Water Quality Analysis of Zinc in Back River, Baltimore County and Baltimore City, Maryland

FINAL

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List of Abbreviations

Ag	Silver
As	Arsenic
AVS	Acid Volatile Sulfide
BWO	Baltimore/Washington International Airport
CBL	Chesapeake Biological Laboratory
Cd	Cadmium
cm	Centimeter
COMAR	Code of Maryland Regulations
Cr	Chromium
Cu	Copper
CWA	Clean Water Act
DO	Dissolved Oxygen
DOC	Dissolved Organic Carbon
EPA	Environmental Protection Agency
ERM	Effects Range Median
HAC	Hardness Adjusted Criteria
MDE	Maryland Department of the Environment
mg/l	Milligrams per Liter
NPDES	National Pollution Discharge Elimination System
NWS	National Weather Service
Pb	Lead
PCBs	Polychlorinated biphenyls
ppt	Parts per Thousand
SCS	Soil Conservation Service
SEM	Simultaneously Extracted Metals
SSURGO	Soil Survey Geographic
TMDL	Total Maximum Daily Load
USGS	United States Geological Survey
WER	Water Effects Ratio
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. 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.

Back River (basin code 02-13-09-01), located in Baltimore County and Baltimore City, MD, was identified on the State's list of WQLSs as impaired by nutrients (1996 listing), suspended sediments (1996 listing), chlordane (1996 listing), polychlorinated biphenyls (PCBs) - sediments (1998 listing), zinc (Zn) (1998 listing), fecal coliform (2002 listing) and impacts to biological communities (2002 listing). 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 Back 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 Zn are being met in the Back River. The analyses support the conclusion that a TMDL for Zn is not necessary to achieve water quality standards in this case. Barring the receipt of any contradictory data, this report will be used to support the removal of the Back River from Maryland's list of WQLSs for Zn 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 nutrient, PCBs, suspended sediment, fecal coliform and impacts to biological communities will be addressed separately at a future date. A TMDL for chlordane was completed in 1999.

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

1.0 INTRODUCTION

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

Back River (basin code 02-13-09-01) was identified on the State's 1996 303(d) list as impaired by nutrients, suspended sediment and chlordane, with zinc (Zn) and polychlorinated biphenyls (PCBs) impairments added to the list in 1998, and fecal coliform and impacts to biological communities added to the list in 2002. All impairments were listed for the tidal waters except for the biological impairment, which is listed for the non-tidal region. Code of Maryland Regulations (COMAR) defines the Back River as a fresh waterbody.

The initial listing for Zn was based on seven sediment samples collected in the Back River for the Baltimore Harbor Spatial Mapping Study conducted in 1996 (Baker, 1997). All seven samples exceeded the Effects Range Median (ERM) for Zn indicating the potential for toxicity. Current studies suggest that an exceedance of the ERM is an insufficient indicator of toxicity due to mitigating factors such as the presence of sulfide, which binds metals in a non-toxic form. A Water Quality Analysis (WQA) of Zn for the tidal waters of Back River was conducted using recent water column chemistry data, sediment chemistry data and sediment toxicity data. Results show no impairment for Zn. The nutrient, suspended sediment, PCB, sedimentation and fecal coliform impairments will be addressed separately at a future date. A TMDL for chlordane was completed in 1999.

The remainder of this report lays out the general setting of the waterbody within the Back River watershed, presents a discussion of the water quality characterization process, and provides conclusions with regard to the characterization. The most recent data establishes that the Back River is achieving water quality standards for Zn.

2.0 GENERAL SETTING

The Back River watershed is located in the Patapsco/Back River region of the Chesapeake Bay watershed within Maryland (see Figure 1). The watershed covers a portion of Baltimore County and Baltimore City. The watershed area covers 34,887 acres.

The Back River watershed lies within the Piedmont and Coastal Plain provinces of Central Maryland. The Piedmont Province is 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 stream bank and stream bed. 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. The Atlantic Coastal Plain surficial geology is characterized by thick, unconsolidated marine sediments deposited over the crystalline rock of the piedmont province. The deposits include clays, silts, sands and gravels (Coastal Environmental Services, 1995).

The Back River watershed drains from northwest to southeast, following the dip of the underlying crystalline bedrock in the Piedmont Province. The surface elevations range from approximately 500 feet to sea level at the Chesapeake Bay shorelines. Stream channels of the sub-watersheds are well incised in the Eastern Piedmont, and exhibit relatively straight reaches and sharp bends, reflecting their tendency to following zones of fractured or weathered rock. The stream channels broaden abruptly as they flow down across the fall line and into the soft, flat Coastal Plain sediments (Coastal Environmental Services, 1995).

The watershed is comprised primarily of B and C type soils. Soil type is categorized by four hydrologic soil groups developed by the Soil Conservation Service (SCS). The definitions of the groups are as follows (SCS, 1976):

> Group A: Soils with high infiltration rates, typically deep well-drained to excessively drained sands or gravels.
> Group B: Soils with moderate infiltration rates, generally moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures.
> Group C: Soils with slow infiltration rates, mainly soils with a layer that impedes downward water movement or soils with moderately fine to fine texture.
> Group D: Soils with very slow infiltration rates, mainly clay soils, soils with a permanently high water table, and shallow soils over nearly impervious material.

The soil distribution within the watershed is approximately 1.6% soil group A, 38.2% soil group B, 38.7% soil group C and 21.5% soil group D. Soil data was obtained from Soil Survey Geographic (SSURGO) coverages created by the National Resources Conservation Service.

The Back River watershed is comprised primarily of residential, commercial and industrial land uses (see Figure 2). There are no major industrial facilities discharging zinc within the watershed. The Back River Waste Water Treatment Plant, a major municipal waste facility, discharges metals including zinc at the outlet of Bread and Cheese Creek, a tributary of the Back River Estuary. The land use distribution in the watershed is approximately 17.7 % forest/herbaceous, 79.0 % urban, 1.9 % agricultural and 1.4 % water (Maryland Department of Planning, 2000).

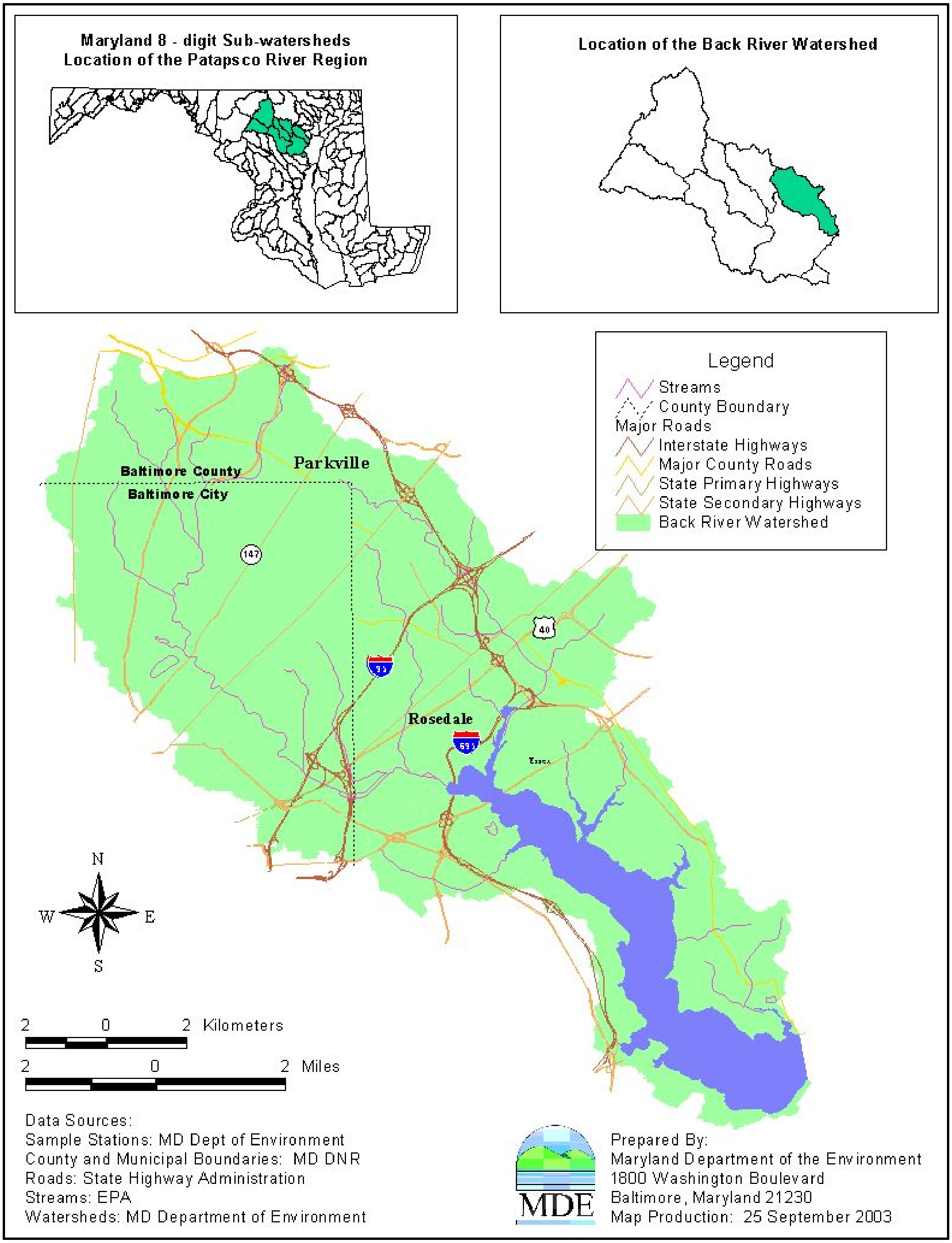

Figure 1: Watershed Map of the Back River

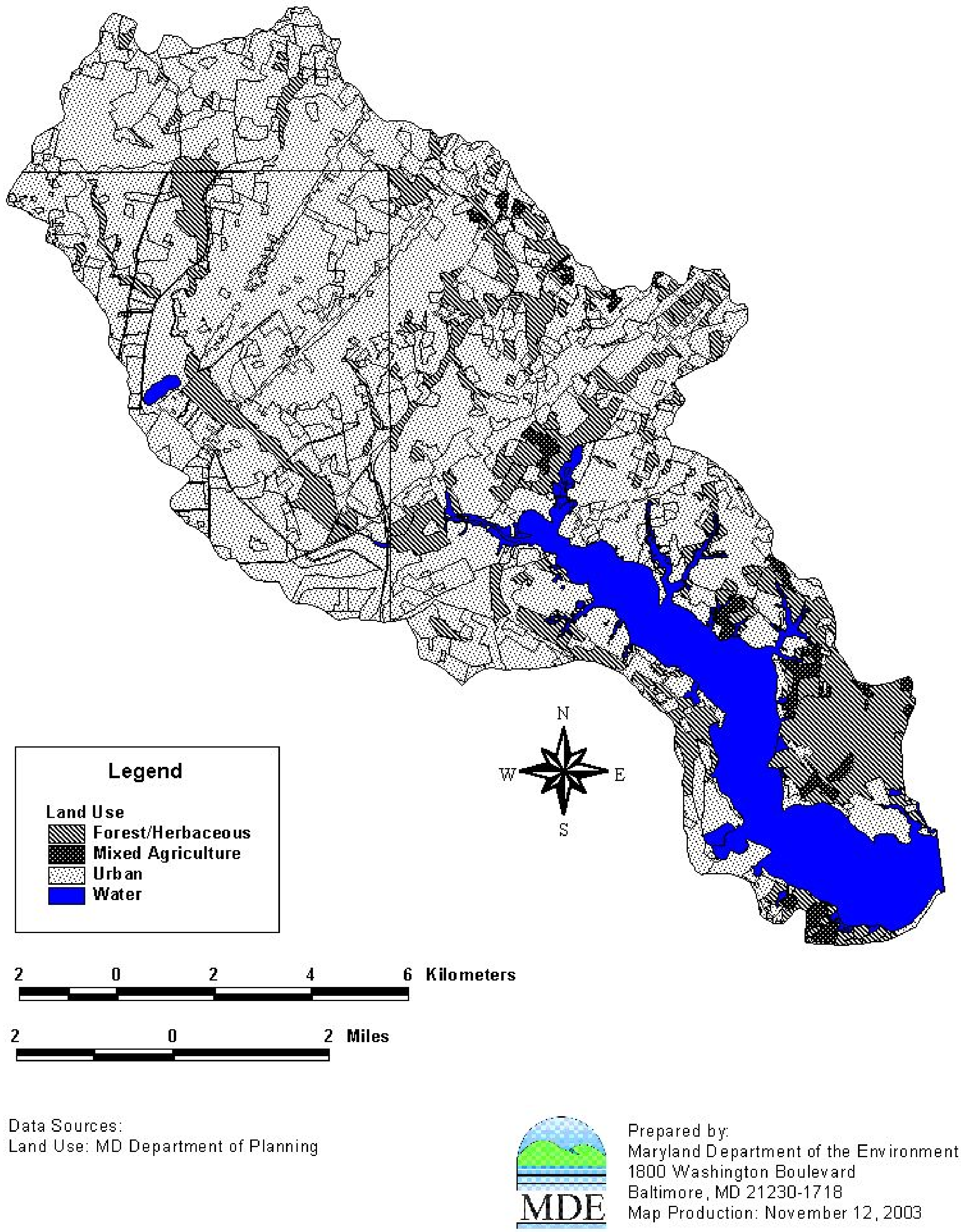

Figure 2: Land Use Map of Back River Watershed

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 (COMAR 26.08.02.08J) for the Patapsco River (basin code 02-13-09) and its tributaries (including Back River) is Use I – *water contact recreation, fishing, and protection of aquatic life and wildlife.* COMAR 26.08.02.03-1(B)(3)(j)(ii) defines the tidal region of the Back River basin considered in this WQA as being freshwater.* The freshwater aquatic life criterion for Zn is displayed below in Table 1 (COMAR 26.08.02.03-2G). The water column data presented in Section 3.1, Table 5 through Table 9, show that concentrations of Zn in the water column do not exceed water quality criterion. An ambient sediment bioassay and sediment chemistry analysis conducted in the Back River establishes that there is no toxicity in the sediment bed as a result of zinc contamination. The water column and sediment in the Back River are, therefore, not impaired by Zn. Thus the designated uses are supported and the water quality standard is being met.

Table 1: Numeric Water Quality Criteria

Metal	Fresh Water Aquatic Life Acute Criteria (µg/l)	Fresh Water Aquatic Life Chronic Criteria (µg/l)
Zn	120	120

Water column surveys, used to support this WQA, were conducted at five stations throughout the Back River estuary from January 2001 to September 2001. For every water column sample, the dissolved concentration of Zn was determined. Water column sampling was performed four times at each station from January 2001 to September 2001 to capture seasonal variation. The sampling dates were as follows: 1/24/01 (winter dry weather); 2/25/01 (winter wet weather); 7/23/01 (summer dry weather); 9/20/01 (summer wet weather). Sediment samples were also collected at 21 stations throughout the Back River estuary including those sampled in the water column survey. Sediment samples were analyzed for metals chemistry and toxicity. Table 2

* Even though COMAR 26.08.02.03-1(B)(3)(j)(ii) defines the Back River as a freshwater body, significant variability in salinity concentrations were found during the water column survey. A comparison of zinc concentrations with saltwater aquatic life criteria was also conducted based on new EPA guidance and no exceedances occurred.

shows the list of stations with their geographical coordinates, descriptive location and water quality characterization analyses performed. The station locations are presented in Figure 3.

Table 2: Sample Stations for Back River

Station	Latitude	Longitude	Description	Water Column Chemistry	Sediment Chemistry	Sediment Toxicity
BR-14	39.241	-76.416	Mid Channel below Claybank Point	-	X	X
BR-26	39.243	-76.400	Outlet of Back River between Cedar and Cuckold Point	-	X	X
BR-27	39.247	-76.449	Greenhill Cove	-	X	X
BR-29	39.247	-76.435	East of Lynch Point	-	X	X
BR-36	39.265	-76.453	Shoreline southwest of Stansbury Point	-	X	X
BR-50	39.254	-76.411	Rock Point Park	-	X	X
BR-55	39.259	-76.446	Mid-Channel west of Witchcoat Point	-	X	X
BR-60	39.269	-76.453	Cove below Stansbury Point	-	X	X
BR-74	39.275	-76.445	Mid-Channel northeast of Stansbury Point	-	X	X
BR-89	39.283	-76.439	Muddy Gut	-	X	X
BR-91	39.287	-76.467	Mid-Channel below Cox Point	-	X	X
BR-101	39.289	-76.485	Bread & Cheese Creek	-	X	X
BR-120	39.300	-76.485	Mid-Channel above Greenmarsh Point	-	X	X
BR-126	39.305	-76.499	Headwaters of Back River	-	-	X
BR-134	39.309	-76.490	Northeast Creek	-	-	X
BR-169	39.303	-76.491	Mid-Channel above Eastern Avenue Bridge	-	-	X
XIF-4450	39.238	-76.409	West of Cuckold Point	X	-	-
XIF-5633	39.256	-76.441	Mid-Channel Northwest of Porter Point	X	-	-
XIF-6633	39.272	-76.440	Near Shoreline east of Stansbury Point	X	X	-
XIF-7615	39.290	-76.472	East of Wetherby Point	X	X	X
XIF-8008	39.300	-76.484	Mid-Channel above Greenmarsh Point	X	X	X

X means data is available - means no data available

For the water quality evaluation, a comparison is made between Zn water column concentrations and fresh water aquatic life chronic criterion, the most stringent of the numeric water quality criterion for Zn. Hardness concentrations were obtained for each station to adjust the fresh water aquatic life chronic criteria that were established at a hardness of 100 mg/l for Zn. The State uses hardness adjustment to calculate fresh water aquatic life chronic criteria for Zn whose toxicity is a function of total hardness. According to EPA's National Recommended Water

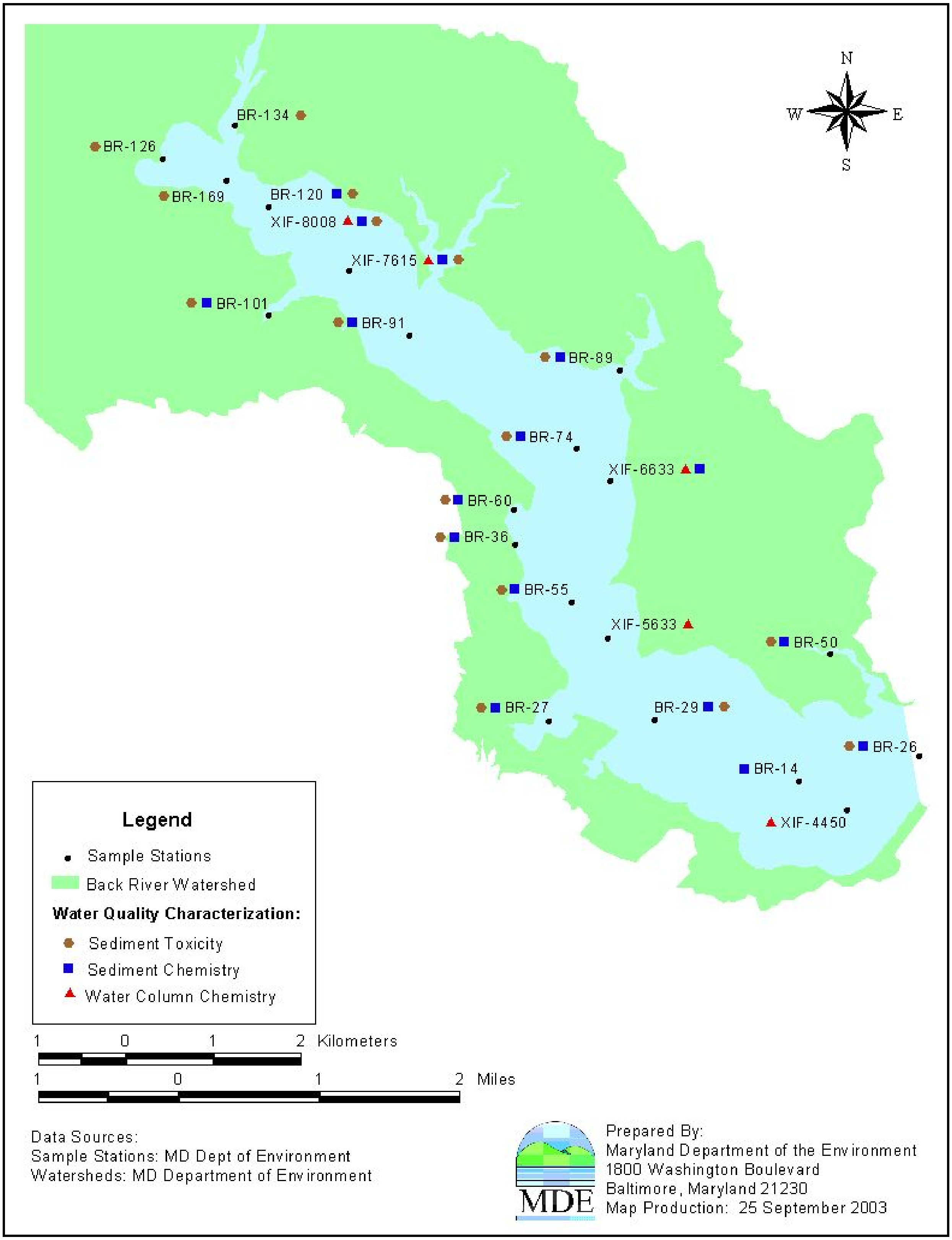

Figure 3: Sample Station Location Map

Quality Criteria (EPA, 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 technical information, EPA's Office of Research and Development does not recommend a lower limit on hardness for adjusting criterion (EPA, 2002). MDE adopts this recommendation. The HAC equation for Zn is as follows (EPA, 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 HAC parameters for Zn 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)
Zn	0.8473	0.884	0.986

The State performs a scientific review of all data submitted where a water quality criterion exceedance was the result of a hardness adjustment below 50 mg/l. This review is necessary because of the scientific uncertainty existing for hardness-toxicity relationships below 50 mg/l due to:

A. Paucity of toxicity test data below 50 mg/l that was used to develop the relationship between hardness and toxicity.
B. Presence/absence of sensitive species in the waterbody of concern.
C. 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.

In instances where hardness data is not available, the State will calculate an average of existing hardness concentrations for each station. In applying average hardness, the sampling date for which hardness data is unavailable must not fall during a storm event substantially greater than the sampling dates used to calculate the average. A major rainfall event has the potential to reduce hardness below the average. An analysis of rainfall data from the National Weather Service (NWS) precipitation gauge (0180465) at Baltimore/Washington International Airport (BWI) shows no significant variation in storm events for the sampling dates, thus the average will apply. This is the closest gauge to Back River and is likely to be representative of the rainfall events that occur within the watershed.

3.1 WATER COLUMN EVALUATION

A data solicitation for metals was conducted by MDE, and all readily available data from the past five years was considered in the WQA. The water column data is presented in Table 5 through Table 9 for each station and is evaluated using the fresh water aquatic life chronic HAC, the more stringent of the numeric water quality criterion for Zn (Baker, 2001). Each table displays hardness (mg/l), sample concentration (µg/l) and fresh water chronic HAC (µg/l) by sampling date. For example, in Table 5 for the sampling date of 9/20/01 the hardness is 1862 mg/l (400mg/l is used for HAC calculation because of the hardness limit), the hardness adjusted criterion for Zn is 382.4 µg/l and the Zn sample concentration is 5.74 µg/l. The hardness concentrations reported in bold are for sampling dates in which hardness was not measured and an average value was applied. The detection limits for the zinc analysis is displayed in Table 4. A hardness limit of 400 mg/l is applied for fresh water HAC as defined by EPA's National Recommended Water Quality Criteria (EPA, 2002).

Table 4: Metals Analysis Detection Limits

Analyte	Detection Limit (µg/l)
Zn	0.25

Table 5: Station XIF-4450 Water Column Data

Sampling Date	1/24/01		2/25/01		7/23/01		9/20/01	
Hardness (mg/l)	**1490**		**1490**		1118		1862	
Analyte	Sample (µg/l)	Criteria* (µg/l)	Sample (µg/l)	Criteria* (µg/l)	Sample (µg/l)	Criteria* (µg/l)	Sample (µg/l)	Criteria* (µg/l)
Zn	0.3	382.4	14.8	382.4	ND	382.4	5.74	382.4

* Fresh Water Aquatic Life Chronic HAC
ND - Not detected
If hardness is greater than 400 mg/l, then a hardness value of 400 mg/l is used for the HAC calculation.

Table 6: Station XIF-5633 Water Column Data

Sampling Date	1/24/01		2/25/01		7/23/01		9/20/01	
Hardness (mg/l)	**1207**		**1207**		881		1533	
Analyte	Sample (µg/l)	Criteria* (µg/l)	Sample (µg/l)	Criteria* (µg/l)	Sample (µg/l)	Criteria* (µg/l)	Sample (µg/l)	Criteria* (µg/l)
Zn	12.9	382.4	11.3	382.4	ND	382.4	11.1	382.4

* Fresh Water Aquatic Life Chronic HAC
ND - Not detected
If hardness is greater than 400 mg/l, then a hardness value of 400 mg/l is used for the HAC calculation.

Table 7: Station XIF-6633 Water Column Data

Sampling Date	1/24/01		2/25/01		7/23/01		9/20/01	
Hardness (mg/l)	**1038**		**1038**		755		1322	
Analyte	Sample (µg/l)	Criteria* (µg/l)	Sample (µg/l)	Criteria* (µg/l)	Sample (µg/l)	Criteria* (µg/l)	Sample (µg/l)	Criteria* (µg/l)
Zn	16.9	382.4	15.1	382.4	ND	382.4	4.3	382.4

* Fresh Water Aquatic Life Chronic HAC
ND - Not detected
If hardness is greater than 400 mg/l, then a hardness value of 400 mg/l is used for the HAC calculation.

Table 8: Station XIF-7615 Water Column Data

Sampling Date	1/24/01		2/25/01		7/23/01		9/20/01	
Hardness (mg/l)	**539**		**539**		320		758	
Analyte	Sample (µg/l)	Criteria* (µg/l)	Sample (µg/l)	Criteria* (µg/l)	Sample (µg/l)	Criteria* (µg/l)	Sample (µg/l)	Criteria* (µg/l)
Zn	38.3	382.4	21.6	382.4	ND	316.5	6.1	382.4

* Fresh Water Aquatic Life Chronic HAC
ND - Not detected
If hardness is greater than 400 mg/l, then a hardness value of 400 mg/l is used for the HAC calculation.

Table 9: Station XIF-8008 Water Column Data

Sampling Date	1/24/01		2/25/01		7/23/01		9/20/01	
Hardness (mg/l)	**354**		**354**		221		486	
Analyte	Sample (µg/l)	Criteria* (µg/l)	Sample (µg/l)	Criteria* (µg/l)	Sample (µg/l)	Criteria* (µg/l)	Sample (µg/l)	Criteria* (µg/l)
Zn	24.6	344.8	24	344.8	ND	231.3	2.9	382.4

* Fresh Water Aquatic Life Chronic HAC
ND - Not detected
If hardness is greater than 400 mg/l, then a hardness value of 400 mg/l is used for the HAC calculation.

The range of concentrations for Zn sampled in the field survey is as follows:

Zn = ND to 38.3 µg/l

Hardness ranged from 221 mg/l to 1862 mg/l. The concentration range of Zn is well below the associated fresh water aquatic life chronic HAC. The criterion was not exceeded by any of the Zn samples.

3.2 SEDIMENT QUALITY EVALUATION

To complete the WQA, sediment quality in the Back River was evaluated using 28-day whole sediment tests with the estuarine amphipod *Leptocheirus plumulosus* (Fisher, 2002*)*. This species was chosen because of its ecological relevance to the waterbody of concern. *L. plumulosus* is an EPA-recommended test species for assessing the toxicity of marine and estuarine sediments (EPA, 2001). Eighteen surficial sediment samples were collected using a petite ponar dredge (top 2 cm) by in the Back River. Refer back to Figure 3 for the station locations. The samples were collected in two batches. The first batch was collected by CBL on 7/23/01 at fifteen stations throughout the Back River. The second batch was collected by the MDE field office on 8/17/01 at three stations in the upper tidal reaches of Back River. A separate sediment toxicity test was required for each batch. The results of Test I (fifteen samples) and Test II (three samples) are presented in Table 10 and Table 11. Twenty amphipods were exposed to the sediment in each sample test. The table displays amphipod survival (#), amphipod growth rate (mg/day), neonates (#), average amphipod survival (%), average amphipod growth rate (mg/day) and average neonates per survivor.

The test considers three performance criteria, which are survival, growth rate, and reproduction. For the test to be valid the average survival of control sample replicates must be greater than 80%, and there must be a measurable growth rate and reproduction of neonates in the control samples. Survival of amphipods in the field sediment samples was not significantly less than the average survival demonstrated in the control samples. This comparison was made using Fisher's Least Significance Difference (LSD) test (ά = 0.05). The average survival for control samples in Test I and II were 84% and 89%. The field sediment sample average survival results were no lower than 77% for Test I and no lower than 88% for Test II. No sediment samples in the Back River exhibited toxicity contributing to mortality.

Table 10: Sediment Toxicity Test I Results

Sample	Amphipod Survival (#)	Amphipod Growth Rate (mg/day)	Neonates (#)	Average Amphipod Survival (%)	Average Amphipod Growth Rate (mg/day)	Average Neonates/survivor
Control A	18	0.052	61	84	0.046	3.3
Control B	15	0.057	75			
Control C	16	0.05	46			
Control D	20	0.036	80			
Control E	15	0.035	30			
BR-126 A	16	0.026	7	77	0.039	1.2
BR-126 B	18	0.045	21			
BR-126 C	14	0.054	7			
BR-126 D	18	0.038	25			
BR-126 E	11	0.034	29			
BR-134 A	16	0.064	58	82	0.045	1.7
BR-134 B	17	0.036	31			
BR-134 C	17	0.027	21			
BR-134 D	14	0.057	7			
BR-134 E	18	0.039	16			
BR-169 A	15	0.033	20	82	0.041	1.5
BR-169 B	15	0.048	18			
BR-169 C	19	0.036	0			
BR-169 D	20	0.042	25			
BR-169 E	13	0.045	51			

Table 11: Sediment Toxicity Test II Results

Sample	Amphipod Survival (#)	Amphipod Growth Rate (mg/day)	Neonates (#)	Average Amphipod Survival (%)	Average Amphipod Growth Rate (mg/day)	Average Neonates/survivor
Control A	17	0.069	86	89	0.068	4.1
Control B	17	0.065	76			
Control C	20	0.075	118			
Control D	16	0.068	43			
Control E	19	0.063	49			
BR-14 A	20	0.05	47	99	0.057	3.6
BR-14 B	20	0.067	145			
BR-14 C	20	0.051	58			
BR-14 D	20	0.054	72			
BR-14 E	19	0.064	37			
BR-26 A	20	0.058	64	98	0.055*	3.3
BR-26 B	19	0.066	95			
BR-26 C	20	0.056	89			
BR-26 D	19	0.045	36			
BR-26 E	20	0.052	64			
BR-27 A	20	0.056	149	99	0.063	8.3
BR-27 B	20	0.059	191			
BR-27 C	20	0.067	120			
BR-27 D	20	0.064	184			
BR-27 E	19	0.066	172			
BR-29 A	19	0.076	139	93	0.063	4.7
BR-29 B	20	0.061	87			
BR-29 C	17	0.053	51			
BR-29 D	18	0.069	101			
BR-29 E	19	0.057	65			
BR-36 A	16	0.047	88	89	0.055*	4.9
BR-36 B	18	0.058	33			
BR-36 C	19	0.058	95			
BR-36 D	16	0.06	109			
BR-36 E	20	0.051	107			
BR-50 A	20	0.05	239	99	0.059	7
BR-50 B	20	0.065	146			
BR-50 C	19	0.061	128			
BR-50 D	20	0.064	117			
BR-50 E	20	0.053	70			
BR-55 A	19	0.071	169	97	0.058	6.7
BR-55 B	20	0.053	132			
BR-55 C	20	0.06	75			
BR-55 D	19	0.053	141			
BR-55 E	19	0.055	131			

* Sample Toxicity

BR-60 A	18	0.048	72	89	0.06	6.5
BR-60 B	20	0.055	111			
BR-60 C	17	0.065	182			
BR-60 D	15	0.079	109			
BR-60 E	19	0.053	100			
BR-74 A	20	0.067	157	92	0.07	6.6
BR-74 B	19	0.064	79			
BR-74 C	19	0.063	134			
BR-74 D	17	0.064	147			
BR-74 E	17	0.092	88			
BR-89 A	18	0.06	142	95	0.059	6.7
BR-89 B	20	0.046	110			
BR-89 C	21	0.064	158			
BR-89 D	19	0.063	89			
BR-89 E	18	0.064	140			
BR-91 A	19	0.056	65	95	0.073	7.6
BR-91 B	20	0.081	263			
BR-91 C	18	0.092	134			
BR-91 D	18	0.076	142			
BR-91 E	22	0.061	131			
BR-101 A	19	0.064	79	90	0.053*	3.3
BR-101 B	20	0.056	83			
BR-101 C	18	0.056	55			
BR-101 D	17	0.048	72			
BR-101 E	16	0.041	19			
BR-120 A	19	0.064	130	88	0.063	5.1
BR-120 B	17	0.066	87			
BR-120 C	17	0.057	36			
BR-120 D	18	0.055	25			
BR-120 E	17	0.072	170			
XIF-7615 A	20	0.051	119	90	0.06	6.1
XIF-7615 B	18	0.052	141			
XIF-7615 C	20	0.07	121			
XIF-7615 D	15	0.057	74			
XIF-7615 E	17	0.068	101			
XIF-8008 A	19	0.065	92	94	0.065	5.3
XIF-8008 B	19	0.067	108			
XIF-8008 C	19	0.055	132			
XIF-8008 D	17	0.074	111			
XIF-8008 E	20	0.062	46			

* Sample Toxicity

Similarly, measurable average amphipod reproduction observed in the field sediment samples, which ranged from 1.2 to 1.7 neonates/survivor in Test I and 3.3 to 8.3 neonates/survivor in Test II, were not significantly less than the reproduction of 3.3 and 4.1 neonates/survivor observed in the control samples for Test I and Test II. This comparison was made using Fisher's Least Significance difference (LSD) test. No sediment samples exhibited toxicity contributing to a lower reproduction.

Average amphipod growth rates were not significantly less than the control samples, with the exception of three stations in Test II, BR-26, BR-36 and BR-101. This comparison was made using Fisher's Least Significance difference (LSD) test. The control sample exhibited an average growth rate of 0.068 mg/day, in contrast to 0.055 mg/day at stations BR-26 and BR-36 and 0.053 mg/day at station BR-101, therefore these stations exhibit toxicity contributing to a reduction in growth.

Ambient sediment bioassays are only capable of establishing the existence of sediment toxicity therefore further analysis was required to determine whether zinc contamination was the primary source of toxicity. A sediment chemistry analysis was conducted in order to measure Zn concentrations within the sediment (Baker, 2001). The analysis was conducted on sixteen of the sediment samples. The sediment concentrations are presented in Table 12 in units of mg/kg dry weight.

Table 12: Zinc Sediment Concentrations

Station	Date	Concentration (mg/kg)
BR-14	7/23/01	349
BR-26	7/23/01	237
BR-27	7/23/01	573
BR-29	7/23/01	358
BR-36	7/23/01	87
BR-50	7/23/01	384
BR-55	7/23/01	664
BR-60	7/23/01	461
BR-74	7/23/01	508
BR-89	7/23/01	132
BR-91	7/23/01	1107
BR-101	7/23/01	1569
BR-101	8/14/03	1110
BR-120	7/23/01	437
XIF-6633	7/23/01	275
XIF-7615	7/23/01	788
XIF-8008	7/23/01	721
XIF-8008	8/13/03	627

The Effects Range Median (ERM) concentration has been used as a screening level indicator of toxicity within the sediment. If the concentration of the pollutant exceeds the ERM it is likely (i.e., a 50% chance) that sediment toxicity will occur. The ERM cannot solely predict toxicity due to mitigating factors such as the presence of acid volatile sulfide (AVS) which reduces the bioavailability of Zn through the formation of an insoluble metallic sulfide compound. The ERM concentration of Zn is 410 mg/kg (dry weight). Stations BR-27, BR-55, BR-60, BR-74, BR-91, XIF-7614 and XIF-8008 exceeded the ERM but did not show signs of sediment toxicity as established by the ambient sediment bioassay, therefore Zn has likely formed an insoluble metallic sulfide and is biologically unavailable to the benthic organisms. Stations BR-26 and BR-36 have Zn concentrations of 237 mg/kg and 87 mg/kg, which are significantly lower than the ERM of 410 mg/kg, thus Zn is not a source of toxicity. Station BR-101 has Zn concentrations of 1569 mg/kg and 1110 mg/kg, which are significantly higher than the ERM.

An AVS-Simultaneously Extracted Metals (SEM) analysis was conducted for station BR-101 to determine whether AVS had completely bound Zn within the sediment (Baker, 2003). AVS-SEM is generally used as an indicator of toxicity due to metals. When the AVS/SEM concentration ratio is greater than one, metals within the sediment are no longer bioavailable due to the formation of insoluble metallic sulfides resulting in no metals toxicity. The concentrations of AVS and its associated metals (Zn, Chromium (Cr), Copper (Cu), Arsenic (As), Silver (Ag), Cadmium (Cd) and Lead (Pb)) are presented in Table 13 in units of µmol/g (dry weight).

Table 13: AVS-SEM Concentrations

Substance	Concentration (umol/g)
AVS	20.4
Cr	1.34
Cu	0.349
Zn	12.3
As	0.0081
Ag	0.0022
Cd	0.0427
Pb	0.823
Sum SEM umol/g=	**14.9**
AVS/SEM Ratio =	**1.4**

With an AVS/SEM ratio of 1.4, Zn is not a source of toxicity. A porewater analysis of this sample was conducted at the same time to confirm that Zn was primarily bound as a metallic sulfide compound and did not partition into the dissolved phase (Baker, 2003). The Zn porewater concentration was 0.65 µg/l which is significantly lower than the fresh water chronic aquatic life criterion of 120 µg/l. The dissolved Zn concentration in the porewater is much lower than in the water column due to anoxic conditions and high levels of sulfide in the sediment.

Significant sulfide binding results in greater partitioning of metals to the sediment relative to the partitioning of metals to suspended particles in the water column.

4.0 CONCLUSION

The WQA shows that the water quality standard for Zn is being achieved. Water column samples collected at five monitoring stations in the Back River, from January 2001 to September 2001, demonstrate that numeric water quality criterion is being met. Bottom sediment samples collected at eighteen monitoring stations, and used for bioassay toxicity tests, demonstrate no impacts on survival and reproduction, and growth rate impacts at three of the eighteen stations, BR-26, BR36 and BR-101. A sediment chemistry analysis demonstrated that Zn concentrations at Stations BR-26 and BR-36 were significantly below the ERM, therefore Zn was not an impairing substance. Even though station BR-101 exhibited a zinc concentration much greater than the ERM, an AVS-SEM and porewater analysis also demonstrated that Zn was not a source of toxicity. Barring the receipt of any contradictory data, this information provides sufficient justification to revise Maryland's 303(d) list to remove Zn as impairing substances in the Back River.

5.0 REFERENCES

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