Water Quality Analysis of Heavy Metals for the Loch Raven Reservoir Impoundment in Baltimore County, Maryland

FINAL

Prepared by:

Maryland Department of the Environment
Montgomery Park Business Center
1800 Washington Boulevard, Suite 540
Baltimore MD 21230-1718

Submitted to:

Watershed Protection Division
U.S. Environmental Protection Agency, Region III
1650 Arch Street
Philadelphia, PA 19103-2029

Submittal: September 24, 2003
EPA Concurrence: November 10, 2003
Document version: September 17, 2003

Table of Contents

List of Figures

List of Tables

List of Abbreviations

As	Arsenic
Be	Beryllium
CBL	Chesapeake Biological Laboratory
Cd	Cadmium
cm	Centimeter
COMAR	Code of Maryland Regulations
Cr	Chromium
Cu	Copper
CWA	Clean Water Act
DOC	Dissolved Organic Carbon
EPA	Environmental Protection Agency
HAC	Hardness Adjusted Criteria
Hg	Mercury
MDE	Maryland Department of the Environment
mg	Milligram
mg/l	Milligrams per Liter
Ni	Nickel
NPDES	National Pollution Discharge Elimination System
Pb	Lead
PCB	Poly-chlorinated Biphenyl
Sb	Antimony
SCS	Soil Conservation Service
Se	Selenium
SSURGO	Soil Survey Geographic
TMDL	Total Maximum Daily Load
USGS	United States Geologic 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 (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. For each WQLS, the State is to either establish a Total Maximum Daily Load (TMDL) of the specified substance that the waterbody can receive without violating water quality standards, or demonstrate that water quality standards are being met.

The Loch Raven Reservoir (basin code 02-13-08-05), located in Baltimore County, MD, was identified on the State's list of WQLSs as impaired by heavy metals (1996 listing), nutrients (1996 listing), suspended sediments (1996 listing), fecal coliform (2002 listing), evidence of biological impacts (2002 listing), polychlorinated biphenyls (PCBs) (2002 listing) and methylmercury (2002 listing). The heavy metal, nutrient, suspended sediment and PCB impairments were listed for the impoundment, and the biological and fecal coliform impairments were listed for the non-tidal streams. This report provides an analysis of recent monitoring data, including hardness data, which shows that the aquatic life criteria for heavy metals and the designated uses supported by those criteria are being met in the Loch Raven Reservoir. The non-tidal streams are not listed for heavy metals therefore they are not addressed in the water quality analysis (WQA). The analysis supports the conclusion that a TMDL of heavy metals 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 Loch Raven Reservoir from Maryland's list of WQLSs for heavy metals when the Maryland Department of the Environment (MDE) proposes the revision of Maryland's 303(d) list for public review in the future. A TMDL for methylmercury in fish tissue was completed in 2002. The nutrient, suspended sediments, bacteria and biological impairments will be addressed separately at a future date.

Although the waters of the Loch Raven Reservoir do not display signs of toxic impairments due to heavy metals, the State reserves the right to require additional pollution controls in the Loch Raven Reservoir watershed if evidence suggests that heavy 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'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) of 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 criteria being met; or 4) correction to errors made in the initial listing.

The Loch Raven Reservoir (basin code 02-13-08-05) was identified on the 1996 303(d) list submitted to EPA by the Maryland Department of the Environment (MDE) as impaired by heavy metals, nutrients and suspended sediments, with fecal coliform, methylmercury, polychlorinated biphenyls (PCBs) and biological impairments added to the list in 2002. The heavy metal, nutrient, suspended sediment and PCB impairments were listed for the impoundment and the biological, and fecal coliform impairments were listed for the non-tidal streams. The initial listing for heavy metals was questionable because: 1) no specific pollutants were defined; 2) the original listing was based on total recoverable metals (current standard is for dissolved metals); 3) inappropriate sampling techniques were applied (lack of filtration); 4) supporting data needed to interpret criteria was not available (hardness); and 5) a default hardness of 100 mg/l was used to convert and relate the total recoverable metals to the dissolved criteria, which superceded the total recoverable metals criteria. A water quality analysis (WQA) of heavy metals for the Loch Raven Reservoir impoundment was performed using recent water column and sediment toxicity data. Results show no impairment for heavy metals. The non-tidal streams are not listed for heavy metals therefore they are not addressed in the WQA. A TMDL for methylmercury in fish tissue was completed in 2002. The nutrient, suspended sediments, bacteria and biological impairments will be addressed separately at a future date.

The term "heavy metals" and "metals" are interchangeable and generally interpreted to include those 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 a significant detriment to aquatic life. For the purposes of this WQA, metals are those priority pollutant metals that are commonly permitted in National Pollution Discharge Elimination System (NPDES) industrial or NPDES stormwater discharges. The following metals were sampled in the Loch Raven Reservoir impoundment: arsenic (As); cadmium (Cd); chromium (Cr); copper (Cu); nickel (Ni); lead (Pb); selenium (Se)

and zinc (Zn). Mercury (Hg), one of the priority pollutant metals, was addressed in the methylmercury fish tissue TMDL completed in 2002, therefore it will not be included in the 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 Loch Raven Reservoir 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 Loch Raven Reservoir is achieving water quality criteria for metals.

2.0 GENERAL SETTING

Loch Raven Reservoir is an impoundment located near Timonium in Baltimore County, Maryland (see Figure 1). The impoundment is owned by the Baltimore City Department Public Works and is situated in the Gunpowder River watershed. The Loch Raven Reservoir is one of the major sources of raw water in the Baltimore area. Prettyboy Reservoir lies in the Loch Raven Reservoir watershed and drains into Loch Raven Reservoir. The Prettyboy Reservoir watershed comprises approximately 26% of the area of the Loch Raven watershed. The City of Baltimore Department of Public Works owns both water bodies and uses them in a system to provide a major source of public water to the Baltimore metropolitan area. In 1912, the dam for the Loch Raven Reservoir was built, and in response to additional water demand, the crest was raised in 1918 to its current 240 feet above sea level. The Loch Raven Dam was modified in 1986. Water is directed for treatment to the Montebello treatment plant, and from there, distributed to Baltimore City and the surrounding areas. Inflow to the Reservoir is primarily via the Gunpowder River. Table 1 lists the physical characteristics of the Loch Raven Reservoir.

Table 1: Physical Characteristics of the Loch Raven Reservoir

Location:	Baltimore County, Maryland Latitude 39.43 Longitude 76.54 (Dam)
Surface Area:	9.7125 km^2
Normal Depth:	23.2 meters
Normal Volume:	8.97 x 10^7 m^3
Drainage Area to Lake:	788.81 km^2
Average Annual Flow:	8.6 m^3/s

* Includes contribution from Prettyboy Reservoir Watershed

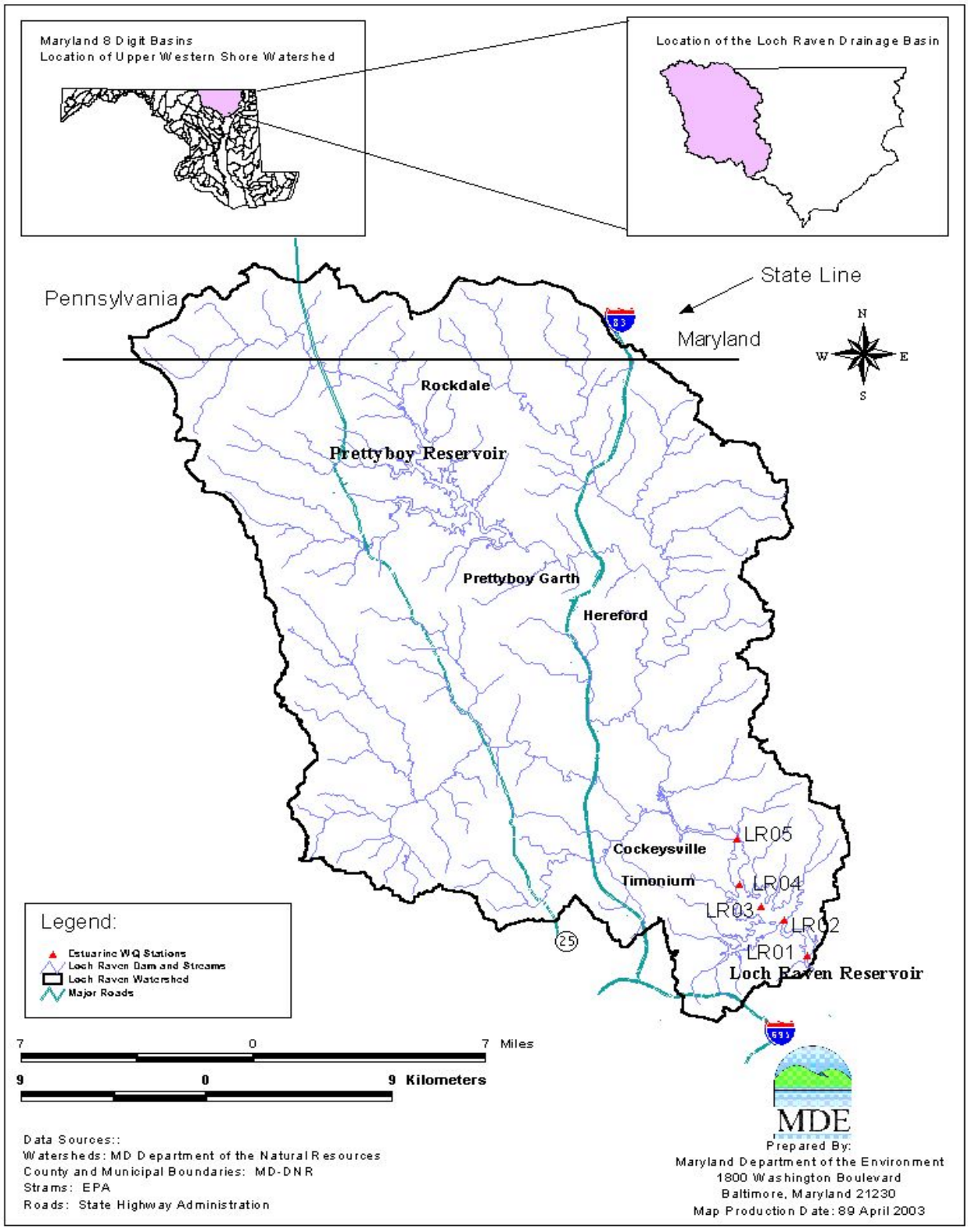

Figure 1: Watershed Map of the Loch Raven Reservoir

The majority of the watershed is in the Piedmont physiographic province. The highest elevation in the study area is 1,087 feet at the extreme northwestern boundary of the watershed in Pennsylvania. The Piedmont area is strongly dissected with rolling to steep topography. The Piedmont region in the watershed is underlain by metamorphic rock of Precambrian and Cambrian age. Deep, unconsolidated marine sediments of early Cretaceous and Pleistocene age overlie the metamorphic rock unconformably in the Coastal Plain province. The underlying metamorphic rock complex in the Piedmont region of the watershed consists mainly of crystalline schists and gneiss with smaller areas of marble. The underlying marble formations consist of Cockeysville Marble and Patuxent Formation. These formations are less resistant to weathering and occur primarily in valleys. Marble areas typically have higher infiltration rates and greater groundwater flow rates.

Soils overlying the bedrock in the Piedmont are seven to twenty feet deep. Soil formation is the result of the interaction of a variety of factors, including climate, parent material, relief, time, and biota. The humid continental climate has resulted in strong weathering and leaching of soils within the watershed. These processes have depleted free carbonates thereby acidifying the soils. The primary soil associations in the Piedmont area of the Loch Raven Reservoir Study area are Manor-Glenelg, Chester-Glenelg, Baltimore-Conestoga-Hagerstown, Beltsville-Chillum-Sassafras, and Glenelg-Chester-Manor.

The watershed is comprised primarily of B 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 1.04% soil group A, 83.5% soil group B, 9.45% soil group C and 6.0% soil group D. Soil data was obtained from Soil Survey Geographic (SSURGO) coverages created by the National Resources Conservation Service.

The area draining to Loch Raven Reservoir is predominately mixed agricultural and forest/herbaceous (see Figure 2). Only one point source, the Noxell Corporation, located in Hunt Valley, MD, discharges metals (Cu) within the Loch Raven Reservoir Watershed. Land use distribution in this watershed is approximately 42% mixed agricultural, 37% forest/herbaceous, 19% developed and 2% water (Maryland Department of Planning, 2000).

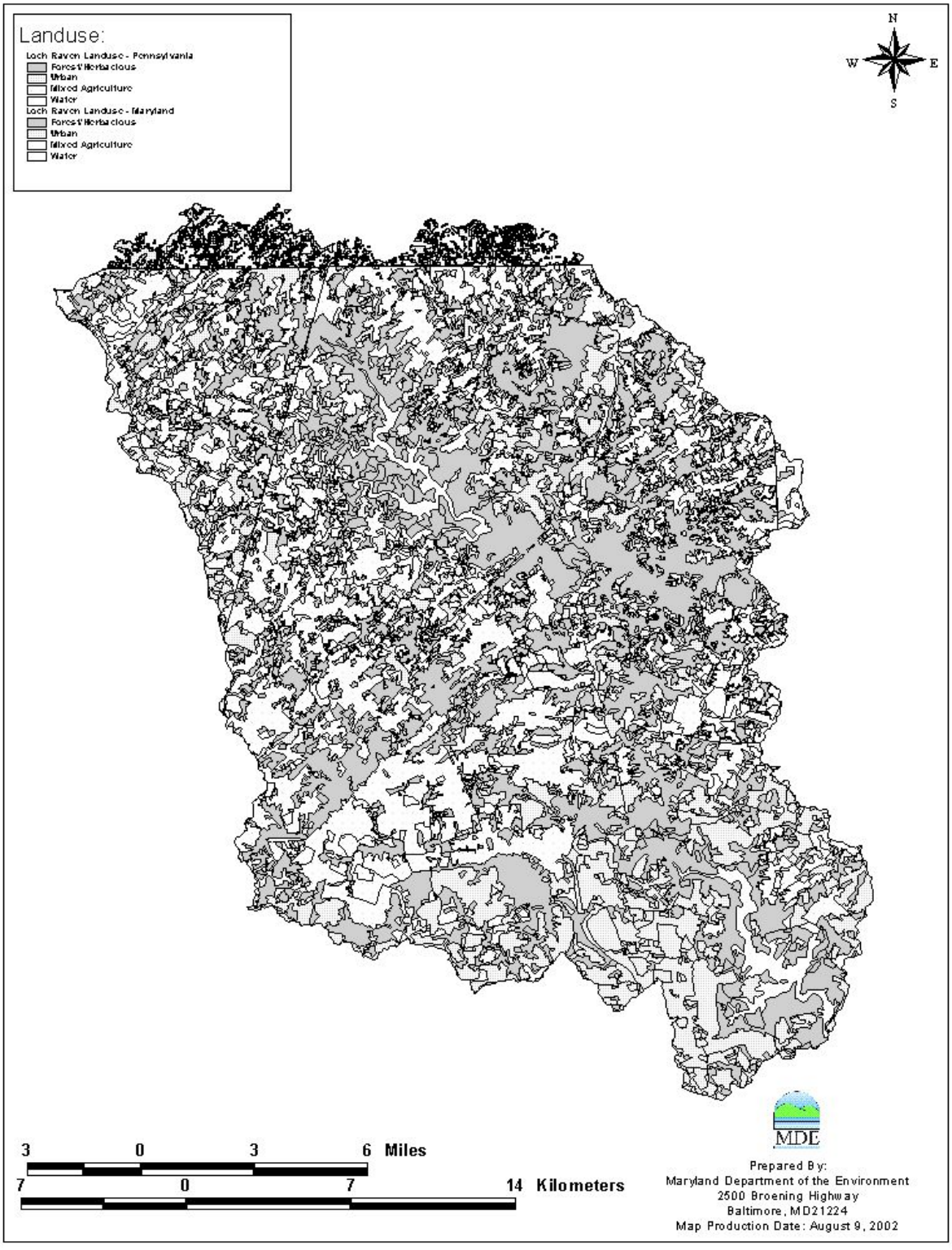

Figure 2: Land Use Map of Loch Raven Reservoir Watershed

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 the designated use 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 (Code of Maryland Regulations (COMAR) 26.08.02.08I) for the Gunpowder River and its tributaries (including Loch Raven Reservoir) is Use III-P – *natural trout waters and public water supply.* In addition, COMAR requires that all waterbodies in the State of Maryland support a Use I designation - *water contact recreation, fishing and protection of aquatic life and wildlife.* The applicable numeric aquatic life and human health (drinking water & fish consumption) criteria for dissolved metals in freshwater are described below in Table 2 (COMAR 26.08.02.03-2G). There are two species of chromium, trivalent Cr (III) and hexavalent Cr (VI). Cr (VI) has the highest toxicity of the Cr species, therefore the numeric criteria is more stringent. Total chromium concentrations were analyzed in the water column survey and are compared with the Cr (VI) numeric water quality criterion. The Loch Raven Reservoir is designated a public water supply therefore the human health (drinking water) criteria for metals must also be achieved. The water column data presented in Section 3.1, Table 6 through Table 10, shows that concentrations of metals in the water column do not exceed the aquatic life or human health (drinking water & fish consumption) criteria. An ambient sediment bioassay conducted in Loch Raven Reservoir establishes that there is no toxicity in the sediment bed of the impoundment (Fisher, 2002). Sediment chemistry analysis was not conducted because toxicity was not observed in the ambient sediment bioassay. The water column and sediment in the Loch Raven Reservoir impoundment is therefore not impaired by metals, thus the designated uses are supported and the water quality standard is being met for these substances.

Water column surveys conducted at five stations in the Loch Raven Reservoir from May 2001 to July 2001 were used to support these WQAs. For every sample, dissolved concentrations of the eight metals were determined. Sediment samples were also collected at all five monitoring stations for the sediment bioassay. Table 3 shows the list of stations with their geographical coordinates and descriptive location in the Loch Raven Reservoir watershed. Refer back to Figure 1 for station locations.

Water column sampling was performed four times for each station from May 2001 to July 2001 to capture seasonal variation. The sampling dates were as follows: 5/21/01 (spring wet weather); 6/11/01 (spring dry weather); 7/25/01 (summer dry weather) and 7/30/01 (summer wet weather).

Table 2: Numeric Water Quality Criteria (Metals)

Metal	Fresh Water Aquatic Life Acute Criteria (µg/l)	Fresh Water Aquatic Life Chronic Criteria (µg/l)	Human Health Criteria Drinking Water (µg/l)	Human Health Criteria Fish Consumption (µg/l)
As	340	150	50	41
Cd	4.3	2.2	5	-
Cr (VI)	16	11	100 *	-
Cu	13	9	1,300	1,300
Ni	470	52	100	4,600
Pb	65	2.5	15	-
Se	20	5	50	11000
Zn	120	120	-	69,000

* Human Health Criterion (drinking water) is designated for Cr

Table 3: Water Quality Analysis Stations for Loch Raven Reservoir

Station I.D.	GPS Coordinates	Station Description
LR01	39.431 76.543	Mouth of Loch Raven Reservoir.
LR02	39.446 76.555	Above LR01, off of Loch Raven Road in the Reservoir.
LR03	39.453 76.569	Above LR02, in the middle of the Reservoir, across from the Loch Raven Golf Course.
LR04	39.463 76.581	Above LR03, In the Reservoir, off of Dulaney Valley Road.
LR05	39.484 76.528	Above LR04, across from Springdale, MD, in the Reservoir.

For the water quality evaluation, a comparison is made between the water column concentrations of the metals and fresh water aquatic life chronic criteria, which is the more stringent of the numeric water quality criteria for metals except for As in which the human health criterion for fish consumption is more stringent and will be applied. Hardness concentrations were obtained for each station to adjust the fresh water aquatic life chronic criteria that are established at a hardness of 100 mg/l for metals. The State used the hardness adjustment to calculate fresh water aquatic life chronic criteria for those metals (Cd, Cu, Ni, Pb, and Zn) for which toxicity is a function of total hardness. The fresh water aquatic life chronic criteria are not adjusted for Cr (VI) and Se and because hardness either 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, 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 criteria (EPA, 2002). MDE adopts this recommendation. The HAC equation for metals is as follows (EPA, 2002):

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

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

The HAC parameters for metals are presented in Table 4.

Table 4: HAC Parameters (Fresh Water Aquatic Life Chronic Criteria)

Chemical	Slope (m)	y Intercept (b)	Conversion Factor (CF)
Cd	0.7852	-2.715	1.102 - ln(hardness)*0.0418
Cu	0.8545	-1.702	0.960
Pb	1.2730	-4.705	1.462 - ln(hardness)*0.146
Ni	0.8460	0.0584	0.997
Zn	0.8473	0.884	0.986

The State will perform 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 Loch Raven Reservoir 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 the MDE and all readily available data from the past five years was considered in the WQA. The water column data is presented in Table 6 through Table 10 for each station and is evaluated using the fresh water aquatic life chronic HAC, the more stringent of the numeric criteria for metals except for As in which the human health criterion is applied (Baker, 2002). Each table displays hardness (mg/l), sample concentrations (µg/l) and fresh water aquatic life chronic HAC (µg/l) by sampling date. For example, in Table 6 for the sampling date of 6/11/01 the hardness is 39.15 mg/l, the hardness adjusted criterion for Cu is 4.02 µg/l and the Cu sample concentration is 0.57 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 metals analysis are displayed in Table 5.

Table 5: Metals Analysis Detection Limits

Analyte	Detection Limit (µg/l)
As	0.09
Cd	0.001
Cr	0.03
Cu	0.01
Ni	0.01
Pb	0.003
Se	0.09
Zn	0.25

The range of concentrations for metals sampled in the field survey are as follows:

As = ND to 0.33 µg/l
Cd = ND to 0.01 µg/l
Cr = ND to 0.24 µg/l
Cu = 0.45 to 0.76 µg/l
Ni = 0.09 to 0.64 µg/l
Pb = ND to 0.02 µg/l
Se = ND to 0.51 µg/l
Zn = ND to 7.79 µg/l

Hardness ranges from 31.65 mg/l to 41.1 mg/l. The concentration ranges of all eight metals are well below their associated fresh water aquatic life chronic hardness adjusted criteria. The criteria were not exceeded by any of the eight metals sampled.

Table 6: Station LR01 Water Column Data

Sampling Date	5/21/01		6/11/01		7/25/01		7/30/01	
Hardness (mg/l)	40.5		39.15		36.9		**38.9**	
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)
As	0.25	41	0.19	41	0.28	41	0.23	41
Cd	ND	1.15	0.01	1.12	ND	1.07	ND	1.12
Cr	0.13	11	0.12	11	0.06	11	0.16	11
Cu	0.74	4.14	0.57	4.02	0.57	3.82	0.49	4.00
Ni	0.46	24.21	0.65	23.52	0.13	22.38	0.30	23.40
Pb	ND	0.93	ND	0.89	0.01	0.84	ND	0.89
Se	0.27	5	0.22	5	0.45	5	ND	5
Zn	0.17	54.93	0.17	53.37	ND	50.8	ND	53.08

* Fresh Water Aquatic Life Chronic HAC
  A) Cr (VI) criterion is applied
  B) Hardness adjustment is unnecessary for Cr (VI) and Se
  C) Human Health Criterion (fish consumption) is applied for As

ND - Not detected

Table 7: Station LR02 Water Column Data

Sampling Date	5/21/01		6/11/01		7/25/01		7/30/01	
Hardness (mg/l)	41.1		39.15		36.45		**38.9**	
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)
As	0.25	41	0.18	41	0.20	41	0.32	41
Cd	ND	1.16	ND	1.12	ND	1.06	ND	1.12
Cr	0.14	11	0.11	11	0.03	11	0.17	11
Cu	0.76	4.19	0.57	4.02	0.55	3.78	0.49	4.00
Ni	0.47	24.51	0.64	23.52	0.09	22.14	0.3	23.40
Pb	ND	0.94	ND	0.89	ND	2.5	ND	0.89
Se	0.22	5	0.24	5	ND	5	ND	5
Zn	0.35	55.62	0.38	53.37	5.26	50.24	ND	53.08

Table 8: Station LR03 Water Column Data

Sampling Date	5/21/01		6/11/01		7/25/01		7/30/01	
Hardness (mg/l)	40.65		39.15		36.15		**38.7**	
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)
As	0.24	41	0.17	41	ND	41	0.33	41
Cd	ND	1.15	ND	1.12	ND	1.05	ND	1.11
Cr	0.11	11	0.13	11	ND	11	0.17	11
Cu	0.75	4.15	0.54	4.02	0.55	3.75	0.45	3.98
Ni	0.49	24.28	0.64	23.52	0.16	21.99	0.28	23.29
Pb	ND	0.93	ND	0.89	0.01	0.82	ND	0.88
Se	0.19	5	0.21	5	0.51	5	ND	5
Zn	0.25	55.10	0.11	53.37	7.79	49.89	ND	52.85

* Fresh Water Aquatic Life Chronic HAC
  A) Cr (VI) criterion is applied
  B) Hardness adjustment is unnecessary for Cr (VI) and Se
  C) Human Health Criterion (fish consumption) is applied for As

ND - Not detected

Table 9: Station LR04 Water Column Data

Sampling Date	5/21/01		6/11/01		7/25/01		7/30/01	
Hardness (mg/l)	40.65		39.15		36		**38.6**	
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)
As	0.27	41	0.19	41	ND	41	0.29	41
Cd	ND	1.15	ND	1.12	ND	1.05	ND	1.11
Cr	0.11	11	0.14	11	0.04	11	0.17	11
Cu	0.73	4.15	0.56	4.02	0.55	3.74	0.47	3.97
Ni	0.48	24.28	0.63	23.52	0.16	21.91	0.28	23.24
Pb	ND	0.93	ND	0.89	0.01	0.81	ND	0.88
Se	0.26	5	0.24	5	ND	5	ND	5
Zn	0.20	55.10	0.22	53.37	4.39	49.71	ND	52.74

Table 10: Station LR05 Water Column Data

Sampling Date	5/21/01		6/11/01		7/25/01		7/30/01	
Hardness (mg/l)	39.75		38.25		31.65		**36.6**	
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)
As	0.24	41	0.15	41	ND	41	0.20	41
Cd	ND	1.13	ND	1.10	ND	0.95	ND	1.06
Cr	0.24	11	0.12	11	0.02	11	0.16	11
Cu	0.68	4.07	0.56	3.94	0.57	3.35	0.47	3.79
Ni	0.48	23.83	0.64	23.07	0.12	19.65	0.42	22.22
Pb	ND	0.91	ND	0.87	0.02	0.71	ND	0.83
Se	0.29	5	0.23	5	0.40	5	ND	5
Zn	0.18	54.06	0.14	52.33	3.77	44.57	ND	50.41

* Fresh Water Aquatic Life Chronic HAC

A) Cr (VI) criterion is applied
B) Hardness adjustment is unnecessary for Cr (VI) and Se
C) Human Health Criterion (fish consumption) is applied for As

ND - Not detected

3.2 SEDIMENT TOXICITY EVALUATION

To complete the WQA, sediment quality in the Loch Raven Reservoir was evaluated using 10-day survival and growth whole sediment tests with the freshwater amphipod *Hyallela azteca.* This species was chosen because of its ecological relevance to the waterbody of concern. *H. azteca* is an EPA-recommended test species for assessing the toxicity of freshwater sediments (EPA, 2000). Five surficial sediment samples were collected using a petite ponar dredge (top 2 cm) by Chesapeake Biological Laboratory (CBL) from Loch Raven Reservoir. The sediment stations correspond to the five monitoring stations sampled in the water column surveys. Refer back to Figure 1 for station locations. Sediment toxicity test results are presented in Table 11. Ten amphipods were exposed to the sediment in each sample test. The table displays amphipod survival (#), amphipod weight (mg), average amphipod survival (%), and average amphipod weight (mg).

The test considers two performance criteria, which are survival and growth. For the test to be valid the average survival in control samples must be greater than 80% and there must be sufficient growth. Survival of amphipods in the field sediment samples was not significantly different than the 91.3 % average survival demonstrated in the control samples [$p < 0.05$]. Field sediment sample average survival results were 97.5, 93.8, 92.5, 91.3, and 95 percent. No sediment samples in the Loch Raven Reservoir exhibited toxicity contributing to mortality.

Table 11: Sediment Toxicity Test Results

Sample	Amphipod Survival (#)	Amphipod Weight (mg)	Average Amphipod Survival (%)	Average Amphipod Weight (mg)
Control A	9	0.159	91.3	0.172
Control B	9	0.181		
Control C	10	0.182		
Control D	10	0.183		
Control E	7	0.184		
Control F	9	0.156		
Control G	10	0.176		
Control H	9	0.157		
LR-01	10	0.229	97.5	0.22
LR-01	10	0.225		
LR-01	9	0.242		
LR-01	9	0.227		
LR-01	10	0.234		
LR-01	10	0.189		
LR-01	10	0.207		
LR-01	10	0.208		
LR-02	10	0.234	93.8	0.229
LR-02	10	0.212		
LR-02	10	0.188		
LR-02	8	0.261		
LR-02	9	0.247		
LR-02	9	0.232		
LR-02	10	0.221		
LR-02	9	0.234		
LR-03	10	0.23	92.5	0.232
LR-03	9	0.241		
LR-03	9	0.261		
LR-03	9	0.217		
LR-03	10	0.196		
LR-03	10	0.243		
LR-03	10	0.21		
LR-03	7	0.259		
LR-04	8	0.201	91.3	0.217
LR-04	8	0.239		
LR-04	10	0.221		
LR-04	10	0.223		
LR-04	10	0.18		
LR-04	10	0.231		
LR-04	10	0.213		
LR-04	7	0.224		
LR-05	10	0.219	95	0.206
LR-05	10	0.201		
LR-05	8	0.188		
LR-05	9	0.213		
LR-05	10	0.192		
LR-05	10	0.216		
LR-05	9	0.198		
LR-05	10	0.22		

Similarly, measured growth in the field sediment samples was not significantly different than in the control samples [$p < 0.05$]. In fact, growth in all of the reservoir samples was greater than in the control sediments. The weight of amphipods at the end of the growth period observed in the field sediment samples ranged from 0.206 g to 0.232 g while the weight observed in the control sample was 0.172 g. No sediment samples exhibited toxicity contributing to a reduction in growth.

4.0 CONCLUSION

The WQA shows that water quality standards for metals are being achieved. Water column samples collected at five monitoring stations in the Loch Raven Reservoir, from May 2001 to July 2001, demonstrate that numeric water quality criteria are being met. Bottom sediment samples collected at five monitoring stations, and used for bioassay toxicity tests, demonstrate no impacts on survival and growth. Barring the receipt of any contradictory data, this information provides sufficient justification to revise Maryland's 303(d) list to remove metals as impairing substances in the Loch Raven Reservoir impoundment.

5.0 REFERENCES

Baker, J.E., Ko, F., Burrell, T., Falco, K., Burley, E. *Upper Western Shore Chemical Contaminant Survey 2001 - 2002, Final Data Report: Streamwater Trace Metals and Nutrients*. University of MD, Chesapeake Biological Laboratory, August 20, 2002.

COMAR 26.08.02.02-2G. *Numerical Criteria for Toxic Substances in Surface Waters*.

COMAR 26.08.02.08I. *Stream Segment Designations***.**

Fisher, D., Yonkos, L., Ziegler, G., Shepard, M. *Assessment of Sediment Toxicity in Back River, Middle River and in Three Reservoirs*. University of MD, Wye Research and Education Center, May 20, 2002.

Maryland Department of Planning, 2000 Land Use, Land Cover Map Series, 2000.

Soil Conservation Service (SCS). *Soil Survey of Baltimore County, MD*, 1976.

U.S. Environmental Protection Agency. *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. 2000.

U.S. Environmental Protection Agency. *National Recommended Water Quality Criteria: 2002*. EPA-822-R-02-047. November 2002.