Water Quality Analysis of Metals in Upper North Branch Potomac River, Garrett County, Maryland

FINAL

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List of Abbreviations

AMD	Acid Mine Drainage
ANOVA	Analysis of Variance
Ag	Silver
Al	Aluminum
As	Arsenic
Be	Beryllium
Cd	Cadmium
COMAR	Code of Maryland Regulations
Cr	Chromium
Cu	Copper
CWA	Clean Water Act
DNR	Maryland Department of Natural Resources
EPA	Environmental Protection Agency
Fe	Iron
HAC	Hardness Adjusted Criteria
MDE	Maryland Department of the Environment
MDP	Maryland Department of Planning
mg/l	Milligrams per Liter
Mn	Manganese
Ni	Nickel
NPDES	National Pollution Discharge Elimination System
NRCS	National Resource Conservation Service
Pb	Lead
Sb	Antimony
SCS	Soil Conservation Service
SD	Significant Difference
Se	Selenium
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.

Upper North Branch Potomac River (basin code 02141005), located in Garrett County, Maryland, was identified on the State's list of WQLSs as impaired by metals (1996 listing), sediments (1996 listing), nutrients (1996 listing), low pH (1996 listing) and impacts to biological communities (2002/2004 listing). The listing for metals is based on a water quality assessment found in the 1996 305(b) report developed by the Maryland Department of Natural Resources (DNR).

This report provides an analysis of recent monitoring data, which shows that the aquatic life criteria and designated uses for metals are being met in the Upper North Branch Potomac River watershed, except for the following tributaries: Sand Run (12-digit basin – 021410050040), Laurel Run (12-digit basin – 021410050039), Three Forks Run (12-digit basin – 021410050048), and Elklick Run (12-digit basin – 021410050049), where exceedances of aluminum (Al) and manganese (Mn), and iron (Fe) criteria were found. Exceedances of Fe are also found at four stations along the Upper North Branch Potomac River mainstem above Jennings Randolph Lake. The analyses support the conclusion that a TMDL for metals in the entire Upper North Branch Potomac River 8-digit watershed is not necessary to achieve water quality standards, but TMDLs will be needed in certain subwatersheds.

The major sources of contamination are found in the tributaries and not in the watershed directly feeding the Upper North Branch Potomac River. TMDL development within the impaired tributaries will allow for water quality standards to be met in the mainstem. Therefore, barring the receipt of contradictory data, this report will be used to support a metals listing change for the Upper North Branch Potomac 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. Two samples were collected at each station. The assessment of metals in the tributaries and mainstem of the Upper North Branch Potomac River found two exceedances of Mn criterion in Laurel Run, Sand Run, Three Forks Run, and Elklick Run; two exceedances of Al criterion in Three Forks Runs; one exceedance of Al criterion in Laurel Run; seven exceedances of Fe criterion in the mainstem above Jennings Randolph Lake; two exceedances of Fe criterion in Laurel Run and Three Forks Run; and one exceedance of Fe criterion in Sand Run.

Based on impairment listing methodologies applied by MDE, the tributaries in the Upper North Branch Potomac River with two exceedances (Laurel Run (Mn and Fe), Elklick Run (Mn) and Three Forks Run (Mn, Al, and Fe)) are impaired and will be placed in Category 5 of the 303(d) List. The tributaries in the Upper North Branch Potomac River with only one exceedance (Sand Run (Fe) and Laurel Run (Al)) contain insufficient data to determine if an impairment exists. Additional monitoring is necessary to establish whether the exceedance was the result of a single anomalous event or further exceedances will occur resulting in an impairment. These tributaries will be placed in Category 3 ("waterbodies having insufficient data or information to determine impairment status") of the 303(d) List. The North Branch Potomac River mainstem above Jennings Randolph Lake will be placed in Category 3 of the 303(d) List. The listings for low pH and impacts to biological communities will be addressed separately at a future date. The listings for sediments and nutrients will be addressed in 2006.

Although the waters of the Upper North Branch Potomac River watershed do not display signs of toxic impairments due to metals except for the individually impacted stream segments, the State reserves the right to require additional pollution controls in the Upper North Branch Potomac River watershed if evidence suggests that metals from the basin are 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 (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 standards, which result in standards being met; or 4) correction to errors made in the initial listing.

The Upper North Branch Potomac River (basin code 02141005) was identified on the State's list of WQLSs as impaired by metals (1996 listing), sediments (1996 listing), nutrients (1996 listing), low pH (1996 listing) and impacts to biological communities (2002/2004 listing). The listing for metals was based on a water quality assessment found in the 1996 305(b) report developed by the Maryland Department of Natural Resources (DNR). The informational basis for this assessment was the Maryland Department of the Environment (MDE) 1988 304(l) list, which states that the Upper North Branch Potomac River was impaired by several metals in various tributaries and the mainstem due to numerous mine discharges and acid mine drainage.

A Water Quality Analysis (WQA) of metals for the Upper North Branch Potomac River was conducted by MDE using recent water column chemistry data and sediment toxicity data to determine if an impairment currently exists. The listings for low pH and impacts to biological communities will be addressed separately at a future date. The listings for sediments and nutrients will be addressed in 2006.

Those metals known to cause toxicity in aquatic life and humans are generally defined as the metallic elements from periodic table groups IIA through VIA. At trace levels, many of these elements are necessary to support life. However, at elevated levels they become toxic, may build up in biological systems, and become harmful to aquatic life. For the purposes of this WQA, metals are those priority pollutant metals that are commonly regulated in National Pollution Discharge Elimination System (NPDES) industrial or NPDES stormwater discharges. The following metals were sampled in the Upper North Branch Potomac River: arsenic (As); cadmium (Cd); chromium (Cr); copper (Cu); nickel (Ni); lead (Pb); selenium (Se); silver (Ag) and zinc (Zn). Historically, the Upper North Branch Potomac River watershed was extensively mined. Over time, these mining operations have been discontinued, leaving behind several regions of abandoned mine land. Without remediation, the abandoned mine lands release acid mine drainage (AMD) to the watershed causing elevated levels of acidity and metals in streams.

Due to the presence of abandoned mine lands in the Upper North Branch Potomac River, three non-priority pollutants associated with AMD: aluminum (Al); iron (Fe) and manganese (Mn), will also be evaluated in this WQA.

Basin geological conditions, land use, and past/present industrial practices did not indicate the potential for the presence of other priority pollutants, such as antimony (Sb) and beryllium (Be) - metals commonly found at Superfund sites. If a specific water quality impairment exists that identifies specific metal(s) as impairing substances, sampling and analysis may be limited to those metal(s) of concern.

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

2.0 GENERAL SETTING

Location

The North Branch of the Potomac River forms the border between Maryland and West Virginia from its origin at the Fairfax Stone downstream to its confluence with the South Branch of the Potomac. The Upper North Branch of the Potomac River is defined as the reach between its headwaters in West Virginia and its confluence with the Savage River (Figure 1). The drainage area of the Upper North Branch Potomac River watershed is 67,252 acres.

Geology/Soils

The Upper North Branch Potomac River watershed is situated within the Appalachian Plateaus Province in western Maryland. The surficial geology of the Appalachian Plateaus Province is characterized by gently folded shale, siltstone, and sandstone. Folding has produced elongated arches across the region, which expose Devonian rock at the surface. Coal-bearing strata are preserved in the intervening synclinal basins of these folds. Consequently, this region has been a productive source for coal mining. The topography in the watershed is often steep and deeply carved by winding streams, with elevations ranging up to 3,200 feet.

The Upper North Branch Potomac River watershed lies primarily in the Dekalb soil series. The Dekalb soil series consists of moderately deep, well-drained, loamy soils that developed in material weathered in place from sandstone and some conglomerate and shale bedrock. These nearly level to very steep soils are normally found in stony, mountainous regions. Dekalb soils have rapid permeability and internal drainage (Natural Resources Conservation Service (NRCS), 1977).

Land use

The land use in the Upper North Branch Potomac River watershed is predominantly forest. There are 49,762 acres (74.2%) of park and forest lands evenly dispersed throughout the watershed. The watershed contains 1,999 acres (3.2%) of residential land use and 4,711 acres (7.2%) of commercial land use. Crops and pasture land uses are dispersed through out the watershed, constituting 5,391 acres (8.0%) and 4,828 acres (7.4%), respectively. The land use distribution is based on 2002 Maryland Department of Planning (MDP) land use/land cover data. The Upper North Branch Potomac River land use coverage is displayed in Figure 2.

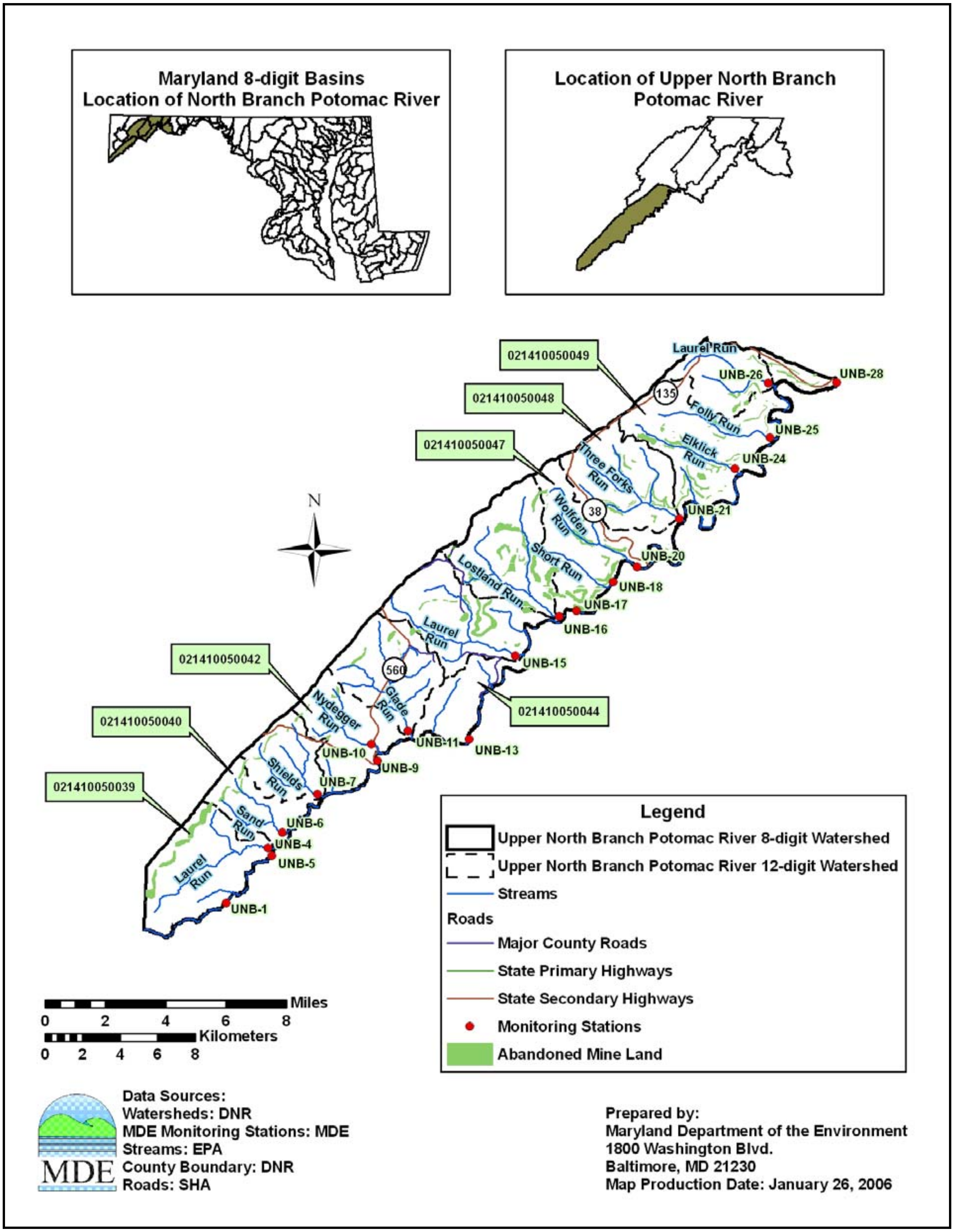

Figure 1: Location Map of the Upper North Branch Potomac River Watershed

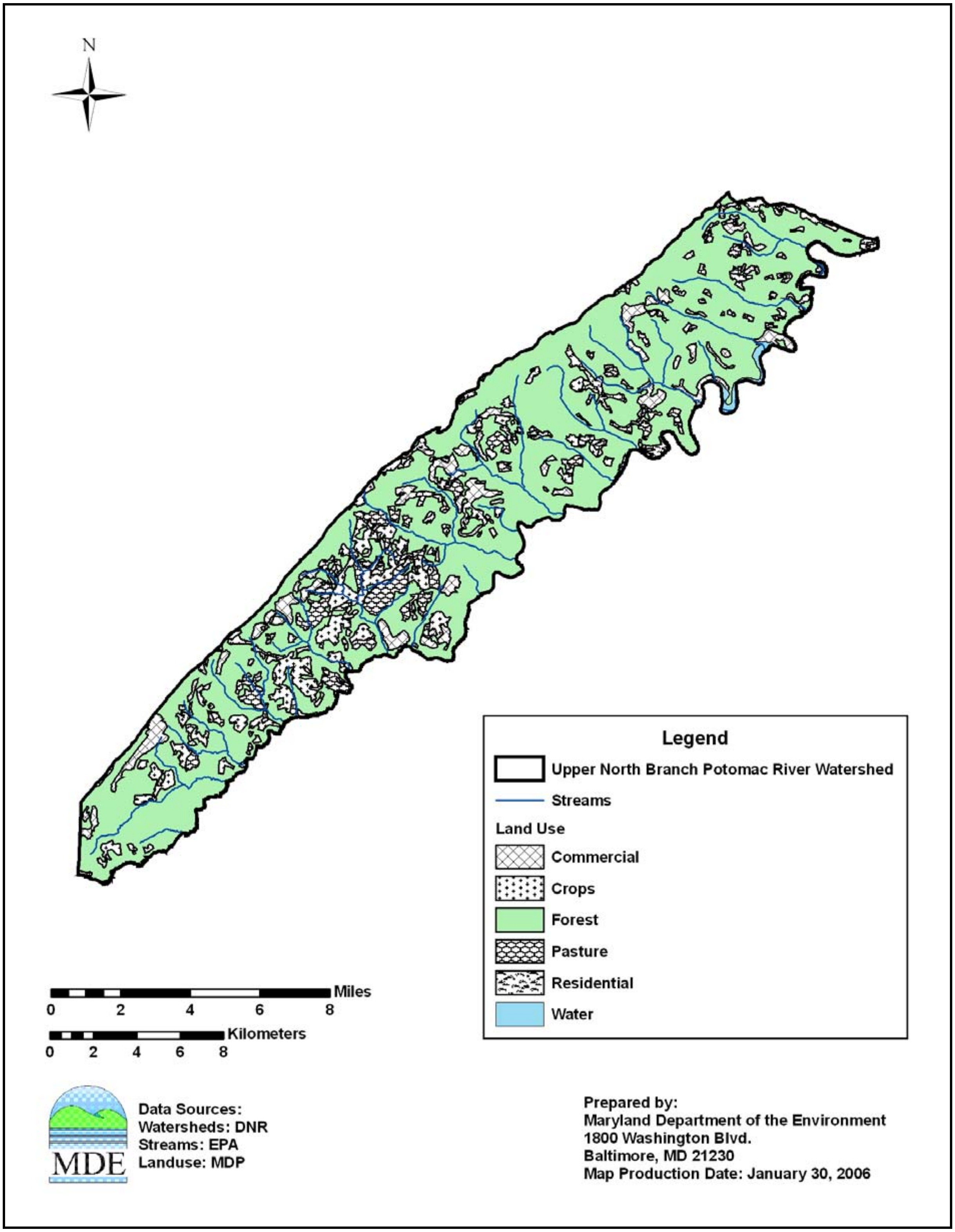

Figure 2: Land Use Map of the Upper North Branch Potomac River Watershed

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, 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 for the Upper North Branch Potomac River (mainstem) is Use I-P, *Water Contact Recreation and Protection of Nontidal Warmwater Aquatic Life and Public Water Supply* (Code of Maryland Regulations (COMAR) 26.08.02.08 (R)(1)(a)). All other tributaries of the Upper North Branch Potomac River are designated Use III-P, *Nontidal Cold Water and Public Water Supply* (COMAR 26.08.02.08 (R)(4)). Samples from the waterbody were analyzed for the following metals*:* As; Cd; Cr; Cu; Ni; Pb; Se; Ag, Zn, Al, Mn, and Fe. Maryland has established numeric water quality criteria for all of these metals except Al, Mn, and Fe.

Although Maryland has not developed numeric water quality criteria for Al, Mn, and Fe, the State's General Water Quality Criteria provide a basis for establishing an appropriate numeric threshold for determining impairment. Specifically, COMAR 26.08.02.03B (2) and (5), the waters of Maryland may not be polluted under the following conditions:

(2) Any material, including floating debris, oil, grease, scum, sludge, and other floating materials attributable to sewage, industrial waste, or other waste in amounts sufficient to:
   - (a) Be unsightly;
   - (b) Produce taste or odor;
   - (c) Change the existing color to produce objectionable color for aesthetic purposes;
   - (d) Create a nuisance; or
   - (e) Interfere directly or indirectly with designated uses;

(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.

Elevated levels of Al and Fe are proven to cause toxicity in aquatic life therefore condition # 5 of the General Water Quality Criteria is applicable to these substances. Mn is non-toxic, though at elevated levels it will cause organoleptic effects (e.g. , taste, staining); therefore, condition # 2 of the General Water Quality Criteria is applicable. EPA's National Recommended Water Quality Criteria for Mn and Fe (EPA, 2006) and West Virginia's water quality criterion for Al (WV

Code of State Rules (CSR) 46-1), address the same effects as those identified in Maryland's General Water Quality Criteria, and the Department finds that they are appropriate for evaluating whether the Upper North Branch Potomac River is impaired by Mn, Fe, and Al.

The aquatic life and human health criteria for the metals considered in this water quality analysis, which protects the identified designated uses, are displayed below in Table 1.

Table 1: Numeric Water Quality Criteria

Metal	Freshwater Aquatic Life* Acute (µg/l)	Freshwater Aquatic Life* Chronic (µg/l)	Human Health (Water + Organism) (µg/l) (10^{-5} risk level)	Human Health (Organism) (µg/l) (10^{-5} risk level)
As	340	150	10	41
Cd	2	0.25	5	-
Cr (III)	570	74	-	-
Cr (VI)	16	11	-	-
Cu	13	9	1300	-
Pb	65	2.5	-	-
Ni	470	52	610	4600
Se	20	5	170	4200
Ag	3.2	-	-	-
Zn	120	120	7400	26000
Al[1]	750	87	-	-
Mn[2]	-	-	500	1000
Fe[3]	-	1000	3000	-

*Aquatic Life Criteria based on default hardness of 100 mg/l
[1]The referenced Al chronic criteria are 87 µg/l for Use III waters and 750 µg/l for Use I waters (WV CSR46-1)
[2]The referenced Mn human health criterion is 500 µg/l for all waters (EPA, 2006)
[3]The referenced Fe human health criterion is 3000 µg/l for all waters (EPA, 2006)

Water column surveys used to support this WQA were conducted by the University of Maryland Center for Environmental Sciences (UMCES) - Appalachian Laboratory at 19 stations throughout the Upper North Branch Potomac River watershed in October 2004 and May 2005. Sediment bulk samples were collected at three stations, UNB-1, UNB-9, and UNB-20. Sediment samples were analyzed for toxicity using a standard EPA freshwater 10-day amphipod test. Table 2 shows the list of stations with their geographical coordinates (See Figure 1 for locations).

Table 2: Sample Stations for the Upper North Branch Potomac River

Station	Latitude	Longitude	Station Description
UNB-1	39.221	-79.437	North Branch Potomac River downstream of headwaters
UNB-4	39.248	-79.413	Laurel Run
UNB-5	39.244	-79.410	North Branch Potomac River upstream of Laurel Run
UNB-6	39.256	-79.403	Sand Run
UNB-7	39.275	-79.382	Shields Run
UNB-9	39.291	-79.346	North Branch Potomac River upstream of Nydegger Run
UNB-10	39.299	-79.346	Nydegger Run
UNB-11	39.305	-79.326	Glade Run
UNB-13	39.325	-79.280	North Branch Potomac River downstream of Laurel Run
UNB-15	39.344	-79.262	Laurel Run
UNB-16	39.363	-79.235	Lostland Run
UNB-17	39.366	-79.226	North Branch Potomac River downstream of Lostland Run
UNB-18	39.380	-79.204	North Branch Potomac River downstream of Short Run
UNB-20	39.396	-79.180	North Branch Potomac River downstream of Wolfden Run
UNB-21	39.412	-79.163	Three Forks Run
UNB-24	39.435	-79.128	Elklick Run
UNB-25	39.452	-79.107	Folly Run
UNB-26	39.477	-79.109	Laurel Run
UNB-28	39.478	-79.068	North Branch Potomac River upstream of Savage River

For the water quality evaluation, a comparison is made between dissolved metals water column concentrations and the freshwater aquatic life chronic criteria. The most stringent numeric water quality criteria for the metals are the aquatic life chronic criteria except for Mn and As in which the human health criteria (fish consumption and drinking water) are more stringent and will be applied. The criteria for Mn and Fe are expressed as total recoverable metals in the water column therefore the water quality evaluation will be made using total instead of dissolved concentrations. For Cr there are two elemental species, trivalent Cr (III) and hexavalent Cr (VI). Cr (VI) has the highest toxicity of the Cr species, therefore the numeric criterion is more stringent. Total dissolved chromium concentrations were analyzed in the water column survey and are compared with the Cr (VI) numeric water quality criterion. Water hardness concentrations were obtained for each station to adjust the freshwater aquatic life criteria that were listed based on a default hardness of 100 mg/l.

MDE calculates freshwater aquatic life criteria as a function of a hardness adjustment formula for metals (Cd, Cu, Pb, Zn and Ni), where toxicity is a function of total hardness. The freshwater aquatic life chronic criteria are not adjusted for As, Cr (VI), Se, Ag, Al, Mn and Fe either because hardness does not affect the bioavailability of these metals to aquatic life or there is significant uncertainty in the correlation between hardness and criteria. 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. When the measured hardness exceeds 400 mg/l, MDE will use this value as an upper limit when calculating the hardness adjusted criteria (HAC). 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 criteria that are less protective of the water quality standard. In analyses where available hardness data indicates a value below 25 mg/l, MDE may perform additional analyses to insure data quality objectives for the assessments were met. When data are of questionable quality, MDE will take additional samples to establish the validity of the initial assessment.

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

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

Where,
HAC = Hardness Adjusted Criteria (µg/l)
m = slope
b = y intercept
CF = Conversion Factor (conversion from totals to dissolved numeric criteria)

The chronic HAC parameters for Cd, Cu, Pb, Ni and Zn are presented in Table 3 (EPA, November 2002).

Table 3: HAC Parameters (Freshwater Aquatic Life Chronic Criteria)

Metal	Slope (m)	y Intercept (b)	Conversion Factor (CF)
Cd	0.7409	-4.719	1.101672-[(ln hardness)(0.041838)]
Cu	0.8545	-1.702	0.96
Pb	1.273	-4.705	1.46203-[(ln hardness)(0.145712)]
Ni	0.846	0.0584	0.997
Zn	0.8473	0.884	0.986

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 and associated criteria for each metal are displayed in Figure 3 through Figure 14 (Morgan, 2005). The water quality data including dissolved metals sample concentrations, hardness, and metals criteria are presented in Appendix A. The method detection limits for metals analyses are displayed in Table 4.

Table 4: Metals Method Detection Limits

Metal	Method Detection Limit (µg/l)
Al	0.204
Cu	0.048
Cd	0.038
Pb	0.036
Zn	0.484
As	0.041
Ni	0.05
Fe	0.1
Cr	0.04
Mn	0.054
Se	0.124
Ag	0.03

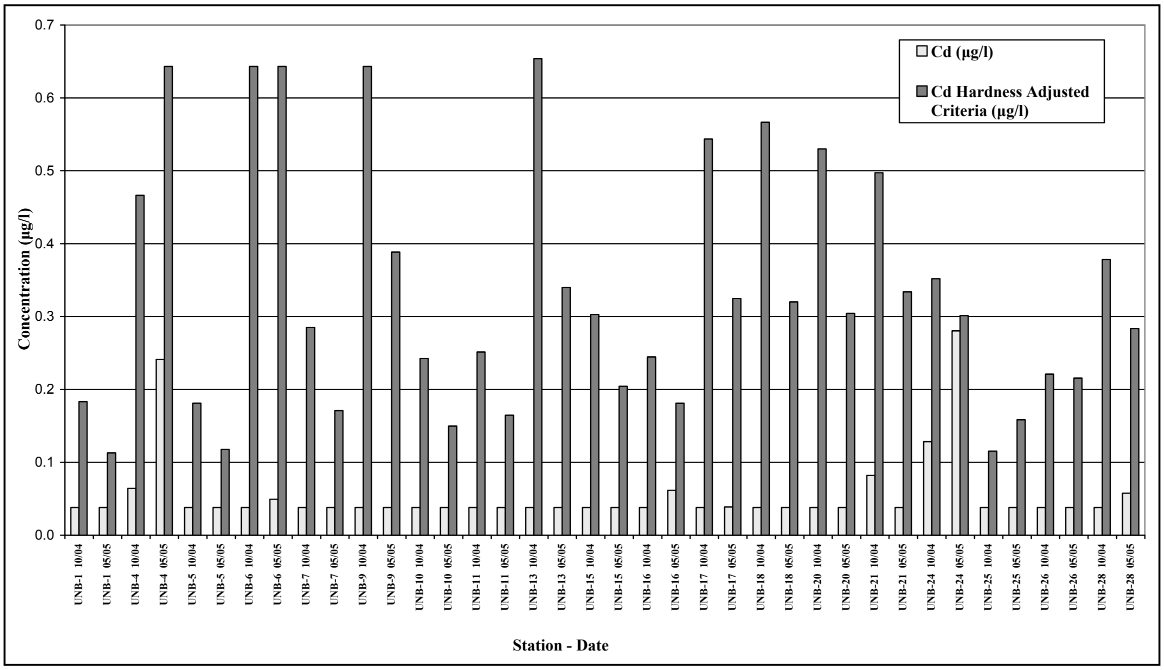

Figure 3: Upper North Branch Potomac River Water Column Data (Cd)

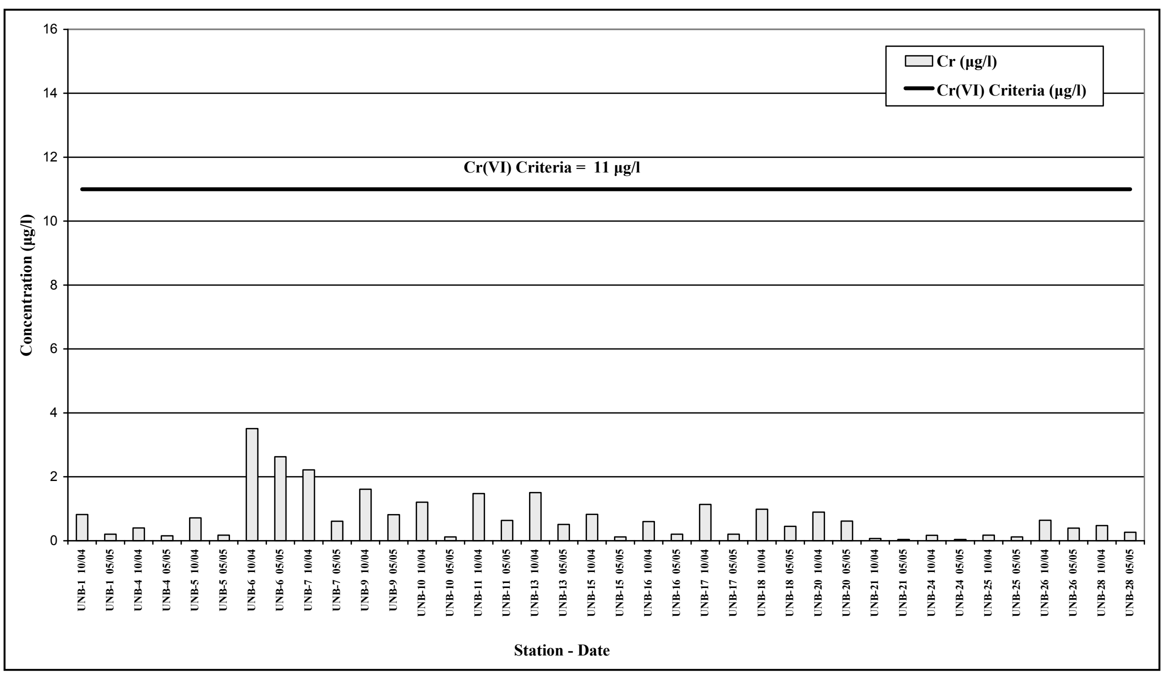

Figure 4: Upper North Branch Potomac River Water Column Data (Cr)

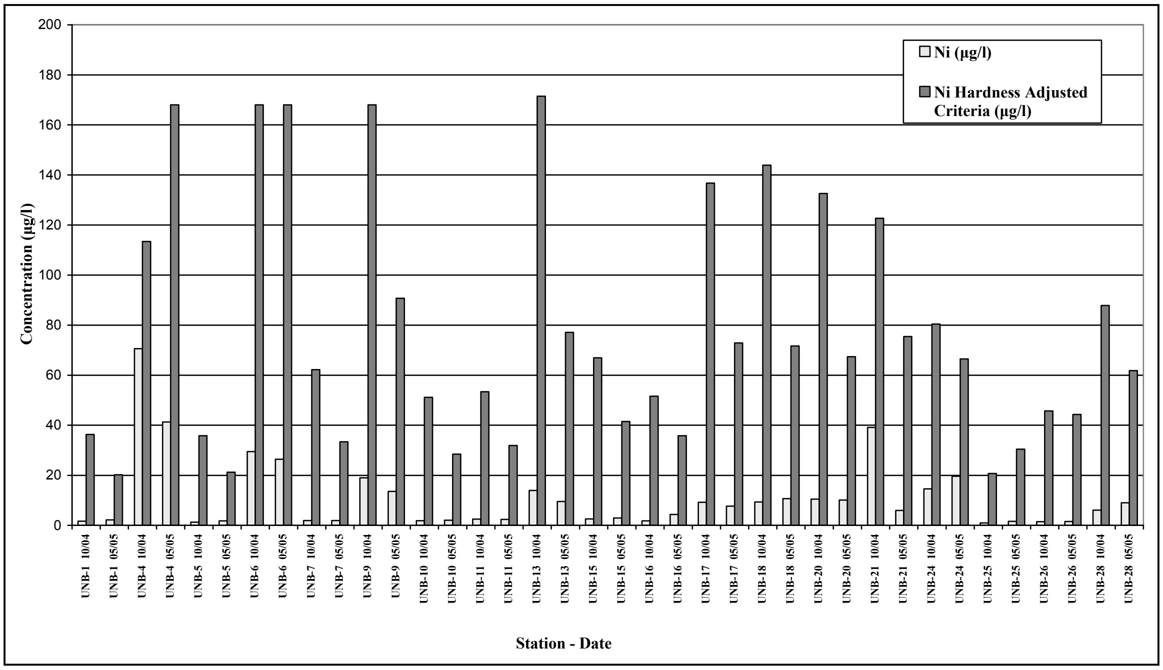

Figure 5: Upper North Branch Potomac River Water Column Data (Ni)

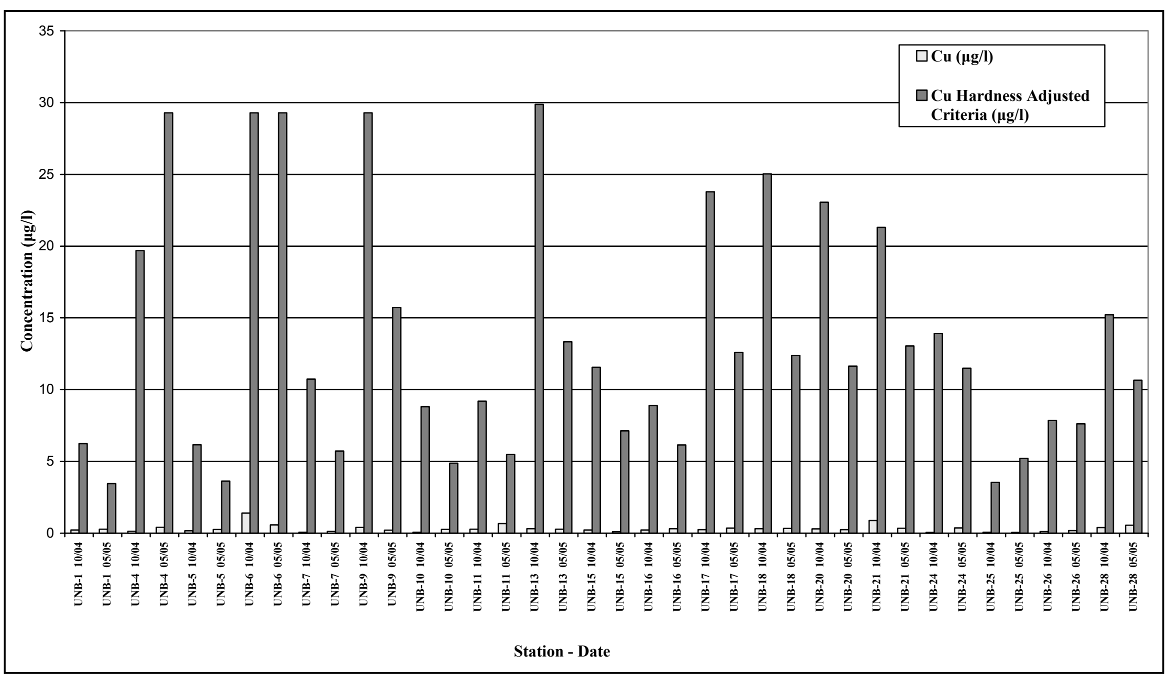

Figure 6: Upper North Branch Potomac River Water Column Data (Cu)

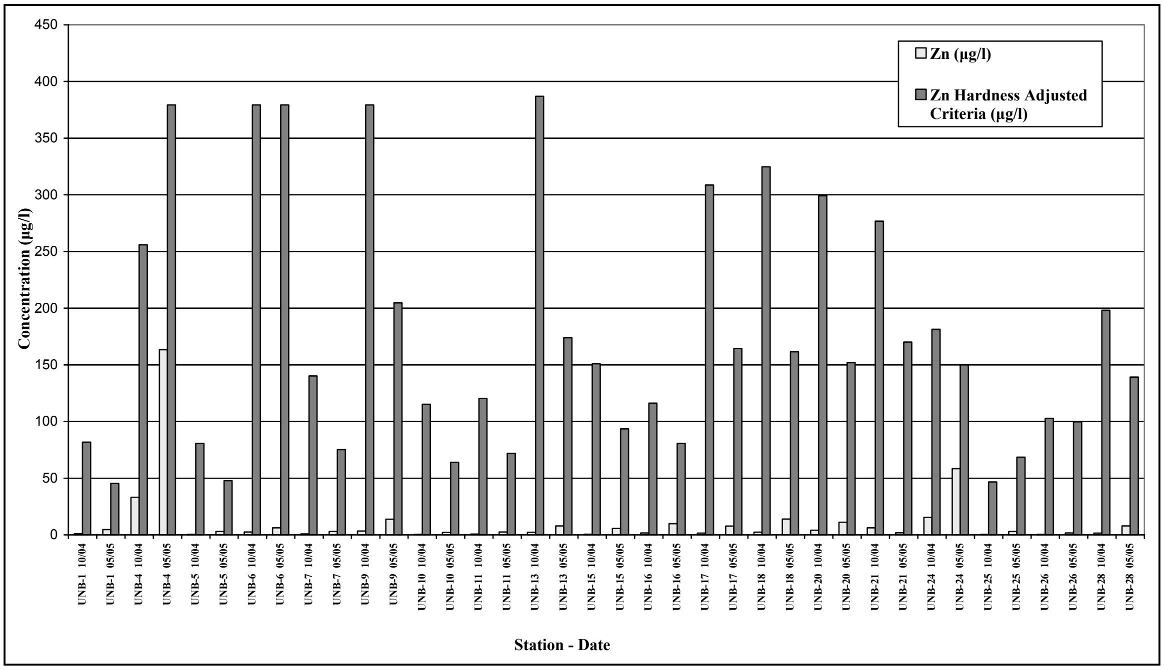

Figure 7: Upper North Branch Potomac River Water Column Data (Zn)

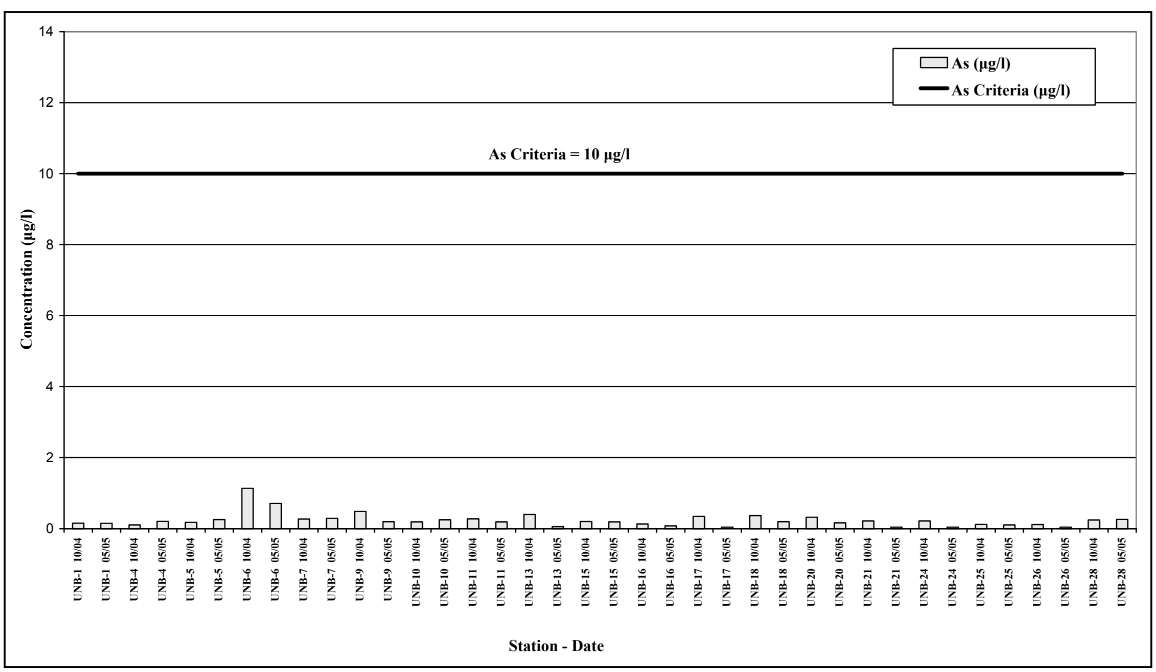

Figure 8: Upper North Branch Potomac River Water Column Data (As)

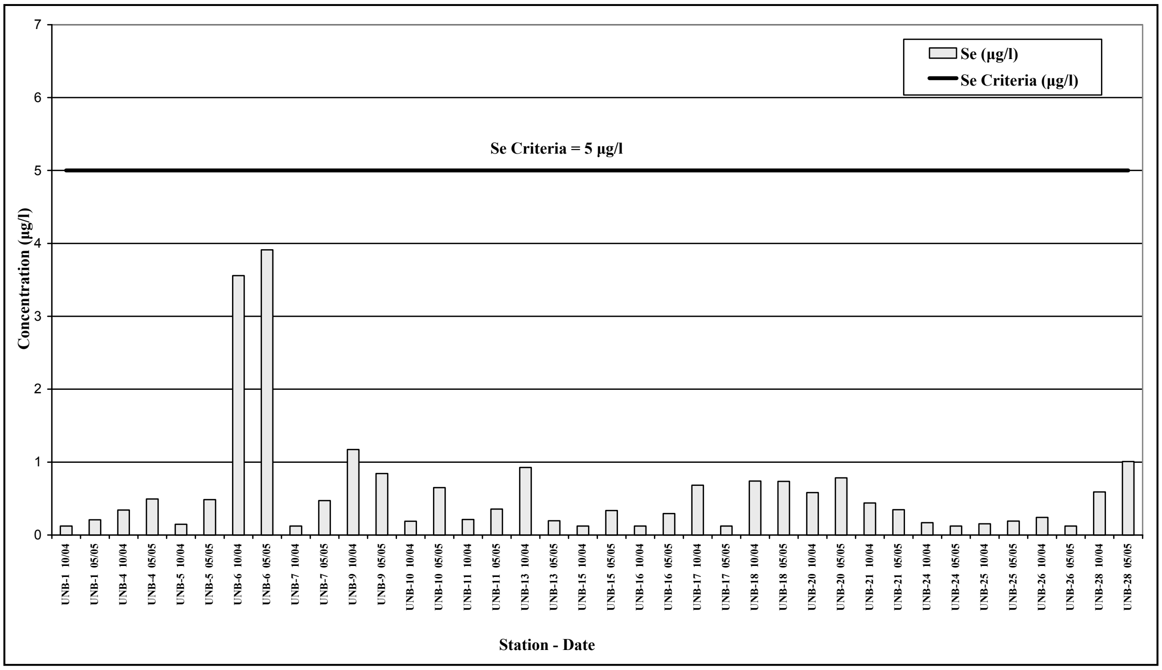

Figure 9: Upper North Branch Potomac River Water Column Data (Se)

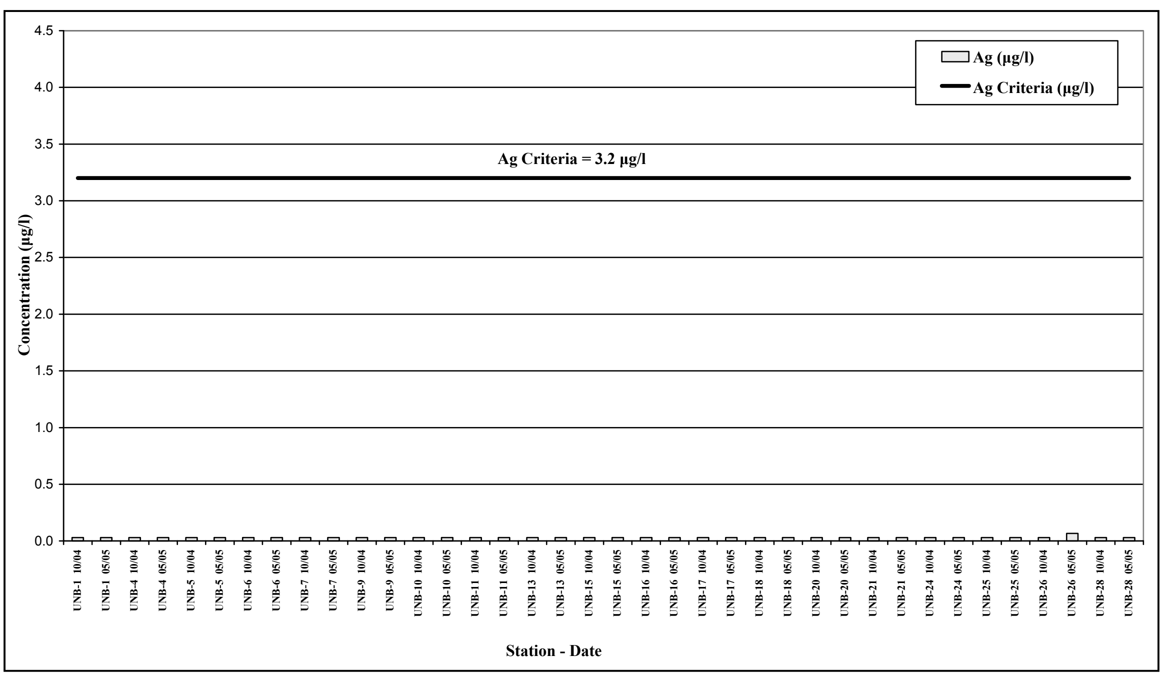

Figure 10: Upper North Branch Potomac River Water Column Data (Ag)

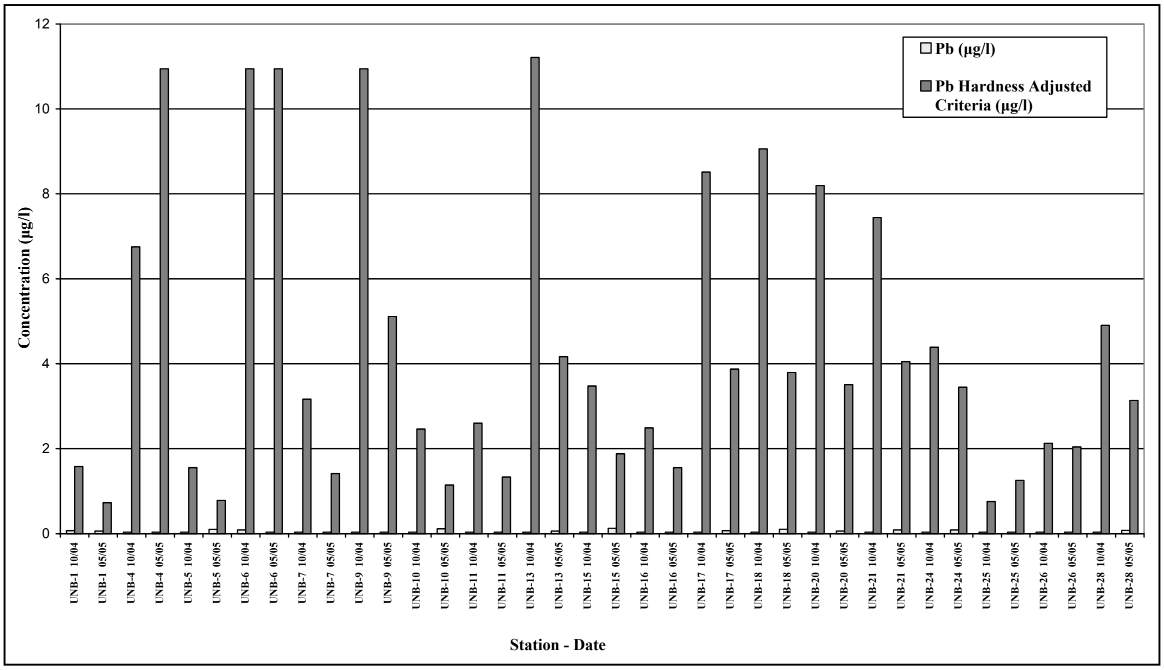

Figure 11: Upper North Branch Potomac River Water Column Data (Pb)

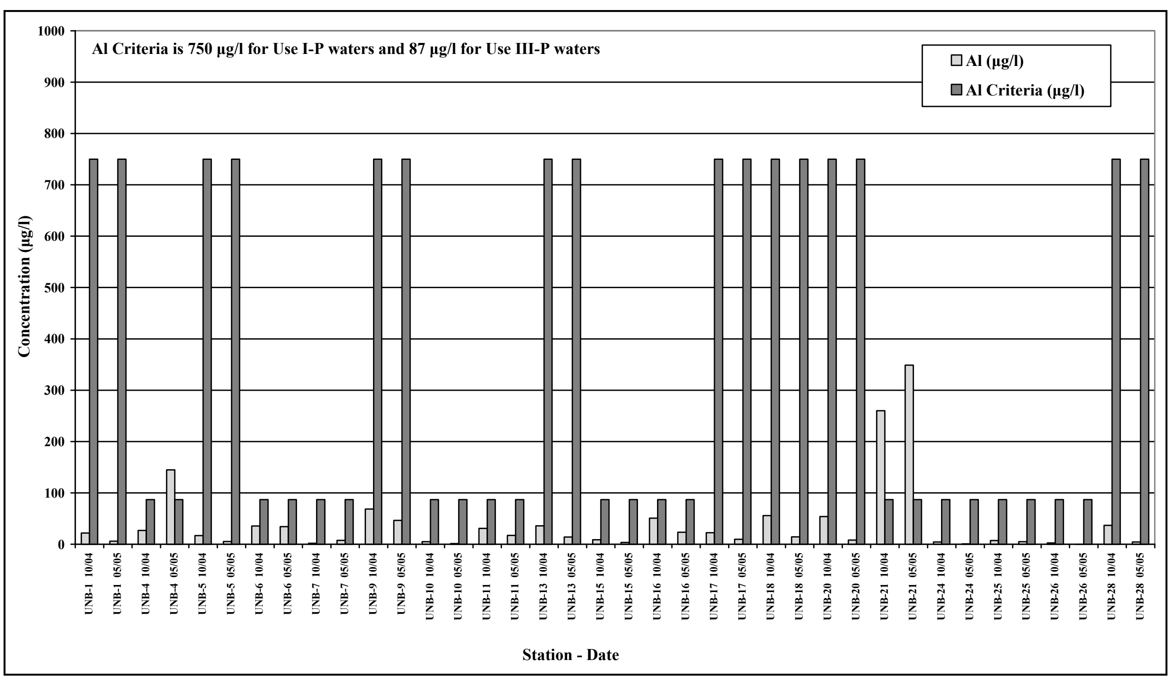

Figure 12: Upper North Branch Potomac River Water Column Data (Al)

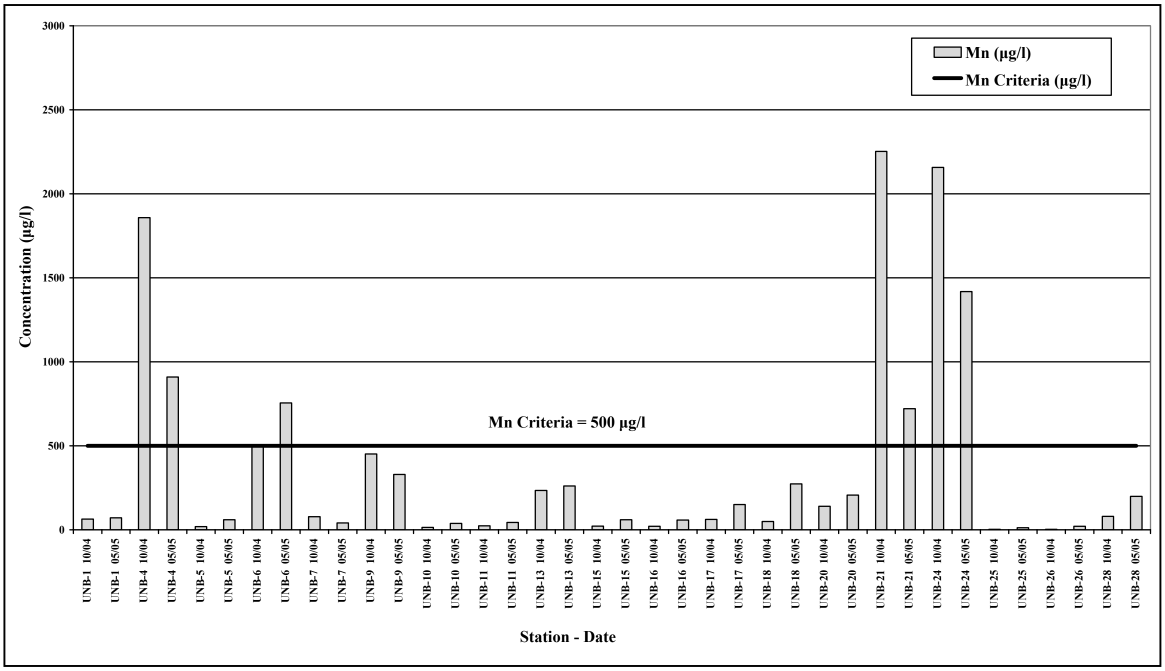

Figure 13: Upper North Branch Potomac River Water Column Data (Mn)

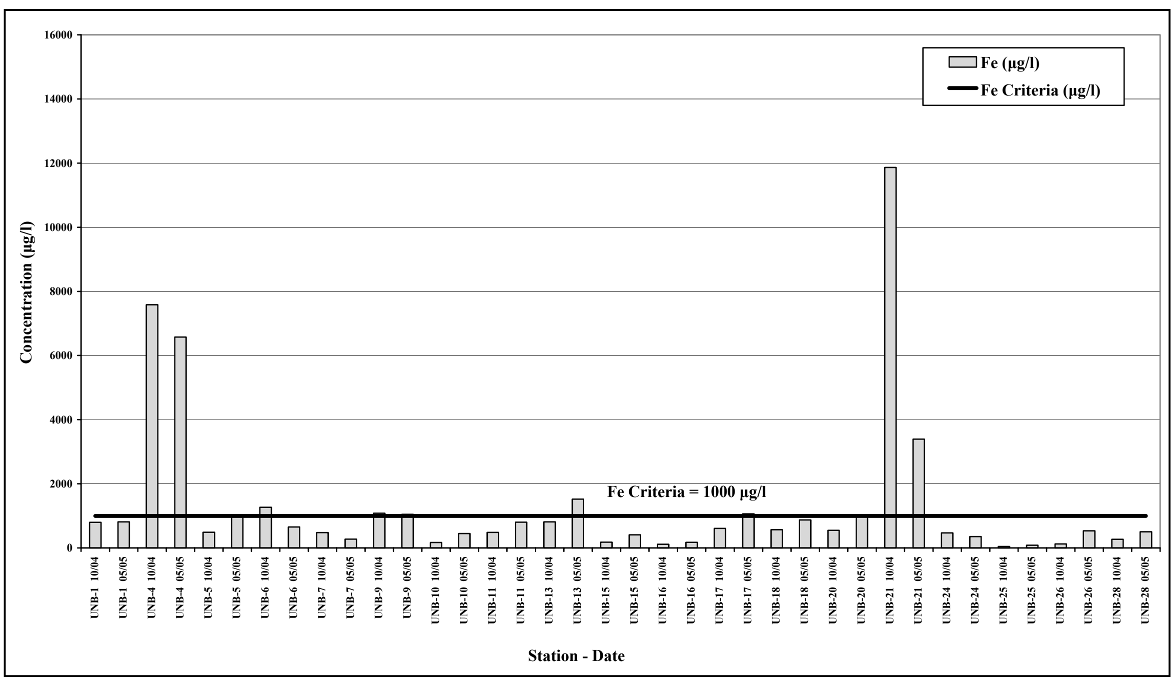

Figure 14: Upper North Branch Potomac River Water Column Data (Fe)

The range of concentrations for each metal is presented in Table 5. All metals concentrations are below their associated criteria except for Al, Mn, and Fe, where three, eight, and ten exceedances occurred, respectively. For Al, two exceedances occur at Station UNB-21 (Three Forks Run) and one exceedance occurs at Station UNB-4 (Laurel Run). For Mn, two exceedances occur at Station UNB-4 (Laurel Run), Station UNB-6 (Sand Run), Station UNB-21 (Three Forks Run), and Station UNB-24 (Elklick Run). For Fe, two exceedances occur at Station UNB-4 (Laurel Run) and Station UNB-21 (Three Forks Run) and one exceedance occurs at Station UNB-6 (Sand Run). In addition, seven exceedances of Fe occur at the following stations along the mainstem of the Upper North Branch Potomac River: UNB-9, UNB-13, UNB-17, and UNB-20.

Table 5: Upper North Branch Potomac River Water Column Data Summary

Metal	Minimum Concentration[1] (µg/l)	Maximum Concentration (µg/l)	Method Detection Limit (µg/l)
Cr	BDL	3.51	0.04
Ni	0.942	70.60	0.05
Cu	BDL	1.40	0.048
Zn	BDL	163.33	0.484
As	BDL	1.14	0.041
Se	BDL	3.91	0.124
Ag	BDL	0.07	0.03
Cd	BDL	0.28	0.038
Pb	BDL	0.13	0.036
Al	BDL	348.87	0.204
Mn[2]	3.2	2252.6	0.054
Fe[2]	45.6	11864.5	0.1

[1] BDL – Below Detection Limit
[2] Metals concentrations are presented as totals

A summary of the metals exceedances that occur in the tributaries and mainstem are displayed in Table 6. Two samples were collected at each station.

Table 6: Upper North Branch Potomac River Water Quality Data Assessment

Station	12-digit Basin	Stream	Al Exceedances	Mn Exceedances	Fe Exceedances
UNB-4	021410050039	Laurel Run	1/2	2/2	2/2
UNB-6	021410050040	Sand Run	0/2	2/2	1/2
UNB-9	021410050042	Mainstem upstream of Nydegger Run	0/2	0/2	2/2
UNB-13	021410050044	Mainstem downstream of Laurel Run	0/2	0/2	1/2
UNB-17	021410050047	Mainstem downstream of Lostland Run	0/2	0/2	1/2
UNB-20	021410050047	Mainstem downstream of Wolfden Run	0/2	0/2	1/2
UNB-21	021410050048	Three Forks Run	2/2	2/2	2/2
UNB-24	021410050049	Elklick Run	0/2	2/2	0/2

3.2 Sediment Quality Evaluation

Sediment quality in the Upper North Branch Potomac River watershed was evaluated using a 10-day whole sediment test with the representative freshwater amphipod *Hyalella azteca* (Fisher, 2005*)*. This species was chosen because of its ecological relevance to the waterbody of concern. *Hyalella azteca* is an EPA-recommended test species for assessin g the toxicity of freshwater (EPA, 2000). Three surficial sediment samples were collected in October 2004 using a petite ponar dredge (top 2 cm) in the Upper North Branch Potomac River watershed. Control sediments were collected from Bigwood Cove, Wye River, from a depositional area previously characterized as low in contaminants (Fisher, 2005). Refer back to Figure 1 for the station locations. The results are presented in Table 7. Eight replicates containing ten amphipods each were exposed to the contaminated sediment samples, as well as a control sediment sample, for testing. The table displays average amphipod survival (%) and average amphipod growth (mg dry weight).

Table 7: Upper North Branch Potomac River Sediment Toxicity Test Results

Sample	Amphipod Survival (#)	Amphipod Growth (mg)	Average Amphipod Survival (%) (SD)*	Average Amphipod Growth (mg) (SD)*
Control A	10	0.093	91.3 (8.35)	0.11 (0.009)
Control B	9	0.099		
Control C	9	0.113		
Control D	9	0.103		
Control E	8	0.113		
Control F	10	0.112		
Control G	8	0.121		
Control H	10	0.116		
UNB-1 A	9	0.159	92.5 (7.07)	0.15 (0.006)
UNB-1 B	10	0.154		
UNB-1 C	10	0.149		
UNB-1 D	10	0.152		
UNB-1 E	8	0.14		
UNB-1 F	9	0.154		
UNB-1 G	9	0.156		
UNB-1 H	9	0.159		
UNB-9 A	10	0.114	92.5 (8.86)	0.13 (0.014)
UNB-9 B	9	0.146		
UNB-9 C	10	0.147		
UNB-9 D	8	0.121		
UNB-9 E	8	0.11		
UNB-9 F	10	0.138		
UNB-9 G	10	0.127		
UNB-9 H	9	0.129		
UNB-20 A	10	0.161	85.0 (13.09)	0.16 (0.015)
UNB-20 B	8	0.166		
UNB-20 C	10	0.177		
UNB-20 D	7	0.151		
UNB-20 E	10	0.155		
UNB-20 F	8	0.174		
UNB-20 G	7	0.131		
UNB-20 H	8	0.168		

*SD-Standard Deviation

The test considers two performance criteria: survival and growth. For the test to be valid the average survival of control samples 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 sediment sample. The average survival for the control sediment sample was 91.3%. The average survival for all field sediment samples ranged between 85.0% and 92.5%. No sediment samples in the Upper North Branch Potomac River exhibited toxicity contributing to mortality.

Average amphipod growth for all field sediment samples was greater than the control sediment sample. The control sediment sample exhibited an average final dry weight of 0.11 mg, in contrast to a range of 0.13 mg to 0.16 mg average final dry weight for field sediment samples. Thus, no samples exhibited toxicity contributing to growth inhibition.

4.0 CONCLUSION

The WQA shows that water quality standards for metals are being met in the Upper North Branch Potomac River watershed except for the following tributaries: Sand Run (12-digit basin – 021410050040), Laurel Run (12-digit basin – 021410050039), Three Forks Run (12-digit basin – 021410050048), and Elklick Run (12-digit basin – 021410050049), where exceedances of Al and Mn, and Fe criteria were found. Exceedances of Fe are also found at four stations along the Upper North Branch Potomac River mainstem above Jennings Randolph Lake. The water column data collected in October 2004 and May 2005 at 19 monitoring stations (presented in Section 3.1) in the Upper North Branch Potomac River, established that two exceedances of Mn criterion were found in Laurel Run (UNB-4), Sand Run (UNB-6), Three Forks Run (UNB-21), and Elklick Run (UNB-24); two exceedances of Al criterion were found in Three Forks Run (Station UNB-21); one exceedance of Al criterion was found in Laurel Run (UNB-4); seven exceedances of Fe criterion were found in the at four stations (UNB-9,13,17, and 20) along the mainstem above Jennings Randolph Lake; two exceedances of Fe criterion were found in Laurel Run (UNB-4) and Three Forks Run (UNB-21); and one exceedance of Fe criterion was found in Sand Run (UNB-6). Two samples were collected at each station. An ambient sediment bioassay conducted in the Upper North Branch Potomac River, by the University of Maryland Wye Research Center, established that there is no toxicity in the sediment as a result of metals contamination. Therefore, the water column and sediment in the Upper North Branch Potomac River 8-digit watershed are not impaired by metals except for the impacted tributaries and Upper North Branch Potomac River mainstem above Jennings Randolph Lake.

Based on 305(b) guidance, as a first analytical step MDE applies a “rule-of-thumb” that a waterbody is impaired by a chemical contaminant in the water column when greater than 10% of the samples, with a minimum of ten samples collected over a three-year period, exceed the applicable criteria (EPA, 1997). If there are less than 10 samples for a given area, MDE may interpret the data and determine if an impairment exists by considering a number of factors including the magnitude of the criteria exceedance and number of criteria exceeded. In addition, current EPA guidelines suggest that a waterbody is not fully use-supporting when more than one exceedance of the acute or chronic water quality criterion occurs over a three-year period (EPA, July 2002). With only two samples collected at each station, when only one exceedance of criteria occurs for Mn, Al or Fe there is insufficient information to determine if an impairment exists. Therefore additional monitoring is required. For stations with two exceedances of criteria for Mn or Al, even though ten samples have not been collected, sufficient data is available to conclude that an impairment exists.

The major sources of contamination are found in the tributaries and not in the watershed directly feeding the Upper North Branch Potomac River. TMDL development within the impaired tributaries will allow for water quality standards to be met in the mainstem. Therefore, barring the receipt of contradictory data, this report will be used to support a metals listing change for the Upper North Branch Potomac River 8-digit watershed 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. Those tributaries with two exceedances are impaired and will be placed in Category 5 of the 303(d) List. Those tributaries with only one exceedance will be placed in Category 3 ("waterbodies having insufficient data or information to determine impairment status") of the 303(d) List. The Upper North Branch Potomac River mainstem above Jennings Randolph Lake will be placed in Category 3 of the 303(d) List. A summary of the listing decisions is displayed in Table 8.

Table 8: 303(d) Listing Decision

Stream	12-digit Basin	Metal	303(d) List
Laurel Run	021410050039	Al	Category 3
		Mn	Category 5
		Fe	Category 5
Sand Run	021410050040	Mn	Category 5
		Fe	Category 3
Mainstem above Jennings Randolph Lake	-	Fe	Category 3
Three Forks Run	021410050048	Al	Category 5
		Mn	Category 5
		Fe	Category 5
Elklick Run	021410050049	Mn	Category 5

Although the waters of the Upper North Branch Potomac River watershed do not display signs of toxic impairments due to metals except for the impaired tributaries and mainstem above Jennings Randolph Lake, the State reserves the right to require additional pollution controls in the Upper North Branch Potomac River watershed if evidence suggests that metals from the basin are contributing to downstream water quality problems.

5.0 REFERENCES

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Appendix A – Upper North Branch Potomac River Water Quality Data

Station	Date	Hardness (mg/l)	Cr (µg/l)	Cr(VI) Criteria (µg/l)	Ni (µg/l)	Ni Criteria (µg/l)	Cu (µg/l)	Cu Criteria (µg/l)	Zn (µg/l)	Zn Criteria (µg/l)	As (µg/l)	As Criteria (µg/l)	Se (µg/l)	Se Criteria (µg/l)
UNB-1	Oct-04	65.4	0.82	11	1.7	36.3	0.21	6.23	0.95	81.77	0.15	10	<0.124	5
	May-05	32.7	0.21	11	2.2	20.2	0.27	3.45	4.68	45.45	0.15	10	0.21	5
UNB-4	Oct-04	251.3	0.40	11	70.6	113.4	0.12	19.68	33.09	255.82	0.11	10	0.34	5
	May-05	766.1	0.16	11	41.3	291.2	0.41	51.02	163.33	657.82	0.21	10	0.50	5
UNB-5	Oct-04	64.4	0.72	11	1.3	35.8	0.16	6.15	0.48	80.71	0.18	10	0.15	5
	May-05	34.7	0.17	11	1.8	21.2	0.25	3.63	2.92	47.79	0.25	10	0.48	5
UNB-6	Oct-04	784.5	3.51	11	29.5	297.1	1.40	52.06	2.51	671.19	1.14	10	3.56	5
	May-05	570.0	2.63	11	26.4	226.7	0.58	39.63	6.23	512.04	0.71	10	3.91	5
UNB-7	Oct-04	123.6	2.22	11	1.9	62.2	0.06	10.73	0.88	140.22	0.27	10	<0.124	5
	May-05	59.2	0.61	11	1.9	33.4	0.12	5.72	3.02	75.15	0.29	10	0.47	5
UNB-9	Oct-04	497.5	1.61	11	19.0	202.1	0.39	35.28	3.35	456.30	0.48	10	1.17	5
	May-05	193.1	0.82	11	13.5	90.7	0.20	15.71	13.82	204.64	0.20	10	0.84	5
UNB-10	Oct-04	98.1	1.20	11	1.9	51.2	0.07	8.81	0.13	115.29	0.19	10	0.19	5
	May-05	49.0	0.12	11	2.0	28.4	0.27	4.87	2.09	64.03	0.25	10	0.65	5
UNB-11	Oct-04	103.2	1.47	11	2.5	53.4	0.28	9.20	0.70	120.35	0.28	10	0.21	5
	May-05	56.2	0.64	11	2.4	31.9	0.67	5.47	2.57	71.91	0.19	10	0.36	5
UNB-13	Oct-04	409.6	1.51	11	13.9	171.4	0.31	29.88	2.24	387.00	0.40	10	0.93	5
	May-05	159.4	0.51	11	9.5	77.1	0.27	13.34	7.92	173.91	0.05	10	0.20	5
UNB-15	Oct-04	134.8	0.82	11	2.5	67.0	0.22	11.56	0.65	150.92	0.20	10	0.09	5
	May-05	76.6	0.12	11	3.0	41.5	0.09	7.13	5.57	93.49	0.19	10	0.33	5
UNB-16	Oct-04	99.1	0.60	11	1.8	51.6	0.22	8.89	1.73	116.29	0.13	10	<0.124	5
	May-05	64.4	0.20	11	4.3	35.8	0.30	6.15	9.87	80.66	0.08	10	0.29	5
UNB-17	Oct-04	313.6	1.14	11	9.2	136.8	0.24	23.78	1.53	308.63	0.34	10	0.68	5
	May-05	149.1	0.21	11	7.7	72.9	0.35	12.60	7.77	164.38	0.04	10	<0.124	5
UNB-18	Oct-04	333.0	0.99	11	9.3	143.9	0.30	25.03	2.37	324.73	0.37	10	0.74	5
	May-05	146.1	0.45	11	10.7	71.7	0.33	12.38	14.04	161.55	0.20	10	0.74	5
UNB-20	Oct-04	302.4	0.90	11	10.5	132.6	0.29	23.05	4.12	299.26	0.32	10	0.58	5
	May-05	135.9	0.62	11	10.1	67.4	0.24	11.64	11.15	151.96	0.16	10	0.78	5
UNB-21	Oct-04	275.8	0.07	11	39.2	122.7	0.88	21.31	6.25	276.80	0.22	10	0.44	5
	May-05	155.3	0.04	11	6.0	75.5	0.34	13.05	1.90	170.15	0.04	10	0.35	5
UNB-24	Oct-04	167.5	0.17	11	14.6	80.5	0.01	13.92	15.43	181.41	0.22	10	0.17	5
	May-05	133.8	0.04	11	19.7	66.5	0.36	11.49	58.43	149.97	0.04	10	<0.124	5
UNB-25	Oct-04	33.7	0.18	11	0.9	20.7	0.06	3.54	0.48	46.62	0.12	10	0.15	5
	May-05	53.1	0.12	11	1.6	30.4	<0.048	5.21	3.03	68.54	0.11	10	0.19	5
UNB-26	Oct-04	85.8	0.64	11	1.5	45.7	0.10	7.86	<0.484	102.92	0.12	10	0.24	5
	May-05	82.7	0.40	11	1.5	44.3	0.18	7.61	1.62	99.76	0.04	10	<0.124	5
UNB-28	Oct-04	185.9	0.48	11	6.1	87.9	0.39	15.21	1.56	198.16	0.24	10	0.59	5
	May-05	122.6	0.26	11	9.0	61.8	0.55	10.66	7.99	139.26	0.26	10	1.01	5

Station	Date	Hardness (mg/l)	Ag (µg/l)	Ag Criteria (µg/l)	Cd (µg/l)	Cd Criteria (µg/l)	Pb (µg/l)	Pb Criteria (µg/l)	Al (µg/l)	Al Criteria (µg/l)	Mn (µg/l)	Mn Criteria (µg/l)	Fe (µg/l)	Fe Criteria (µg/l)
UNB-1	Oct-04	65.4	<0.03	3.2	<0.038	0.18	0.07	1.6	21.8	750	64.1	500	799.8	1000
	May-05	32.7	<0.03	3.2	<0.038	0.11	0.06	0.7	6.1	750	71.6	500	814.8	1000
UNB-4	Oct-04	251.3	<0.03	3.2	0.06	0.47	<0.036	6.8	26.7	87	**1858.0**	500	**7584.8**	1000
	May-05	766.1	<0.03	3.2	0.24	1.01	<0.036	21.0	**144.8**	87	**910.0**	500	**6574.3**	1000
UNB-5	Oct-04	64.4	<0.03	3.2	<0.038	0.18	<0.036	1.6	16.8	750	19.1	500	492.8	1000
	May-05	34.7	<0.03	3.2	<0.038	0.12	0.10	0.8	5.3	750	60.1	500	971.4	1000
UNB-6	Oct-04	784.5	<0.03	3.2	<0.038	1.02	0.09	21.5	35.5	87	**505.7**	500	**1270.1**	1000
	May-05	570.0	<0.03	3.2	0.05	0.82	<0.036	15.7	34.4	87	**755.6**	500	657.6	1000
UNB-7	Oct-04	123.6	<0.03	3.2	<0.038	0.29	<0.036	3.2	1.7	87	78.3	500	480.3	1000
	May-05	59.2	<0.03	3.2	<0.038	0.17	<0.036	1.4	7.5	87	42.0	500	274.8	1000
UNB-9	Oct-04	497.5	<0.03	3.2	<0.038	0.75	<0.036	13.7	68.7	750	451.5	500	**1085.9**	1000
	May-05	193.1	<0.03	3.2	<0.038	0.39	<0.036	5.1	46.4	750	330.5	500	**1047.6**	1000
UNB-10	Oct-04	98.1	<0.03	3.2	<0.038	0.24	<0.036	2.5	5.1	87	15.1	500	172.9	1000
	May-05	49.0	<0.03	3.2	<0.038	0.15	0.11	1.1	1.3	87	38.5	500	449.1	1000
UNB-11	Oct-04	103.2	<0.03	3.2	<0.038	0.25	<0.036	2.6	30.9	87	24.0	500	487.3	1000
	May-05	56.2	<0.03	3.2	<0.038	0.16	<0.036	1.3	17.1	87	44.2	500	804.5	1000
UNB-13	Oct-04	409.6	<0.03	3.2	<0.038	0.65	<0.036	11.2	35.9	750	234.7	500	812.8	1000
	May-05	159.4	<0.03	3.2	<0.038	0.34	0.06	4.2	14.1	750	261.3	500	**1526.3**	1000
UNB-15	Oct-04	134.8	<0.03	3.2	<0.038	0.30	<0.036	3.5	8.6	87	21.8	500	182.9	1000
	May-05	76.6	<0.03	3.2	<0.038	0.20	0.13	1.9	3.3	87	60.3	500	411.0	1000
UNB-16	Oct-04	99.1	<0.03	3.2	<0.038	0.24	<0.036	2.5	50.7	87	21.1	500	115.0	1000
	May-05	64.4	<0.03	3.2	0.06	0.18	<0.036	1.6	23.5	87	58.3	500	175.3	1000
UNB-17	Oct-04	313.6	<0.03	3.2	<0.038	0.54	<0.036	8.5	22.5	750	62.7	500	609.9	1000
	May-05	149.1	<0.03	3.2	<0.038	0.32	0.07	3.9	9.8	750	150.7	500	**1063.7**	1000
UNB-18	Oct-04	333.0	<0.03	3.2	<0.038	0.57	<0.036	9.1	55.7	750	49.5	500	569.4	1000
	May-05	146.1	<0.03	3.2	<0.038	0.32	0.11	3.8	14.3	750	274.1	500	874.3	1000
UNB-20	Oct-04	302.4	<0.03	3.2	<0.038	0.53	<0.036	8.2	54.0	750	140.6	500	550.3	1000
	May-05	135.9	<0.03	3.2	<0.038	0.30	0.06	3.5	8.1	750	207.1	500	**1015.2**	1000
UNB-21	Oct-04	275.8	<0.03	3.2	0.08	0.50	<0.036	7.4	**260.0**	87	**2252.6**	500	**11864.5**	1000
	May-05	155.3	<0.03	3.2	<0.038	0.33	0.09	4.1	**348.9**	87	**721.1**	500	**3394.1**	1000
UNB-24	Oct-04	167.5	<0.03	3.2	0.13	0.35	<0.036	4.4	4.3	87	**2157.4**	500	472.6	1000
	May-05	133.8	<0.03	3.2	0.28	0.30	0.09	3.5	0.6	87	**1418.5**	500	353.4	1000
UNB-25	Oct-04	33.7	<0.03	3.2	<0.038	0.12	<0.036	0.8	7.2	87	3.2	500	45.6	1000
	May-05	53.1	<0.03	3.2	<0.038	0.16	<0.036	1.3	5.2	87	12.9	500	87.6	1000
UNB-26	Oct-04	85.8	<0.03	3.2	<0.038	0.22	<0.036	2.1	2.4	87	3.4	500	125.3	1000
	May-05	82.7	0.0676	3.2	<0.038	0.22	<0.036	2.0	<0.204	87	21.1	500	533.5	1000
UNB-28	Oct-04	185.9	<0.03	3.2	<0.038	0.38	<0.036	4.9	36.9	750	80.4	500	271.3	1000
	May-05	122.6	<0.03	3.2	0.06	0.28	<0.036	3.1	4.4	750	199.8	500	505.0	1000

Appendix B

FINAL

WREC-05-01

Toxicity of Sediment Samples from the North Branch of the Potomac River Using the Freshwater Amphipod *Hyalella azteca* 10-d Whole Sediment Survival and Growth Test

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ABSTRACT

The University of Maryland Wye Research and Education Center was contacted to conduct whole sediment toxicity tests on sediments from the North Branch of the Potomac River by Dr. Ray Morgan of the Appalachian Laboratory, The University of Maryland Center for Environmental Science in Frostburg, Maryland. Toxicity was assessed using the U.S. Environmental Protection Agency's freshwater amphipod *Hyalella azteca* 10-d survival and growth test. The sediments were not sieved prior to test initiation. The endpoints of the test were survival and growth (dry weight). There were no sediments that caused reduced amphipod survival or growth when compared to the control sediment amphipod data. Average control amphipod survival was 91.3%, while average control amphipod dry weight was 0.11 mg. These tests passed the test performance requirements with control amphipod survival above 80% and measurable growth in the control amphipods over 10 days. The average survival for the 10 Upper Potomac sites was 91.9%, while the average control amphipod dry weight for these sites was 0.15 mg.

INTRODUCTION

The University of Maryland Wye Research and Education Center (WREC) was contacted by Dr. Ray Morgan of the Appalachian Laboratory, The University of Maryland Center for Environmental Science, Frostburg, Maryland to conduct whole sediment toxicity tests on sediments from the North Branch of the Potomac River using the freshwater amphipod *Hyalella azteca*. The North Branch of the Potomac River is defined as the river stretch between the Preston County, West Virginia and Garrett County, Maryland (39.125E N 79.4922E W) border and the confluence of the North and South branches of the Potomac (39.528E N 78.5873E W) near Oldtown, Maryland. The toxicity tests were in support of the North Branch Potomac River Survey.

MATERIALS AND METHODS

Sample Sites

Sediment samples were tested from ten sites in the North Branch of the Potomac River and a negative control sediment from Bigwood Cove, Wye River, Maryland for sediment toxicity. The sample designations were: UNB-01, UNB-09, UNB-20, UNB-31, LNB-33, LNB-37, WC-40, WC-42, LNB-53, and LNB-57.

Sediment Toxicity Tests

A 10-d amphipod whole sediment toxicity test method was used for this study. The tests were conducted using the *Hyalella azteca* procedure outlined in the most recent U.S. Environmental Protection Agency (U.S. EPA, 2000) method document. A summary of the method is presented in Table 1. Dr. Ray Morgan's group collected and shipped all of the sediments to WREC. The sediments were shipped on October 20, 2004 and received at the WREC on October 21, 2004. The samples were kept in coolers on ice during collection and shipping. Upon receipt the samples were stored in the dark at 4EC prior to test initiation at WREC. The sediment samples were not sieved before testing. Sediment tests were initiated on November 2, 2004 and completed on November 12, 2004. The endpoints measured were survival and growth (dry weight) at the end of 10 days. Due to a problem in the laboratory two test beakers were lost during the tests (UNB-31 Replicate G and LNB-57 Replicate C). Because of this there were not equal numbers of replicate beakers at each site at the end of the test.

Data were analyzed in accordance with procedures outlined in the U.S. EPA (2000) method. The statistical package SigmaStat 3.2® was used to analyze the data. Survival data were arcsine square-root transformed prior to analysis. The data were analyzed by comparing the endpoints in the various treatments with the endpoints in the control. Data were assessed for normality and homogeneity of variance using the Kolmogorov-Smirnov Test and the Levene Median Test, respectively (alpha = 0.05). Transformed survival data were not normal so a Kruskal-Wallace One Way ANAOVA on Ranks was performed. Growth data were normal and homogeneous. Because of the unequal replicate sizes, a Bonferroni's Test was used to compare treatment mean growth against the control mean growth.

RESULTS AND DISCUSSION

Water Quality

Average water quality data for each sediment test treatment are presented in Table 2. The lowest dissolved oxygen concentration of 3.1 mg/L recorded during the test was in overlying water in a test beaker from site LNB-37. All dissolved oxygen minimum values were above the minimum of 2.5 mg/L required by the method (U.S. EPA, 2000). Porewater and overlying water ammonia concentrations were all low, where measurable, and well below levels thought to be toxic (U.S. EPA, 2000). Porewater was only measured from Control, UNB-01 and UNB-09 sediments. Sufficient porewater could not be collected from the other sediments due to their sandy nature.

Sediment Toxicity Tests

The toxicity test met the acceptability criteria established by the U.S. EPA (2000) (Table 1). Survival in the control sediment was 91.3% and growth was measurable. The average amphipod dry weight at the end of the test (0.11 mg) in the control treatment was significantly greater than the dry weight of a representative sample of the test amphipods at test initiation (0.04 mg). The comparison was made using a two sample *t*-test.

Results showed that no sediments from the North Branch of the Potomac caused significant reductions in amphipod survival or growth (dry weight) compared to the laboratory control (Table 3). Notice that all of the treatments had amphipod dry weights that were greater than the laboratory control animals, with the largest amphipods from site WC-40. Amphipods from this site were 4.25 times bigger than at the beginning of the test. Amphipods from the control treatment were 2.75 times bigger than the amphipods at the start of the test. All of the test samples had significant amounts of organic material, including organic debris, compared to our laboratory control. This could have served as an additional food source for the amphipods.

The average amphipod survival for the ten Upper Potomac sites was 91.9%. Survival ranged from 83.8% at LNB-37 to 98.6 at LNB-57. The average control amphipod dry weight for these sites was 0.15 mg with a range from 0.13 mg at UNB-09 to 0.17 mg at WC-40.

LITERATURE CITED

U.S. EPA. 2000. Methods for measuring the toxicity and bioaccumulation of sediment-associated contaminants with freshwater invertebrates. Second ed. EPA/600/R-99/064. U.S. Environmental Protection Agency, Duluth, MN. 192 pp.

Table 1. Test conditions for 10-d whole sediment toxicity tests with *Hyalella azteca*.

1. Test type	Whole sediment, static renewal of overlying water
2. Temperature	23 ± 1EC
3. Overlying water	95:5 well water/saltwater mix
4. Renewal of overlying water	2 volume additions/d using automatic renewal system
5. Light	Wide-spectrum fluorescent lights, 100 to 1000 lux
6. Photoperiod	16:8 (L/D)
7. Test chamber	300 mL lip-less beaker with screened hole for water renewal (Randomly assigned on test table)
8. Sediment volume	100 ml
9. Overlying water volume	175 ml
10. Size and life stage of amphipods	7- to 14-d old; size sorted on nested 710 and 500 Φm mesh sieves
11. Number of organisms/replicate	10 (Randomly assigned to test replicates)
12. Number of replicates	8
13. Feeding	1.0 ml YCT daily
14. Aeration	none
15. Water quality	Alkalinity, hardness, and total ammonia at beginning and end of test. Temperature, D.O., and pH daily. Porewater ammonia in dummy beaker at test initiation.
16. Test duration	10 d
17. Endpoints	Survival and growth
18. Performance criteria	Control survival $\geq$ 80% Measurable growth in control amphipods

Table 2. Water chemistry summary for the 2004 North Branch Potomac River 10-d amphipod *Hyalella azteca* sediment toxicity test conducted 11/02-11/12/04 [mean (S.D.) unless otherwise stated].

Station	DO mg/L	pH range	Temp °C	Conductivity μmhos	Alkalinity mg/L $CaCO_3$	Hardness mg/L $CaCO_3$	Ammonia (mg/L) Overlying day 0	Ammonia (mg/L) Overlying day 10	Ammonia (mg/L) Porewater day 0
Control	6.7 (0.48)	7.71-8.29	22.4 (0.57)	2300 (141.4)	105 (7.1)	266 (25.5)	0.6	0.4	4
UNB-01	5.4 (1.10)	7.24 - 7.78	22.2 (0.59)	2350 (70.7)	283 (130.8)	274 (48.1)	0.2	0.5	3
UNB-09	5.5 (0.99)	7.46 - 7.96	22.3 (0.61)	2325 (106.1)	143 (24.7)	314 (8.5)	0.2	0.1	2
UNB-20	5.9 (1.02)	7.54 - 8.01	22.2 (0.64)	2350 (70.7)	138 (31.8)	298 (53.7)	<0.1	0.2	*
UNB-31	5.7 (0.88)	7.62 - 8.07	22.2 (0.56)	2350 (70.7)	270 (148.5)	316 (5.7)	<0.1	0.3	*
LNB-33	5.2 (1.01)	7.36 - 7.80	22.3 (0.59)	2350 (70.7)	158 (10.6)	304 (22.6)	0.3	0.4	*
LNB-37	3.9 (0.92)	7.07 - 7.59	22.2 (0.63)	2350 (70.7)	153 (31.8)	294 (19.8)	0.7	1.4	*
WC-40	5.4 (0.90)	7.58 - 8.01	22.2 (0.60)	2350 (70.7)	168 (3.5)	304 (22.6)	<0.1	0.2	*
WC-42	5.8 (1.00)	7.56 - 7.91	22.2 (0.56)	2350 (70.7)	158 (10.6)	314 (8.5)	0.3	0.2	*
LNB-53	4.7 (1.04)	7.33 - 7.91	22.3 (0.67)	2350 (70.7)	143 (17.7)	312 (11.3)	0.3	0.9	*
LNB-57	5.0 (0.86)	7.32 - 7.86	22.2 (0.63)	2350 (70.7)	140 (7.1)	292 (5.7)	0.6	0.6	*

* Unmeasured due to insufficient porewater sample

Table 3. Upper Potomac River amphipod *Hyalella azteca* 10 day survival and growth sediment test results (11/02-11/12/04). An * indicates a treatment significantly < the control (% = 0.05).

Treatment REP	# Surviving amphipods	0 Rep. dry wt. (mg)	0 Treatment % Survival (SD)	0 Treatment mg. dry wt. (SD)
Control A	10	0.093	91.3 (8.35)	0.11 (0.009)
Control B	9	0.099		
Control C	9	0.113		
Control D	9	0.103		
Control E	8	0.113		
Control F	10	0.112		
Control G	8	0.121		
Control H	10	0.116		
UNB-01 A	9	0.159	92.5 (7.07)	0.15 (0.006)
UNB-01 B	10	0.154		
UNB-01 C	10	0.149		
UNB-01 D	10	0.152		
UNB-01 E	8	0.140		
UNB-01 F	9	0.154		
UNB-01 G	9	0.156		
UNB-01 H	9	0.159		
UNB-09 A	10	0.114	92.5 (8.86)	0.13 (0.014)
UNB-09 B	9	0.146		
UNB-09 C	10	0.147		
UNB-09 D	8	0.121		
UNB-09 E	8	0.110		
UNB-09 F	10	0.138		
UNB-09 G	10	0.127		
UNB-09 H	9	0.129		
UNB-20 A	10	0.161	85.0 (13.09)	0.16 (0.015)
UNB-20 B	8	0.166		
UNB-20 C	10	0.177		
UNB-20 D	7	0.151		
UNB-20 E	10	0.155		
UNB-20 F	8	0.174		
UNB-20 G	7	0.131		
UNB-20 H	8	0.168		

Table 3. Continued

Treatment REP	# Surviving amphipods	0 Rep. dry wt. (mg)	0 Treatment % Survival (SD)	0 Treatment mg. dry wt. (SD)
UNB-31 A	10	0.166	94.3 (9.76)	0.15 (0.011)
UNB-31 B	8	0.156		
UNB-31 C	10	0.132		
UNB-31 D	10	0.146		
UNB-31 E	10	0.149		
UNB-31 F	10	0.137		
UNB-31 G	Replicate lost			
UNB-31 H	8	0.149		
LNB-33 A	10	0.167	96.3 (5.18)	0.15 (0.011)
LNB-33 B	10	0.142		
LNB-33 C	9	0.132		
LNB-33 D	10	0.144		
LNB-33 E	10	0.148		
LNB-33 F	9	0.138		
LNB-33 G	9	0.147		
LNB-33 H	10	0.138		
LNB-37 A	7	0.096	83.8 (10.61)	0.12 (0.021)
LNB-37 B	7	0.151		
LNB-37 C	9	0.141		
LNB-37 D	9	0.100		
LNB-37 E	10	0.147		
LNB-37 F	9	0.122		
LNB-37 G	8	0.110		
LNB-37 H	8	0.118		
WC-40 A	10	0.144	93.8 (9.16)	0.17 (0.012)
WC-40 B	10	0.176		
WC-40 C	10	0.157		
WC-40 D	8	0.171		
WC-40 E	10	0.180		
WC-40 F	8	0.159		
WC-40 G	10	0.172		
WC-40 H	9	0.158		

Table 3. Continued

Treatment REP	# Surviving amphipods	0 Rep. dry wt. (mg)	0 Treatment % Survival (SD)	0 Treatment mg. dry wt. (SD)
WC-42 A	10	0.159	93.8 (10.61)	0.16 (0.015)
WC-42 B	7	0.150		
WC-42 C	9	0.180		
WC-42 D	10	0.167		
WC-42 E	10	0.158		
WC-42 F	10	0.155		
WC-42 G	9	0.191		
WC-42 H	10	0.152		
LNB-53 A	10	0.143	88.8 (18.85)	0.15 (0.017)
LNB-53 B	10	0.144		
LNB-53 C	5	0.114		
LNB-53 D	10	0.141		
LNB-53 E	9	0.152		
LNB-53 F	10	0.173		
LNB-53 G	7	0.161		
LNB-53 H	10	0.148		
LNB-57 A	10	0.161	98.6 (3.78)	0.16 (0.013)
LNB-57 B	10	0.180		
LNB-57 C	Replicate lost			
LNB-57 D	10	0.173		
LNB-57 E	10	0.162		
LNB-57 F	9	0.154		
LNB-57 G	10	0.138		
LNB-57 H	10	0.160		
Day 0 amphipod A[1]	10	0.042		0.04 (0.002)
Day 0 amphipod B	10	0.042		
Day 0 amphipod C	10	0.039		
Day 0 amphipod D	10	0.042		
Day 0 amphipod E	10	0.042		
Day 0 amphipod F	10	0.039		
Day 0 amphipod G	10	0.039		
Day 0 amphipod H	10	0.037		

[1]These are the dry weights of the amphipods at day 0 used to determine if there was measurable growth in the control amphipods as compared to the control amphipod weights at day 10.