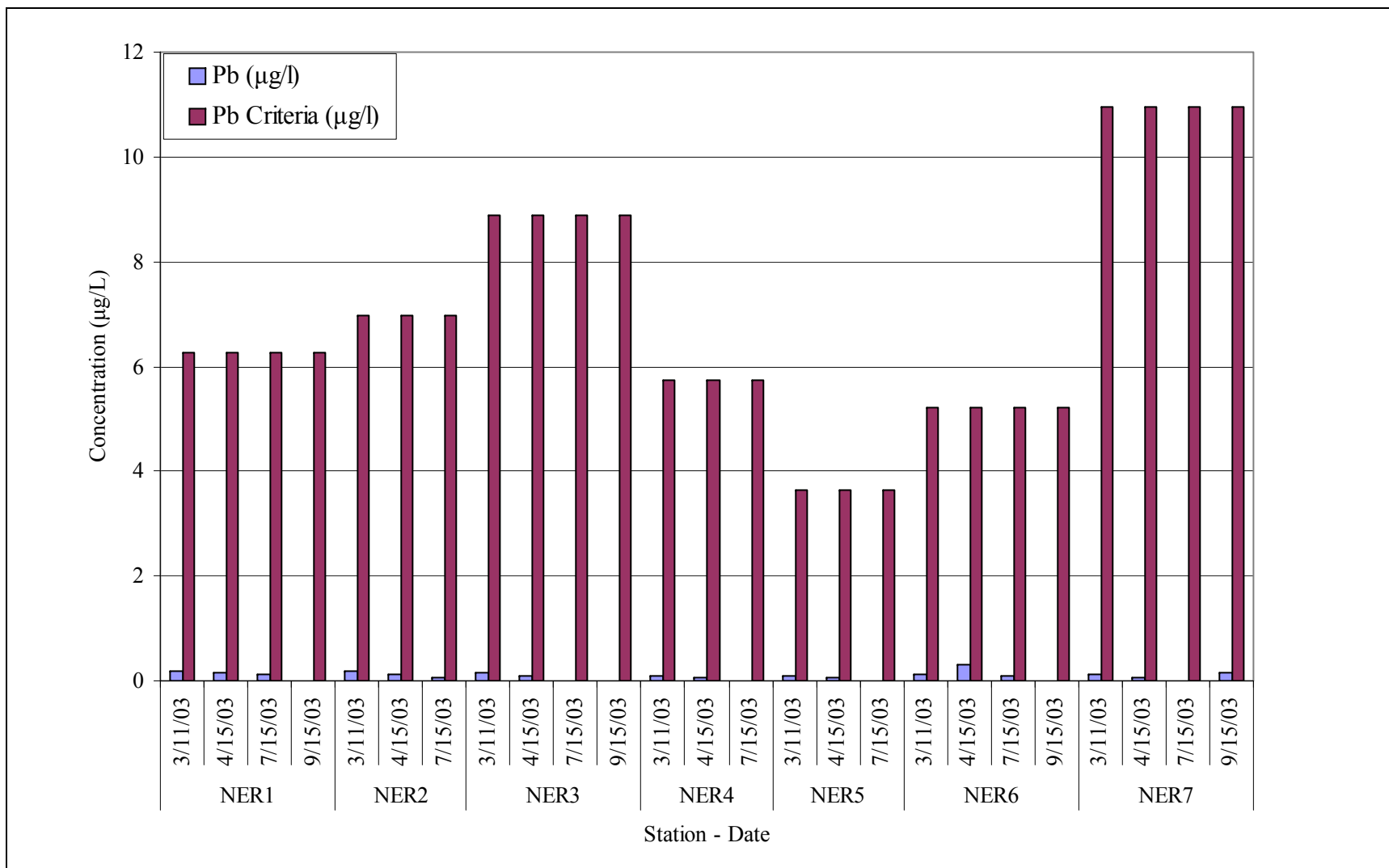


Figure 5: Northeast River Water Column Data (Pb)

### 3.2 Sediment Quality Evaluation

Sediment quality in the Northeast River was evaluated using a 10-day whole sediment test with the freshwater amphipod *Hyalella azteca* (Fisher, 2007). This species was chosen because of its ecological relevance to the waterbody of concern. *Hyalella azteca* is an EPA-recommended test species for assessing the toxicity of freshwater (EPA, 2000). Seven surficial sediment samples were collected on 7/15/03 using a petite ponar dredge (top 2 cm) in the Northeast River. Control sediments were collected from the Wye River, from a depositional area previously characterized as low in contaminants (Fisher, personal communication). Refer back to Figure 4 for the station locations. The results are presented in Table 5. Eight replicates containing ten amphipods each were exposed to the contaminated sediment, as well as a control sediment, for testing. The table displays amphipod survival (#), amphipod growth rate (mg/day), neonates (#), average amphipod survival (%), and average amphipod growth rate (mg/day).

The test considers two performance criteria: survival and growth. For the test to be valid the survival of control sample replicates must be greater than 80% and there must be measurable growth. Survival of amphipods in the field sediment samples was not significantly less than the average survival demonstrated in the control samples. The average survival for control samples in the test was 97.5%. The field sediment sample average survival results were no lower than 93.8%. No sediment samples in the Northeast River exhibited toxicity contributing to mortality.

Average amphipod growth for all field sediment samples was greater than the average growth demonstrated in the control sediment sample. The control sediment sample exhibited an average final dry weight of 0.19 mg, in contrast to a range of 0.21 mg to 0.25 mg average final dry weight for field sediment samples. Thus, no samples exhibited toxicity contributing to growth inhibition.

### 4.0 CONCLUSION

The WQA establishes that the water quality standard for Pb is being met in the Northeast River. The water column data collected from March 2003 through September 2003 at seven monitoring stations (presented in Section 3.1, Table 4) shows that concentrations of Pb in the water column do not exceed the water quality criterion. An ambient sediment bioassay conducted by the University of Maryland Wye Research Center established that there is not toxicity in the sediment as a result of Pb or other toxic substance contamination. Therefore, Pb does not impair the water column or sediment in the Northeast River. 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 Pb listing changed for the Northeast River 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 Northeast River do not display signs of toxic impairments due to Pb, the State reserves the right to require additional pollution controls in the Northeast River if evidence suggests that Pb from the basin is contributing to downstream water quality problems.



**Table 5: Northeast River Sediment Toxicity Test Results**

Test Replicate	Amphipod Survival (#)	Amphipod Weight (mg)	Average Amphipod Survival (%) (SD)	Average Amphipod Weight (mg) (SD)
Control A	10	0.18	97.5 (4.63)	0.19 (0.011)
Control B	9	0.2		
Control C	10	0.2		
Control D	10	0.19		
Control E	9	0.19		
Control F	10	0.17		
Control G	10	0.18		
Control H	10	0.2		
NER-1 A	9	0.18	93.8 (7.44)	0.23 (0.026)
NER-1 B	8	0.25		
NER-1 C	9	0.23		
NER-1 D	10	0.23		
NER-1 E	10	0.22		
NER-1 F	9	0.27		
NER-1 G	10	0.24		
NER-1 H	10	0.22		
NER-2 A	10	0.21	98.8 (3.54)	0.23 (0.016)
NER-2 B	10	0.22		
NER-2 C	10	0.21		
NER-2 D	10	0.24		
NER-2 E	10	0.23		
NER-2 F	9	0.24		
NER-2 G	10	0.21		
NER-2 H	10	0.25		
NER-3 A	10	0.19	96.3 (7.44)	0.22 (0.013)
NER-3 B	10	0.21		
NER-3 C	10	0.21		
NER-3 D	10	0.22		
NER-3 E	8	0.23		
NER-3 F	10	0.22		
NER-3 G	10	0.22		
NER-3 H	9	0.23		

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Test Replicate	Amphipod Survival (#)	Amphipod Weight (mg)	Average Amphipod Survival (%) (SD)	Average Amphipod Weight (mg) (SD)
NER-4 2 A	9	0.22	98.8 (3.54)	0.21 (0.023)
NER-4 2 B	10	0.2		
NER-4 2 C	10	0.21		
NER-4 2 D	10	0.23		
NER-4 2 E	10	0.23		
NER-4 2 F	10	0.19		
NER-4 2 G	10	0.18		
NER-4 2 H	10	0.25		
NER-5 A	11	0.23	97.5 (4.63)	0.24 (0.031)
NER-5 B	9	0.24		
NER-5 C	10	0.22		
NER-5 D	10	0.22		
NER-5 E	9	0.28		
NER-5 F	10	0.23		
NER-5 G	10	0.29		
NER-5 H	10	0.2		
NER-6 A	10	0.22	100.0 (0.00)	0.25 (0.023)
NER-6 B	10	0.26		
NER-6 C	10	0.27		
NER-6 D	10	0.23		
NER-6 E	10	0.21		
NER-6 F	10	0.27		
NER-6 G	10	0.25		
NER-6 H	10	0.25		
NER-7 A	10	0.22	95.0 (5.35)	0.21 (0.018)
NER-7 B	9	0.21		
NER-7 C	10	0.23		
NER-7 D	10	0.21		
NER-7 E	9	0.24		
NER-7 F	9	0.21		
NER-7 G	9	0.18		
NER-7 H	10	0.21		

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