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## **APPENDIX 1**

### **Water Quality Analysis of Copper in Jones Falls Watershed**

## Table of Contents

List of Abbreviations .....	164
List of Figure .....	164
List of Table .....	164
Executive Summary .....	165
1.0 Introduction .....	166
2.0 General Setting.....	167
3.0 Water Quality Characterization .....	172
4.0 Water Column Evaluation.....	173
5.0 Conclusions.....	173
6.0 Reference .....	174



## List of Abbreviations

b.....	Y-intercept
CCC.....	Criterion Continuous Concentration
CF.....	Conversion Factor
COMAR.....	Code of Maryland Regulation
Cu.....	Copper
CWA.....	Clean Water Act
EPA.....	Environmental Protection Agency
HAC.....	Hardness Adjusted Criteria
m.....	Slope
MDE.....	Maryland Department of the Environment
mg/l.....	Milligram per liter
TMDL.....	Total Maximum Daily Load
µg/l.....	Microgram per liter
UMCES.....	University of Maryland Center for Environmental Science
WQA.....	Water Quality Analysis
WQLS.....	Water Quality Limited Segments

## List of Figures

Figure 1: Location Map of Jones Falls watershed.....	168
Figure 2: Station Map Jones Falls watershed.....	169
Figure 3: Freshwater Aquatic life Hardness adjusted chronic Criteria for (Cu).....	172

## List of Tables

Table 1: Freshwater Aquatic Life Criteria for Cu.....	170
Table 2: Locations of water quality stations in Jones Falls watershed.....	170
Table 3: Hardness-adjusted criteria Parameters.....	171
Table 4: Jones Falls water column data (Cu).....	171

## 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.

The Jones Falls (basin code 02-13-09-04) was identified on the State's 1996 list of water quality limited segments (WQLS) as impaired by nutrients, suspended sediments, zinc, copper, lead and chloride. As a result of the WQA in 2006 the 12-digit basin (02-1309-04-10-32) was listed as impaired by copper (Cu). This report provides an analysis of recent monitoring data, including hardness data, which shows that the aquatic life criteria and designated uses associated with copper are being met in the Jones Falls. Barring the receipt of contradictory data, this report will be used to support a Cu listing change for Jones Falls from Category 5 ("Waterbody 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. This analysis supports the conclusion that a TMDL for Cu, for 12-digit basin (02-1309-04-10-32) is not necessary to achieve water quality standards. The nutrient, suspended sediment, lead, and chloride impairments will be addressed separately at a future date.

Although the remaining 12-digit basins in the Jones Falls do not display signs of toxic impairments due to Cu exceeding water quality criteria, the State reserves the right to require additional pollution controls in the Jones Falls watershed if evidence suggest that Cu from the basin is contributing to downstream water quality problems.

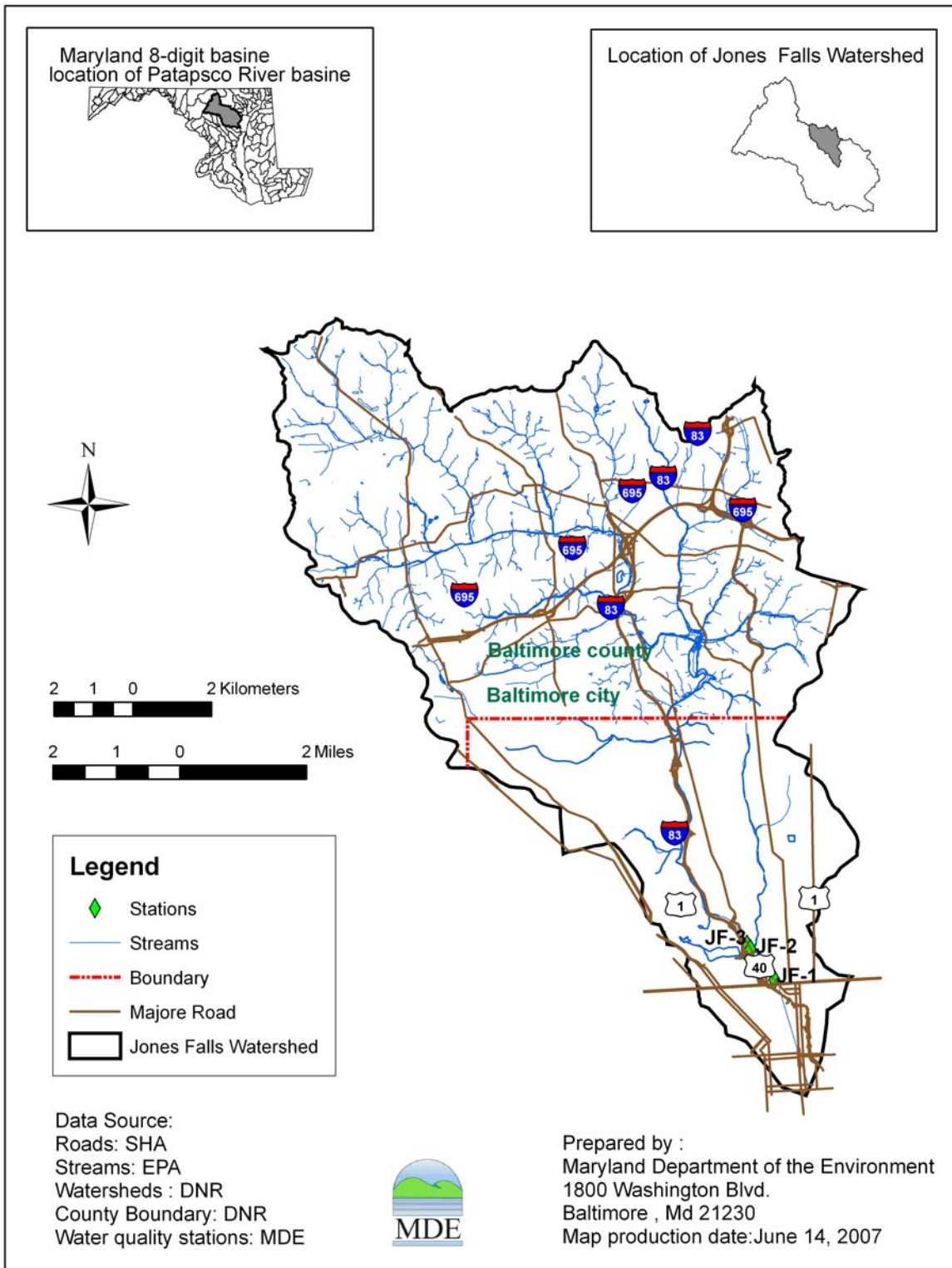
## 1.0 INTRODUCTION

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 (WQLS), 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 water body can receive without violating water quality standards, or demonstrate that water quality standards are being met.

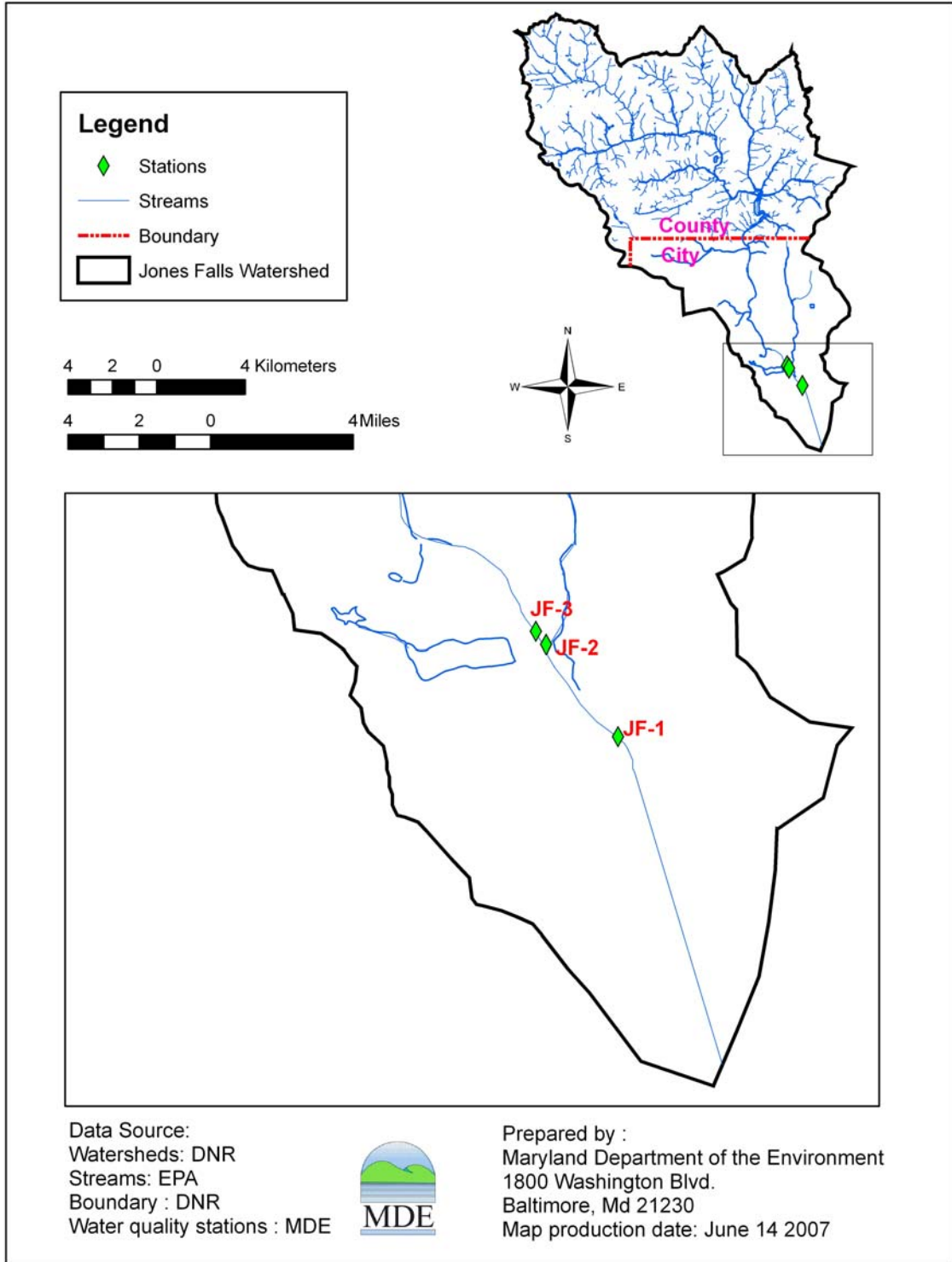
The Jones Falls (basin code 02-13-09-04) was identified on the State's 1996 list of water quality limited segments (WQLS) as impaired by nutrients, suspended sediments, zinc, copper, lead and chloride. As a result of the WQA in 2006 the 12-digit basin (02-1309-04-10-32) was listed as impaired by copper (Cu). This report provides an analysis of recent monitoring data, which shows that the aquatic life criteria and designated uses associated with copper are being met in the Jones Falls. This analysis supports the conclusion that a TMDL of copper is not necessary to achieve water quality standards in this case. The nutrient, suspended sediment, lead, and chloride impairments will be addressed separately at a future date.

## **2.0 GENERAL SETTING**

The Jones Falls watershed is located in the upper western shore region of the Chesapeake Bay watershed within Maryland. The watershed covers portions of Baltimore City and Baltimore County. The watershed area covers 37,700 acres. The Jones Falls watershed drains from northwest to southeast, following the dip of the underlying crystalline bedrock in the Piedmont province. The surface elevations range from approximately 680 feet to sea level at Chesapeake Bay shorelines. Stream channels of the sub-watershed are well incised in the Eastern Piedmont, and exhibit relatively straight reaches and sharp bend, reflecting their tendency to following zones of fractured or weathered rock. The stream channels broaden abruptly as they flow across the fall line and into the soft, flat coastal plain sediments (Coastal Environmental Services, 1995).



**Figure 1: Location Map of Jones Falls Watershed**



**Figure 2: Station Map of Jones Falls Watershed**

### 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. The Maryland surface water use designation (COMAR 26.08.02.08K) for the Patapsco River (basin code 02-13-09) and its tributaries (including Jones Falls) is Use-I, water contact recreation, fishing, and protection of aquatic life and wildlife. 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 substance also address sediment quality to ensure the bottom sediment of a water-body is capable of supporting aquatic life, thus protecting the designated uses. The applicable numeric criteria for copper (dissolved phase) in freshwater is described below in Table 1 (COMAR26.08.02.03-2G).

**Table 1: Freshwater Aquatic Life Criteria For Cu**

Metal	Fresh Water Aquatic Life Criteria (µg/l)		Human Health for Consumption of: (Risk level=10 <sup>-5</sup> (µg/l))	
	Acute	Chronic	Drinking Water + Organism	Organism Only
Copper	13	9	1,300	-

Water column surveys, used to support this Water Quality Analysis, were conducted by the University of Maryland Center for Environmental Science (UMCES). Samples were taken from three stations in 2005 and 2006 (11/15/05 to 05/30/06) and analyzed. Table 2 shows the list of stations with their geographical coordinates and descriptive location in the Jones Falls Watersheds.

**Table 2: Location of Water Quality Stations in Jones Falls Watershed**

Station Id	Coordinates		Station descriptions
	Latitude	Longitude	
Jon-1	39.312	-76.621	Bank sample across Falls Rd. from street car Museum
Jon-2	39.320	-76.629	Falls rd. bank sample north of Potts and Callahan lots.
Jon-3	39.319	-76.628	Bank sample at bottom of paved jogging trail starting at west side of Remington Ave. bridge

For the water column evaluation, a comparison is made between copper dissolved column concentrations and fresh water aquatic life chronic criterion, the best stringent of numeric

criterion for Cu. Water hardness concentrations were obtained for each station to adjust the criteria that were based on a default hardness of 100mg/l. According to EPA’s national recommended water quality criteria (EPA 2002) allowable hardness values must fall within the range of 25-400mg/l. The hardness dependant metals criteria were calculated from the following equation (EPA 1996).

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

Where:

HAC = hardness-adjusted criteria

m = slope

b = y-intercept

CF = conversion factor (conversion from totals to dissolved numeric criteria)

**Table 3: Hardness Adjusted Criteria Parameters**

Chemical	m	b	CF
Copper (Cu)	0.8545	-1.702	0.960

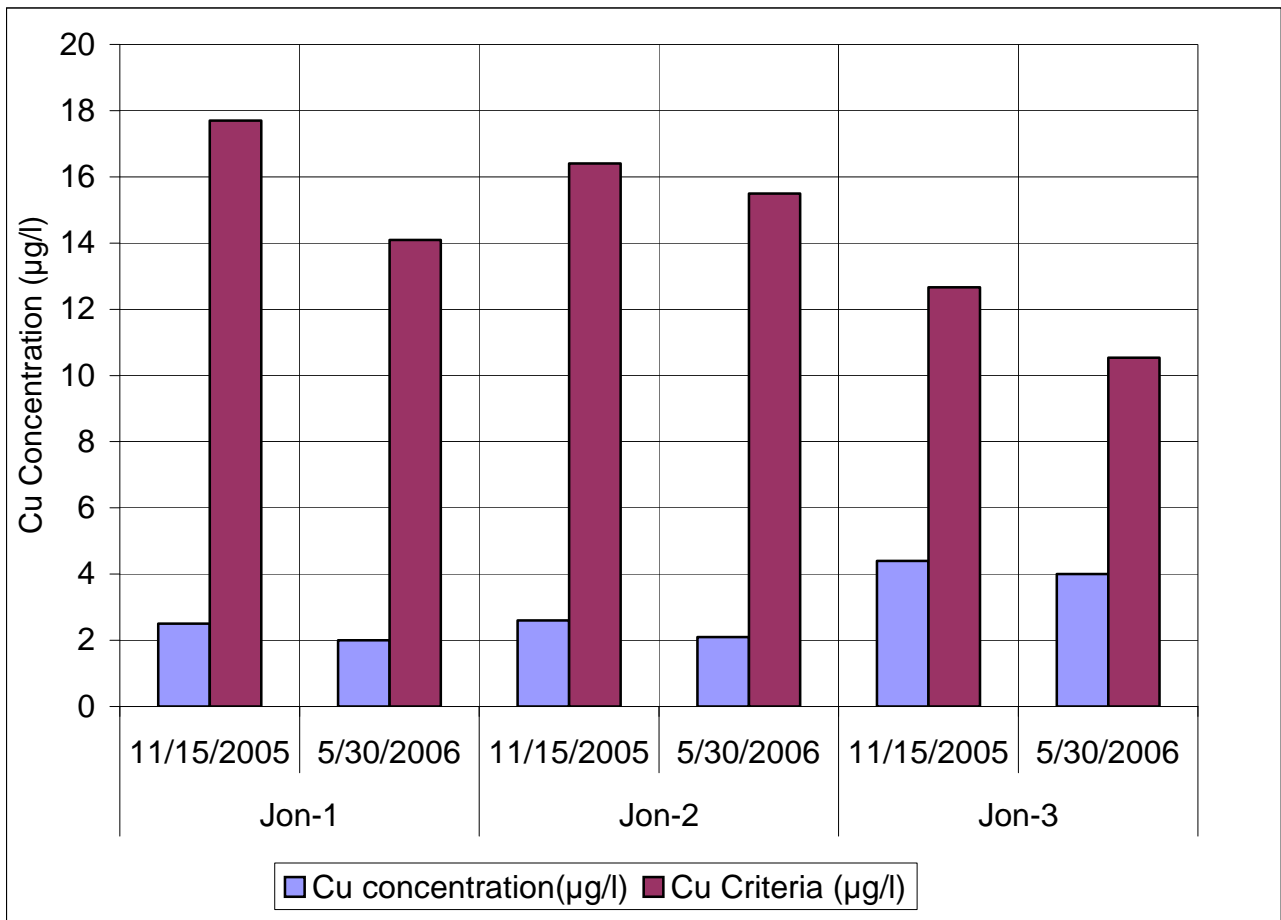
#### 4.0 WATER COLUMN EVALUATION

The water column data is presented in Table 4, for each sampling period. The table displays the hardness (mg/l), copper sample concentration (µg/l) and hardness adjusted chronic criteria concentration (µg/l) for copper at each stations.

**Table 4: Jones Falls Water Column Data (Cu)**

Station Id	Date	Hardness (mg/l)	Cu concentration (µg/l)	Cu criteria (µg/l)
Jon-1	11/15/05	222.0	2.5	17.7
	05/30/06	70.0	2.0	14.0
Jon-2	11/15/05	203.0	2.6	16.4
	05/30/06	190.0	2.1	15.4
Jon-3	11/15/05	150.0	4.4	12.6
	05/30/06	121.0	4.0	10.5





**Figure 3: Freshwater Aquatic Life Hardness Adjusted Chronic Criteria**

The water column data (presented in Section 4.0, Table 4) shows that all concentrations of Cu in the water column are well below their associated fresh water aquatic life hardness adjusted chronic criteria (do not exceed the water quality criterion).

## 5.0 CONCLUSIONS

The data presented above demonstrate that the water quality data analysis for each sampling period in all three stations shows no Cu impairment for 12 digit (02-13-09-04-10-32) Jones Falls basin. The water column data (presented in Section 4.0, Table 4) shows that, all concentrations of Cu in the water column are well below their associated fresh water aquatic life hardness adjusted chronic criteria (do not exceed the water quality criterion). Barring the receipt of contradictory data, this report will be used to support a Cu listing change for Jones Falls from Category 5 (“Waterbody 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. This analysis supports the conclusion that a TMDL for Cu is not necessary to achieve water quality standards for 12 digit (02-13-09-04-10-32) Jones Falls. Although the remaining 12-digit basins in the Jones Falls do not display signs of toxic impairments due to Cu exceeding water quality criteria, the State reserves the right to require additional pollution controls in the Jones Falls watershed if evidence suggest that Cu from the basin is contributing to downstream water quality problems.

## **6.0 REFERENCES**

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## **APPENDIX 2**

### **Water Quality Analysis of Copper and Lead in Lower North Branch Patapsco River Watershed**

## Table of Contents

List of Abbreviations .....	177
List of Figures .....	177
List of Tables .....	177
Executive Summary .....	178
1.0 Introduction .....	179
2.0 General setting .....	179
3.0 Water Quality Characterization .....	182
4.0 Water Column Evaluation.....	183
5.0 Conclusions.....	185
6.0 Reference .....	186

**List of Abbreviations**

b.....Y-intercept  
CF.....Conversion Factor  
COMAR.....Code of Maryland Regulation  
Cu.....Copper  
CWA.....Clean Water Act  
EPA.....Environmental Protection Agency  
HAC.....Hardness Adjusted Criteria  
LNB.....Lower North Branch  
m.....Slope  
mg/l.....Milligram per liter  
MDE.....Maryland Department of the Environment  
Pb.....Lead

TMDL.....Total Maximum Daily Load  
µg/l.....Microgram per liter  
UMCES.....University of Maryland Center for Environmental Science  
WQA.....Water Quality Analysis  
WQLS.....Water Quality Limited Segments

**List of Figures**

Figure 1: Location map of LNB Patapsco River watershed .....180  
Figure 2: Station map LNB Patapsco River watershed .....181  
Figure 3: LNB Patapsco River water column data (Cu).....184  
Figure 4: LNB Patapsco River water column data (Pb) .....185

**List of Tables**

Table 1: Freshwater Aquatic Life Criteria for Cu and Pb.....182  
Table 2: Locations of water quality monitoring stations in LNB Patapsco River .....183  
Table 3: Hardness-adjusted criteria Parameters.....183  
Table 4: LNB Patapsco River water column data (Cu) .....184  
Table 5: LNB Patapsco River water column data (Pb).....184

## 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 water body can receive without violating water quality standards, or demonstrate that water quality standards are being met.

The Lower North Branch (LNB) Patapsco River (basin code 02-13-09-06), located in Baltimore, Howard, and Anne Arundel Counties and Baltimore City was identified on the State's 1996 listing of water quality limited segments (WQLSs) as impaired by nutrients, suspended sediments, heavy metals (1996 listing), fecal coliform (2002 listing), evidence of biological impacts (2002 listing). All the impairments are listed for the non-tidal streams. As a result of the WQA in 2006 the 12-digit basin (02-13-09-06-10-12) was listed as impaired by Copper (Cu) and Lead (Pb). This report provides an analysis of recent monitoring data, including hardness data, which shows that the aquatic life criteria and designated uses associated with Cu and Pb are being met in the Lower North Branch Patapsco River. Barring the receipt of contradictory data, this report will be used to support a Cu and Pb listing change for Lower North Branch Patapsco River from Category 5 ("Waterbody 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. This analysis supports the conclusion that a TMDL for Cu and Pb is not necessary to achieve water quality standards. A Water Quality Analysis for arsenic, cadmium, chromium, mercury, nickel, selenium, and zinc was approved in 2006. The remaining nutrient, suspended sediment, fecal coliform, and biological impairments will be addressed separately at a future date.

Although the remaining 12-digit basins in the LNB Patapsco do not display signs of toxic impairments due to Cu and Pb exceeding water quality criteria, the State reserves the right to require additional pollution controls in the LNB Patapsco watershed if evidence suggest that Cu or Pb from the basin are contributing to downstream water quality problems.

## **1.0 INTRODUCTION**

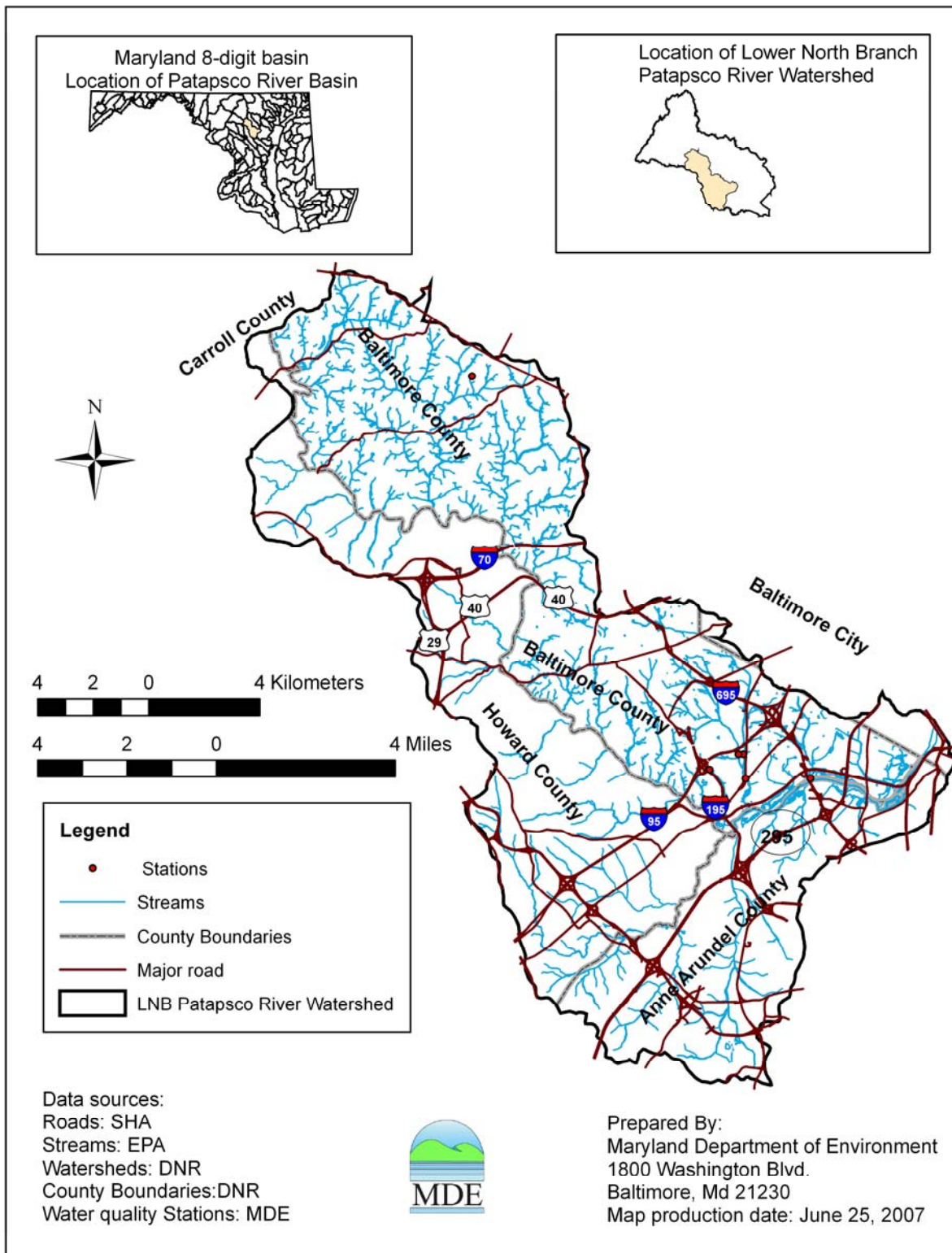
Section 303(d) of the federal Clean Water Act (CWA) and the U.S. Environmental Protection Agency's (EPA) implementing regulations direct each state to identify and list waters, known as water quality limited segments (WQLS), in which current required controls of a specified substance are inadequate to 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 water body can receive without violating water quality standards, or demonstrate that water quality standards are being met.

The Lower North Branch Patapsco River (basin code 02-13-09-06) was identified on the State's 1996 list of water quality limited segments (WQLS) as impaired by nutrients, suspended sediments, heavy metals (1996 listing), fecal coliform (2002 listing), evidence of biological impacts (2002 listing). All the impairments are listed for the non-tidal streams. As a result of the WQA in 2006 the 12-digit basin (02-13-09-06-10-12) was listed as impaired by Cu and Pb. This report provides an analysis of recent monitoring data, which shows that the aquatic life criteria and designated uses associated with Cu and Pb are being met in the Lower North Branch Patapsco River. This analysis supports the conclusion that a TMDL of copper is not necessary to achieve water quality standards in this case. A Water Quality Analysis for arsenic, cadmium, chromium, mercury, nickel, selenium, and zinc was approved in 2006. The remaining nutrient, suspended sediment, fecal coliform, and biological impairments will be addressed separately at a future date.

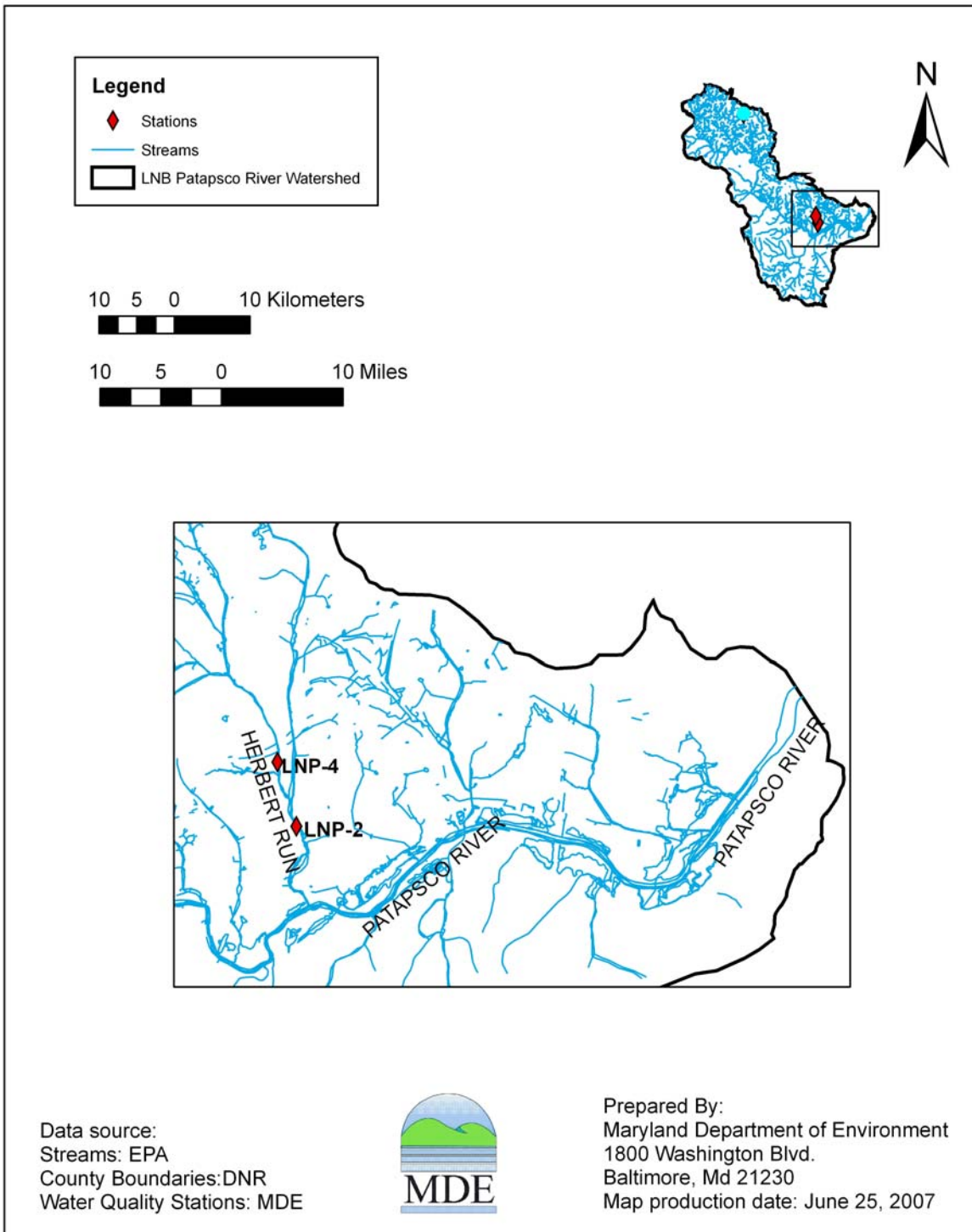
## **2.0 GENERAL SETTING**

The Lower North Branch Patapsco River watershed is located in the Patapsco River region of the Chesapeake Bay watershed within the Maryland. The watershed covers a portion of Baltimore, Howard, and Anne Arundel Counties and Baltimore City. The watershed area covers 75,756 acres. The LNB Patapsco River watershed lies within the Piedmont and Coastal Plain provinces of Central Maryland. The piedmont provinces characterized by gentle to steep rolling topography, low hills and ridges. The surficial geology is characterized by crystalline rocks of volcanic origin consisting primarily of schist and gneiss. These formations are resistant to short-term erosion and often determine the limits of streams bank and streambed. These crystalline formations decrease in elevation from northwest to southeast and eventually extend beneath the younger sediments of the Coastal Plain. The fall line represents the transition between the Atlantic Coastal Plain Province and the Piedmont Province. Thick, unconsolidated marine sediments deposited over the crystalline rock of the piedmont province characterized the Atlantic Coastal plain surficial geology. The deposits include clays, silts, sands and gravels. The surface elevations range from approximately 620 feet to sea level at Chesapeake Bay shorelines. Stream channels of the sub watershed are well incised in the Eastern Piedmont, and exhibit relatively straight reaches and sharp bend, reflecting their tendency to following zones of fractured or weathered rock. The stream channels broaden abruptly as they flow across the fall line and into the soft, flat coastal plain sediments (Coastal Environmental Services, 1995)





**Figure 1: Location Map of LNB Patapsco River Watershed**



**Figure 2: Station Map of Jones Falls Watershed**

### 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. Wild - life and human health.

The Maryland surface water use designation (COMAR 26.08.02.08K) for the Patapsco River (basin code 02-13-09) and its tributaries is Use I, water contact recreation, fishing, and protection of aquatic life and wildlife. Water quality standards for toxic substance also address sediment quality to ensure the bottom sediment of a waterbody is capable of supporting aquatic life, thus protecting the designated uses. The applicable numeric criteria for copper and lead (dissolved phase) in freshwater is described below in Table 1 (COMAR 26.08.02.03-2G).

**Table 1: Freshwater Aquatic Life Criteria for Cu and Pb**

Metal	Fresh Water Aquatic Life Criteria (µg/l)		Human health for consumption of: (Risk level=10 <sup>-5</sup> (µg/l))	
	Acute	Chronic	Drinking Water + Organism	Organism Only
Copper	13	9	1,300	-
Lead	65	2.5	700	220,000

Water column surveys, used to support this Water Quality Analysis, were conducted by the University of Maryland Center for Environmental Science (UMCES). Samples were taken from two stations at Herbert Run in 2005 and 2006 (11/16/05 to 05/30/06) and analyzed. Table 2 shows the list of stations with their geographical coordinates and descriptive location in the LNB Patapsco River Watershed.

**Table 2: Location of Water Quality Stations in LNB Patapsco River Watershed**

Station Id	Coordinates		Descriptions
	Latitude	Longitude	
LNB-2	39.23	-76.69	Herbert Run @ Sulferspring Rd.
LNB-4	39.23	-76.69	Herbert run @Washington Blvd.

For the water column evaluation, a comparison is made between metals (Cu, Pb) dissolved column concentrations and fresh water aquatic life chronic criterion, the best stringent of numeric criterion for Cu and Pb. Water hardness concentrations were obtained for each station to adjust the criteria that were based on a default hardness of 100mg/l. According to EPA’s national recommended water quality criteria (EPA 2002) allowable hardness values must fall within the range of 25-400mg/l. The hardness dependant metals criteria were calculated from the following equation (EPA 1996).

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

Where:

HAC = hardness-adjusted criteria

m = slope

b = y-intercept

CF = conversion factor (conversion from totals to dissolved numeric criteria)

**Table 3: Hardness Adjusted Criteria Parameters.**

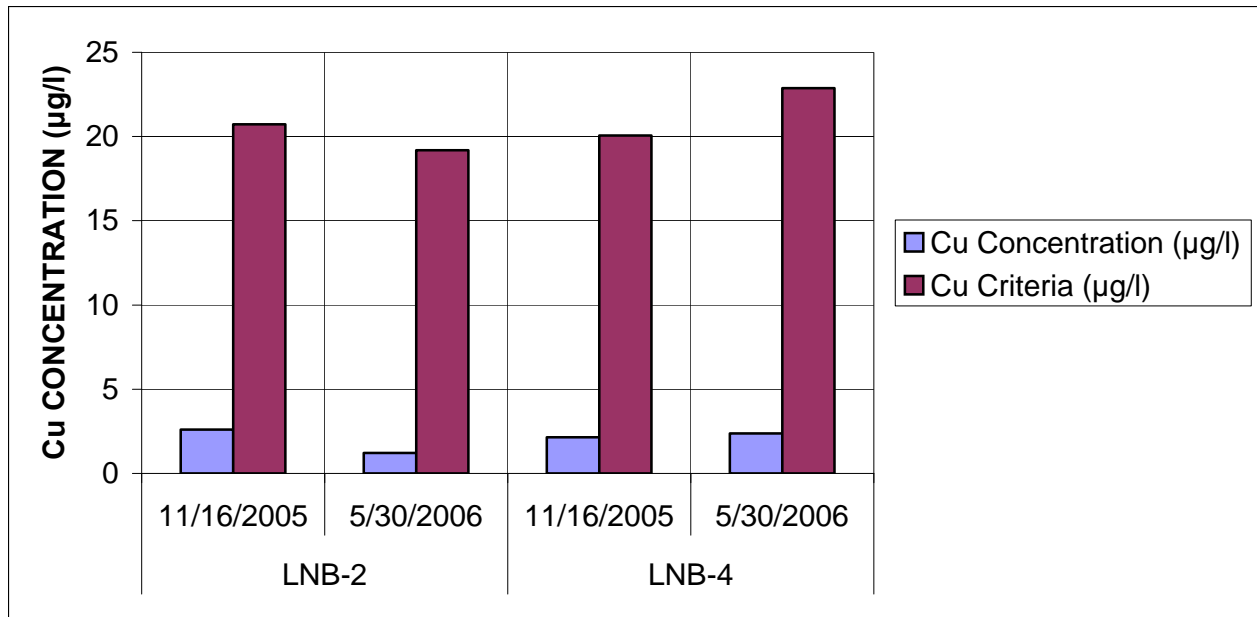
Chemical	m	b	CF
Copper (Cu)	0.8545	-1.702	0.960
Lead (Pb)	1.273	-4.705	$1.46203 - [(\ln \text{hardness})(0.145712)]$

#### 4.0 WATER COLUMN EVALUATION

The water column data is presented in Table 4 (copper) and Table 5 (lead), for each sampling period. The tables display the hardness (mg/l), copper and lead sample concentration (µg/l) and hardness adjusted chronic criteria concentration (µg/l) for copper and lead at each stations.

**Table 4: LNB Patapsco River Water Column Data for Cu.**

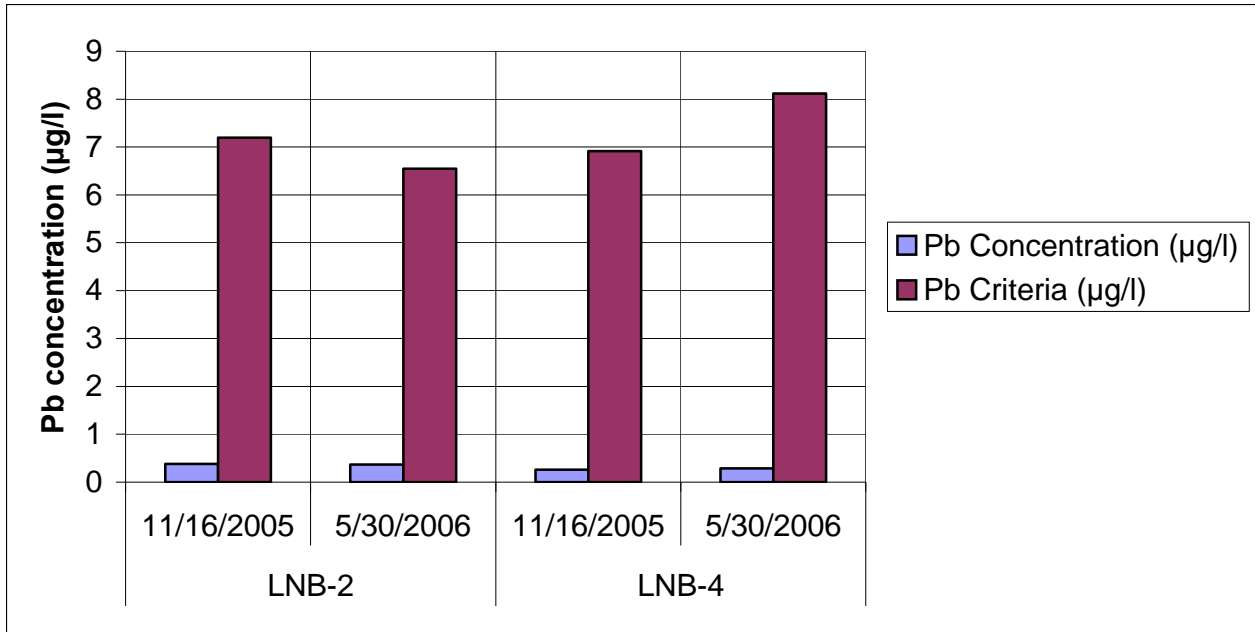
Stations ID	Date	Hardness (mg/l)	Cu concentration (µg/l)	Cu criteria (µg/l)
LNB - 2	11/16/2005	267	2.61	20.73
	05/30/2006	244	1.21	19.19
LNB - 4	11/16/2005	257	2.15	20.06
	05/30/2006	299	2.38	22.87



**Figure 3: LNB Patapsco River Water Column Data for Cu**

**Table 5: LNB Patapsco River Water Column Data for Pb.**

Stations ID	Date	Hardness (mg/l)	Pb concentration (µg/l)	Pb criteria (µg/l)
LNB - 2	11/16/2005	267	0.38	7.19
	05/30/2006	244	0.37	6.54
LNB - 4	11/16/2005	257	0.26	6.91
	05/30/2006	299	0.29	8.11



**Figure 4: LNB Patapsco River Water Column Data for Pb.**

The water column data (presented in Section 4.0, Table 4 and Table 5 ) shows that all concentrations of Cu and Pb in the water column are well below their associated fresh water aquatic life hardness adjusted chronic criteria (do not exceed the water quality criterion).

## 5.0 CONCLUSION

The WQA establishes that water quality standards for Cu and Pb are achieved in Herbert Run a tributary of the main branch in the lower most 12-digit basin (basin code 02-13-09-04-10-12), The water column data ( presented in section 4.0, Table 4 and Table 5 ) shows that all concentrations of Cu and Pb in the water column are well below their associated fresh water aquatic life hardness adjusted chronic criteria (do not exceed the water quality criterion). Barring the receipt of contradictory data, this report will be used to support a Cu and Pb listing change for Lower North Branch Patapsco River from Category 5 ( “Water body 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. This analysis supports the conclusion that a TMDL for Cu and Pb is not necessary to achieve water quality standards for the 12-digit basin (basin code 02-13-09-04-10-12).

Although the remaining 12-digit basins in the LNB Patapsco do not display signs of toxic impairments due to Cu and Pb exceeding water quality criteria, the State reserves the right to require additional pollution controls in the LNB Patapsco watershed if evidence suggest that Cu or Pb from the basin are contributing to downstream water quality problems.

## **6.0 REFERENCES**

COMAR 26.08.02.02-2G. Numeric Criteria for Toxic Substances in Surface Water.

COMAR 26.08.02.08. Stream Segment Designations.

Coastal Environmental Service, Inc. Patapsco/Back River Watershed Study.  
MDE and TARSA, September 30, 1995.

U.S Environmental Protection Agency: National Recommended water Quality criteria: 2002.  
EPA-822-R-02-047 November 2002