

North Carolina DENR – Division of Water Resources

# Total and Dissolved Metals in North Carolina Surface Waters: RAMS Data Exploration

January 2007 – June 2013

*November 7, 2014*

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## **EXECUTIVE SUMMARY**

Total and dissolved metals results from 120 Random Ambient Monitoring System (RAMS) stations were explored in regard to current and proposed freshwater metals standards. Three methods of evaluation were used:

- Were results higher than standards over ten percent of the time?
- Were results higher than standards over ten percent of the time AND was statistical confidence in the ten percent rate at least ninety percent?
- Were results higher than standards more than once in three years of monitoring?

While some individual results were higher than standards, the overall results from the majority (98/120) of RAMS stations were not higher than standards for any total or dissolved metal through any of the three evaluation methods. Twenty-two stations returned results over standards for one or more metal(s) through the evaluation methods above. For each parameter with results over current or proposed standards, results were over the evaluation threshold(s) at two to twelve stations.

- No stations returned results over the evaluation thresholds for current Aquatic Life standards for total arsenic, beryllium, cadmium, chromium or lead, nor over Water Supply standards for total nickel. No stations had results over proposed chronic or acute standards for dissolved arsenic, beryllium, cadmium, chromium<sup>1</sup>, lead (acute) or nickel.
- Arsenic: Results from two stations were over current and proposed (unchanged) total arsenic Human Health standards.
- Copper: Results from seven stations were over the current total copper standard. Results from twelve stations were over proposed calculated hardness-dependent chronic dissolved copper standards. Results from six stations were over proposed calculated hardness-dependent acute dissolved copper standards.
- Lead: Results from two stations were over proposed calculated hardness-dependent chronic dissolved lead standards.
- Mercury, Selenium and Silver: There are no proposed changes to total mercury and total selenium standards. Results were not available for silver evaluation. Please see relevant sections within the report for details on these metals.
- Zinc: Results from seven stations were over the current total zinc standard. Results from five stations were over proposed calculated hardness-dependent chronic and acute dissolved zinc standards.

The frequency and duration component of the proposed standards were not evaluated with this dataset, and assumptions were made to be able to evaluate the magnitude component of the proposed standards. Currently, no RAMS stations are located in waters classified as salt waters, so summaries of data related to salt water quality standards were not possible in this evaluation.

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<sup>1</sup> Dissolved whole chromium results were evaluated; see Chromium section below for details and assumptions.

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## **BACKGROUND**

### **WATER QUALITY STANDARDS FOR TOTAL AND DISSOLVED METALS**

Water quality standards are used to determine if the designated uses of a water body are being protected. Those uses are defined by classifications assigned to the water body. There may be more than one classification assigned to a water body and there may also be more than one standard that applies based on the classifications of a water body. Surface water standards are used to determine the status of a waterbody. Waters that are meeting all of the surface water standards and that have good biological communities are considered to be supporting monitored standards and uses<sup>2</sup>.

Current surface water quality standards for metals are based on chronic instream concentrations of total recoverable metals. Concentrations of total metals represent both the portion of metal bound to sediments in the water and the portion of metal dissolved within the water column. Data used for water quality assessment through comparison with water quality standards are generated through ambient surface water monitoring programs, such as the North Carolina Division of Water Resources (DWR) Ambient Monitoring System (AMS)<sup>3</sup>. Current monitoring practices usually produce a maximum of one result per day for a given total metal at a particular sampling location (station).

In May 2014, NC DENR proposed to the Environmental Management Commission, modifications to current fresh and salt water quality standards which include acute and chronic instream concentrations of dissolved metals in most cases<sup>4</sup>. The concentration of dissolved metals is a primary factor in evaluating potential toxicity to fish and other forms of aquatic life. Other factors such as water hardness and pH also influence toxicity<sup>5</sup>. Proposed freshwater standards for some dissolved metals (i.e. cadmium in Trout waters, chromium III, copper, lead, nickel, silver (acute) and zinc) will be related to the hardness of the surface water at the time of sample collection, such that the standard will be calculated for each sampling event. Standards for other dissolved metals (arsenic, beryllium, chromium VI and silver (chronic)) are not hardness-dependent and will, therefore, not change depending upon instream hardness. Total recoverable metals standards are proposed to remain in place for mercury and selenium in all surface waters, as well as for some other metals in waters with certain classifications.

In regard to standards that could be compared to ambient fresh surface water monitoring results, the proposed standards include instructions for calculation of hardness-dependent formula-based dissolved metals standards:

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<sup>2</sup> <http://portal.ncdenr.org/web/wq/ps/csu/swstandards>

<sup>3</sup> <http://portal.ncdenr.org/web/wq/ess/eco/ams>

<sup>4</sup> Link to the Hearing Officer's Report Triennial Review from <http://portal.ncdenr.org/web/emc/november-13-2014>

<sup>5</sup> NCDWQ. 2012. Probabilistic Monitoring of North Carolina Freshwater Streams – 2007-2010. North Carolina Division of Water Quality – Environmental Sciences Section. Raleigh, NC. Available as a link from <http://portal.ncdenr.org/web/wq/ess/eco/rams>.

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*Hardness-dependent metals standards shall be derived using the equations specified in Table A<sup>6</sup>: Dissolved Freshwater Standards for Hardness-Dependent Metals. If the actual instream hardness (expressed as CaCO<sub>3</sub> or Ca+Mg) is less than 25 milligrams/liter (mg/l), standards shall be calculated based upon 25 mg/l hardness. If the actual instream hardness is greater than 25 mg/l and less than 400 mg/l, standards will be calculated based upon the actual instream hardness. If the instream hardness is greater than 400 mg/l, the maximum applicable hardness shall be 400 mg/l.*

For this exploration, hardness was calculated using the instream total calcium and total magnesium results from each station on each sampling day. Proposed hardness-dependent standards were calculated using this hardness value (or 25 mg/L if the actual hardness was less than 25 mg/L; no RAMS hardness values exceeded 400 mg/L) and were compared to the dissolved metals sample results from the same station on the same sampling day.

The proposed standards will require obtaining multiple samples to evaluate compliance with metals standards:

*“Compliance with acute instream metals standards shall only be evaluated using an average of two or more samples collected within one hour. Compliance with chronic instream metals standards shall only be evaluated using averages of four samples taken on consecutive days, or as a 96-hour average.”*

The samples evaluated in this report were **not** collected in accordance with the proposed acute and chronic sampling requirements. In most cases, one sample result was available for each total metal and each dissolved metal per sampling day. When duplicate samples were taken, and therefore two results were available for a given day, the higher value was used in this exploration.

### **RANDOM AMBIENT MONITORING SYSTEM**

The Random Ambient Monitoring System (RAMS), started in January 2007, is a probabilistic component of the AMS. RAMS sampling locations are randomly located on freshwater streams throughout the state. The RAMS program is designed to monitor approximately 30 stations monthly, with new sampling sites selected every two years. Randomized site selection and the limited number of RAMS monitoring stations provide several valuable features. Because most streams in North Carolina are small, the majority of RAMS sites are also on small streams. In addition, RAMS allows DWR to collect data on water quality parameters that are rarely examined and to answer broad questions about the water quality of North Carolina streams with a statistical rigor that had not been possible before.

The following parameters are collected once per month for a total of 24 times in two years: dissolved oxygen, specific conductance, temperature and pH; alkalinity, chloride, fluoride, sulfate, dissolved organic carbon, turbidity, **total metals, dissolved metals, hardness<sup>7</sup>**, mercury and volatile organics. The

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<sup>6</sup> As included in proposed standards, available via link from <http://portal.ncdenr.org/web/emc/november-13-2014>

<sup>7</sup> Calculated using total calcium and total magnesium analytical results; see Report Notes for hardness formula

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following parameters are collected once every other month for a total of 12 times in two years: cyanide, sulfide, semi-volatile organics, pesticides and PCBs<sup>8</sup>.

This exploration utilized all RAMS data that were publicly-accessible via the US Environmental Protection Agency's STORage and RETrieval data management system (STORET)<sup>9</sup> at the time of the exploration. Results were available from up to 24 sampling events per station in the RAMS system during 2007-2012 and up to 6 sampling events per station during January-June 2013 (Table 1) if sample collection was achieved during every month of each RAMS cycle. Some stations may have had fewer sampling events due to extreme low flow or weather conditions during certain months, changes in safety, accessibility or landowner of a station, or sampling errors such as faulty equipment. Data that were flagged<sup>10</sup> in STORET as not meeting all field and laboratory quality assurance requirements were removed from consideration prior to the exploration.

**Table 1. Maximum number of sampling events per RAMS station, January 2007-June 2013**

RAMS Cycle	# Stations	Max # Sampling Events
2007-2008	29	24
2009-2010	31	24
2011-2012	29	24
2013-2014	31	6

### OBJECTIVE

Total and dissolved metals results from 120 RAMS stations were evaluated in regard to current and proposed metals standards. Hardness samples for use in this exploration were collected concurrently with each collection of total and dissolved instream metals samples. At the time of this report, RAMS data were available from January 2007 – June 2013, including all of the first three RAMS 2-year cycles and the first 6 months of the 2013-2014 cycle. Most evaluations included 24 results (or 6 results for the 2013-2014 cycle) per parameter per station. Assumptions and comments on how the analyses were prepared are noted in the [Report Notes Section](#).

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<sup>8</sup> <http://portal.ncdenr.org/web/wq/ess/eco/rams>

<sup>9</sup> See information at <http://portal.ncdenr.org/web/wq/storethome>; link to STORET at <http://www.epa.gov/storet/>

<sup>10</sup> See the list of Qualifier Codes used by the WSS Chemistry Lab (revised 3/10/2011) at <http://portal.ncdenr.org/web/wq/lab/ops/methods-and-pqls>

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## SUMMARIZED DATA

### RAMS STATIONS

RAMS stations are randomly located throughout North Carolina (Figure 1). Station identification numbers begin with a letter that represents the river basin (Table 2) and end with a combination of 7 numbers (e.g. A1520000) related to the station's location within the stream network.

Table 2. North Carolina river basins

A – Broad	F – Hiwassee	K – New	P – White Oak
B – Cape Fear	G – Little Tennessee	L – Watauga	Q – Yadkin
C – Catawba	H – Savannah	M – Pasquotank	
D – Chowan	I – Lumber	N – Roanoke	
E – French Broad	J – Neuse	O – Tar-Pamlico	

The majority of RAMS stations (98/120) returned no results above current or proposed total or dissolved metals standards through the three evaluation methods (Figure 1, Table 3).

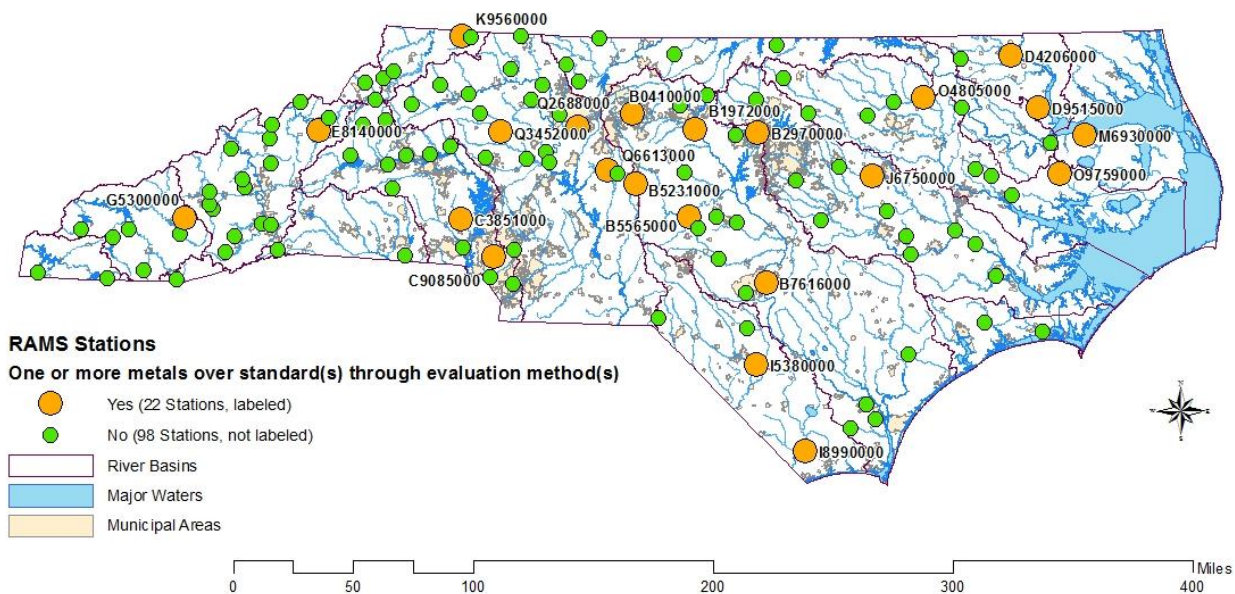


Figure 1. RAMS sampling station locations. Stations with metals results over current and/or proposed standards, per the evaluation methods, are labeled with the Station ID.



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**Table 3. RAMS sampling station descriptions**

Station	Location	County	Stream Class	Drainage Area (sq. mi.)	Sampling Events (n)	Over Current Standard(s)	Over Proposed Chronic Std	Over Proposed Acute Std
A2008500	DAVIS CRK AT CAMP GREEN COVE NR TUXEDO	HENDERSON	B Tr	1.5	24	No	No	No
A8190000	JAKES BRANCH OFF NC 226 NR GROVER	CLEVELAND	C	4.4	24	No	No	No
B0410000	N BUFFALO CRK AT W FRIENDLY AVE AT GREENSBORO	GUILFORD	WS-V NSW	4.8	6	Yes	Yes	Yes
B1000000	DRY CRK BESIDE SR 1530 NR BURLINGTON	ALAMANCE	WS-V NSW	4.0	24	No	No	No
B1279000	UT TO STAGG CRK OFF NC 49 NR PLEASANT GROVE	ALAMANCE	WS-II HQW NSW	2.6	24	No	No	No
B1972000	VARNALS CRK AT SR 2116 NR SWEPSONVILLE	ALAMANCE	WS-V NSW	11.6	6	No	Yes	No
B2970000	THIRD FORK CRK AT NC 55 AT DURHAM	DURHAM	C NSW	2.7	24	Yes	Yes	Yes
B3050000	BOOKER CRK AT NC 86 AT CHAPEL HILL	ORANGE	B NSW	0.8	24	No	No	No
B5231000	TANTRAUGH BRANCH OFF SR 2839 NR ASHEBORO	RANDOLPH	C	0.5	22	No	Yes	No
B5565000	MCLENDONS CRK AT SR 1006 NR GLENDON	MOORE	C	99.8	6	Yes	Yes	Yes
B5569000	BIG GOVERNORS CRK OFF SR 1651 NR CARTHAGE	MOORE	C	6.5	5	No	No	No
B5700000	PERSIMMON CRK AT SR 1237 AT SANFORD	LEE	C	1.6	24	No	No	No
B5885000	LOVES CRK OFF MOONRISE MEADOW DR AT SILER CITY	CHATHAM	C	7.8	24	No	No	No
B6820100	UT TO UPPER LITTLE RIV AT SR 1279 NR SEMINOLE	HARNETT	C	0.9	23	No	No	No
B7256000	CRANE CRK AT SR 2017 NR LOBELIA	MOORE	WS-III	96.2	6	No	No	No
B7616000	UT TO LOCKS CRK AT US 301 NR FAYETTEVILLE	CUMBERLAND	C	1.0	16	Yes	Yes	Yes
B8060000	BEAVER CRK AT SR 1141 AT CUMBERLAND	CUMBERLAND	C	32.1	24	No	No	No
B8459000	HOOD CRK OFF SR 1422 NR HOOPER HILL	BRUNSWICK	C Sw	39.9	6	No	No	No
B9496000	MILL POND AT NC 53 NR MAPLE HILL	PENDER	C Sw	16.4	24	No	No	No
B9776000	STURGEON CRK OFF HIGHLAND HILLS DR NE NR LELAND	BRUNSWICK	C Sw	3.1	23	No	No	No
B9841000	UT TO LEWIS SWAMP OFF SR 1413 NR RABONTOWN	BRUNSWICK	C Sw	0.04	6	No	No	No
C0990000	SHOOKS CRK OFF SR 1239 NR NEBO	BURKE	C Tr	1.0	24	No	No	No
C1328000	UT TO HUNTING CRK AT SR 1819 CRESTVIEW ST AT MORGANTON	BURKE	WS-IV	0.1	24	No	No	No
C1379000	HARPER CRK AT FR 58 AT KAWANA	AVERY	C Tr ORW	3.4	21	No	No	No
C1431000	UT TO FRANKUM CRK OFF MYRTLES PL NR MULBERRY	CALDWELL	C HQW	0.5	24	No	No	No
C2044000	FREEMASON CRK AT SR 1123 NR BATON	CALDWELL	WS-IV	2.9	24	No	No	No
C2588000	ISAAC CRK AT SR 1143 NR HICKORY	ALEXANDER	WS-IV B CA	3.7	24	No	No	No
C2990000	GLADE CRK OFF GLADE CREEK DR NR MILLERSVILLE	ALEXANDER	WS-IV	11.5	24	No	No	No
C3851000	LEEPERS CRK AT SR 1404 NR MARIPOSA	LINCOLN	C	45.2	24	Yes	No	No
C4368900	LITTLE RIV AT SOUTH MOUNTAIN BAPTIST CAMP NR PLEASANT GROVE	BURKE	WS-III Tr ORW	4.6	24	No	No	No

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Station	Location	County	Stream Class	Drainage Area (sq. mi.)	Sampling Events (n)	Over Current Standard(s)	Over Proposed Chronic Std	Over Proposed Acute Std
C6570000	UT TO S FORK CATAWBA RIV OFF NC 7 AT MCADENVILLE	GASTON	WS-V	1.5	6	No	No	No
C9085000	LITTLE SUGAR CRK AT EAST MOREHEAD ST AT CHARLOTTE	MECKLENBURG	C	11.7	24	Yes	No	No
C9620000	MCMULLEN CRK OFF PARK VISTA CIRCLE AT PINEVILLE	MECKLENBURG	C	14.5	24	No	No	No
C9811000	DAVIS MINE CRK OFF SR 1442 NR STALLINGS	UNION	C	2.4	15	No	No	No
D4008000	WICCACANEE SWAMP AT SR 1500 NR JACKSON	NORTHAMPTON	C NSW	4.8	24	No	No	No
D4206000	POTECASI CRK OFF NC 158 NR MAPLETON	HERTFORD	C NSW	244	6	No	Yes	Yes
D9515000	CRICKET SWAMP OFF SR 1346 NR ASHLAND	BERTIE	C NSW	4.0	24	No	Yes	Yes
E0380000	CHERRYFIELD CRK OFF STILL WATERS LN NR ROSMAN	TRANSYLVANIA	C Tr	2.1	6	No	No	No
E0750000	DAVIDSON RIV OFF US 276 NR BREVARD	TRANSYLVANIA	WS-V B Tr HQW	30.6	24	No	No	No
E1445000	UT TO FRENCH BROAD AT SR 1314 NR MILLS RIVER	HENDERSON	WS-IV B	0.2	24	No	No	No
E2140000	UT TO MUD CRK AT US 25 AT HILLGIRT	HENDERSON	C	0.1	23	No	No	No
E3205000	UT TO LITTLE POLE CRK OFF SR 1223 NR NEW CHANDLER	BUNCOMBE	C	0.2	24	No	No	No
E4571000	NEWFOUND CRK OFF SR 1381 NR LEICESTER	BUNCOMBE	C	12.6	6	No	No	No
E4770200	COLES COVE BRANCH OFF SR 2142 NR WEAVERVILLE	BUNCOMBE	C	0.9	24	No	No	No
E4824000	HOLCOMBE BRANCH OFF SR 1348 NR MARS HILL	MADISON	WS-II HQW	1.0	24	No	No	No
E5205000	UT PUNCHEON CAMP BRANCH AT SR 1154 NR WORLEY	MADISON	C	0.4	6	No	No	No
E5221000	WOLF LAUREL BRANCH BESIDE OAKRIDGE LN NR ENGLISH	MADISON	C Tr ORW	0.04	24	No	No	No
E5430000	INMAN BRANCH AT SR 1119 NR BETHEL	HAYWOOD	WS-III Tr	0.9	24	No	No	No
E6110200	UT TO RACCOON CRK OFF PIPPIN LN NR WAYNESVILLE	HAYWOOD	B	0.2	24	No	No	No
E6190000	RICHLAND CRK BESIDE SR 1519 RICHLAND CREEK RD NR LAKE JUNALUSKA	HAYWOOD	C	68.1	6	No	No	No
E8140000	LILY BRANCH OFF SR 1170 NR BOONFORD	MITCHELL	C Tr	0.3	6	Yes	No	No
E8531000	RIGHT FORK CANE CRK AT SR 1206 NR HAWK	MITCHELL	C Tr	3.3	6	No	No	No
E9993000	HOLLOW POPLAR CRK AT SR 1321 AT UPPER POPLAR	MITCHELL	C Tr	0.7	24	No	No	No
F0550000	NATTIE BRANCH AT SR 1165 NR SHOOTING CREEK	CLAY	C Tr	0.7	24	No	No	No
F6514200	UT TO N FORK RAPIER MILL CRK OFF SR 1117 NR RANGER	CHEROKEE	C	1.0	24	No	No	No
G0033000	DRYMAN FORK AT SR 1112 NR OTTO	MACON	C Tr	4.2	24	No	No	No
G3080000	RATTLESNAKE CRK AT BIG DOG RD NR LAUADA	SWAIN	C	2.2	24	No	No	No
G3700000	NANTAHALA RIV OFF SR 1310 NR BEECHERTOWN	MACON	B Tr	127	24	No	No	No
G4210000	UT TO TUCKASEGEE RIV AT SR 1172 NR EAST LAPORT	JACKSON	WS-III B Tr	0.1	24	No	No	No

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Station	Location	County	Stream Class	Drainage Area (sq. mi.)	Sampling Events (n)	Over Current Standard(s)	Over Proposed Chronic Std	Over Proposed Acute Std
G5300000	S FORK SUGARLOAF CRK AT W CLUBHOUSE RD AT BALSAM MT PRESERVE	JACKSON	C	0.9	6	No	Yes	Yes
G9820800	LITTLE SNOWBIRD CRK BESIDE SR 1115 NR ROBBINSVILLE	GRAHAM	C Tr	18.9	6	No	No	No
H3200000	BIG CRK BESIDE SR 1608 NR HIGHLANDS	MACON	C Tr ORW	5.9	24	No	No	No
I0930000	JOES CRK AT SR 1156 NR LAUREL HILL	SCOTLAND	C Sw	12.5	6	No	No	No
I5129950	BIG BRANCH AT SR 1006 AT SAINT PAULS	ROBESON	C Sw	4.4	21	No	No	No
I5380000	UT TO BIG SWAMP AT SR 2100 NR LUMBERTON	ROBESON	C Sw	0.1	19	No	Yes	Yes
I8990000	WET ASH SWAMP AT SR 1300 NR ASH	BRUNSWICK	C Sw	25.3	24	Yes	No	No
J0836000	UT TO MOUNTAIN CRK OFF US 501 NR BAHAMA	DURHAM	WS-II HQW NSW	0.9	24	No	No	No
J4489000	UT TO SWIFT CRK OFF HADRIAN DR AT GARNER	WAKE	WS-III NSW CA	1.5	24	No	No	No
J5403000	UT TO JUNIPER SWAMP AT ALLEN ST AT FOUR OAKS	JOHNSTON	C NSW	0.6	24	No	No	No
J5661000	SNIPES CRK OFF SR 1728 NR WENDELL	JOHNSTON	C NSW	5.6	24	No	No	No
J6044250	MEETING HOUSE BRANCH AT SR 1507 NR LAGRANGE	LENOIR	C Sw NSW	1.7	24	No	No	No
J6045000	NEUSE RIV AT SR 1152 NR STRABANE	LENOIR	WS-IV NSW	2602	24	No	No	No
J6750000	LITTLE SWAMP AT I 95N EXIT RAMP NR ROCK RIDGE	WILSON	WS-IV NSW	3.5	6	No	Yes	No
J7301000	MOCCASIN RUN AT SR 1543 NR PIKEVILLE	WAYNE	C Sw NSW	0.9	24	No	No	No
J7810000	CONTENTNEA CRK NR SR 1800 AT GRIFTON	PITT	C Sw NSW	994	24	No	No	No
J7855000	CORE CRK OFF SR 1480 NR FORT BARNWELL	CRAVEN	C Sw NSW	61.2	24	No	No	No
J8768000	HAYWARD CRK OFF US 17 NR RHEMS	CRAVEN	C Sw NSW	0.3	24	No	No	No
K2500000	COBB CRK OFF RAYFIELD RD NR BOONE	WATAUGA	C Tr +	0.4	24	No	No	No
K2790000	PINE ORCHARD CRK BESIDE NC 194 AT TODD	WATAUGA	WS-IV Tr +	5.0	24	No	No	No
K9560000	UT TO LITTLE RIV AT SR 1418 NR SPARTA	ALLEGHANY	C	0.2	6	No	Yes	Yes
K9750000	LITTLE RIV OFF RIVERSIDE DR NR BLEVINS CROSSROADS	ALLEGHANY	C	59.4	24	No	No	No
L0450000	COLD PRONG AT PRICE LAKE LOOP TRAIL AT JULIAN PRICE MEMORIAL PARK	WATAUGA	C Tr ORW	1.2	24	No	No	No
L4650000	COVE CRK BESIDE SR 1121 NR SUGAR GROVE	WATAUGA	C	34.8	24	No	No	No
M6930000	DEEP CRK AT SR 1303 NR SCUPPERNONG	WASHINGTON	C Sw	10.1	6	No	Yes	No
N0590000	NEATMAN CRK OFF SR 1954 TWIN CREEK RD NR GERMANTON	STOKES	C	19.3	24	No	No	No
N1360000	CROOKED CRK OFF SR 1626 NR AMOSTOWN	STOKES	C	15.8	24	No	No	No
N3410000	HOGANS CRK AT SR 1301 NR RUFFIN	CASWELL	C	66.0	24	No	No	No
N4595000	UT TO AARONS CRK OFF SR 1326 AT WILBOURNS	GRANVILLE	C	1.2	6	No	No	No
N8249900	UT TO KEHUKEE SWAMP AT NC 903 NR SCOTLAND NECK	HALIFAX	C	5.4	6	No	No	No

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N9685000	CONABY CRK OFF DEERFIELD RD AT PLYMOUTH	WASHINGTON	C Sw	27.9	24	No	No	No
O0065000	NORTH FORK TAR RIV AT SR 1151 NR BEREA	GRANVILLE	WS-IV NSW	21.2	18	No	No	No
O1190000	CEDAR CRK AT SR 1127 NR POCOMOKE	FRANKLIN	WS-II HQW NSW	1.6	24	No	No	No
O2650000	BACK SWAMP OFF SR 1321 NR CASTALIA	NASH	C NSW	1.6	24	No	No	No
O4640000	LITTLE FISHING CRK OFF SR 1343 NR WHITE OAK	HALIFAX	C NSW	188	6	No	No	No
O4805000	UT TO BEECH SWAMP AT SR 1003 AT ENFIELD	HALIFAX	C Sw NSW	0.4	13	Yes	Yes	Yes
O7116000	BRIERY SWAMP BESIDE SR 1545 NR STOKES	PITT	C Sw NSW	4.3	6	No	No	No
O7119000	HAW BRANCH AT VOICE OF AMERICA NR LEGGETTS CROSSROADS	BEAUFORT	C Sw NSW	0.6	22	No	No	No
O7660000	UT TO HERRING RUN OFF SR 1518 NR WASHINGTON	BEAUFORT	C NSW	0.8	24	No	No	No
O9759000	UT TO CUCKOLDS CRK BESIDE SR 1626 NR WENONA	BEAUFORT	C NSW	41.2	24	Yes	No	No
P6290000	MULBERRY CRK AT SR 1428 NR PALO ALTO	ONSLow	C	1.5	6	No	No	No
P8510000	UT NEWPORT RIV AT BUSINESS DR NR MOREHEAD CITY	CARTERET	C	0.2	24	No	No	No
Q0205000	ELK CRK BESIDE SR 1162 NR DARBY	WILKES	B ORW	38.5	6	No	No	No
Q0340000	REDDIES RIV AT SR 1559 NR MILLERS CREEK	WILKES	WS-II HQW	60.6	24	No	No	No
Q0633000	FISHING CRK AT SR 2318 NR ROARING RIVER	WILKES	C	10.0	24	No	No	No
Q1275000	KING CRK AT SR 1109 NR FAIRVIEW	SURRY	C	1.8	24	No	No	No
Q1664000	PAULS CRK AT SR 1625 NR MT AIRY	SURRY	WS-IV	20.9	24	No	No	No
Q1958000	UT TO YADKIN RIV OFF TWO TURTLE LN NR EAST BEND	YADKIN	WS-IV	0.5	24	No	No	No
Q1970000	EAST PRONG LITTLE YADKIN RIV AT SR 2006 NR CAPELLA	STOKES	B	0.5	6	No	No	No
Q2050000	FORBUSH CRK AT SR 1597 NR SHACKTOWN	YADKIN	C	13.8	24	No	No	No
Q2289500	MUDDY CRK AT US 421 NR WINSTON SALEM	FORSYTH	C	83.9	6	No	No	No
Q2688000	UT TO LEAK CRK AT DERENDE ST NR WINSTON SALEM	FORSYTH	C	0.8	6	Yes	Yes	No
Q3120500	UT TO DUTCHMAN CRK AT SR 1837 NR FORK CHURCH	DAVIE	C	1.7	24	No	No	No
Q3190000	FROST CRK AT SR 1163 NR CHURCHLAND	DAVIDSON	WS-IV	2.1	24	No	No	No
Q3452000	DUTCHMAN CRK AT SR 1844 NR HARMONY	IREDELL	C	1.7	6	No	Yes	No
Q3481000	HUNTING CRK AT SR 2423 NR OSBORNVILLE	WILKES	WS-III	32.2	24	No	No	No
Q3599900	GREGORY CRK OFF NC 115 AT STATESVILLE	IREDELL	C	2.51	24	No	No	No
Q3740000	FOURTH CRK AT SR 1985 NR WOODLEAF	ROWAN	C	81.6	24	No	No	No
Q6613000	UT UWHARRIE RIV OFF SR 1311 NR MOTLETA	RANDOLPH	WS-III CA	2.1	24	Yes	Yes*	No
Q6660000	CARAWAY CRK AT SR 1331 NR ASHEBORO	RANDOLPH	C	43.2	24	No	No	No
Q7714000	REEDY CRK AT SR 2826 NR WILGROVE	MECKLENBURG	C	7.2	24	No	No	No

\*Over current and future Human Health 10 µg/L total arsenic standard (not proposed to change); not over proposed chronic or acute dissolved arsenic standards

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### EVALUATION OF METALS STANDARDS

RAMS results were compared to current and proposed water quality standards for total and dissolved metals. The results from each RAMS station were compared to all applicable total or proposed dissolved metals standards. For hardness-dependent dissolved metals standards, the standards were calculated for every sampling event using the hardness result for that event. The dissolved metals analytical results were then compared to the calculated standards.

Three different evaluation methods were applied to determine if a station's results were over one or more standard(s) past certain thresholds:

- More than 10% of the results were over the standard
- More than 10% of the results were over the standard, and there was at least 90% statistical confidence that the true overage rate was greater than 10%<sup>11</sup>
- More than one result in three years was over the standard

Biological assessments are done at RAMS stations that meet certain environmental conditions<sup>12</sup>. Biological community ratings, when available, were considered for all RAMS stations with results over standards through any of the three evaluation methods. Biological integrity was indicated by a community rating of Good-Fair, Good or Excellent (Moderate or above in swamp waters) in **all** biological communities (fish and/or benthic macroinvertebrates) evaluated.

Results are presented in two tables below. Table 4 lists the water quality standards, the number of stations with results over each standard via one or more of the three evaluation methods, and the number of those stations that demonstrated biological integrity. (Exception: For standards specific to the protection of human health, biological community assessment was not considered.) Table 5 lists all of the RAMS stations with results over one or more standard(s) with overages through one or more evaluation method(s). Standards for which no station had results over the standard through an evaluation method were not included in the table. Color coding in this table notes whether or not biological assessment was performed, and if so, whether or not biological integrity was demonstrated at the station.

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<sup>11</sup> For more information, see Providing Confidence in the Exceedances of Water Quality Standards (page 10) in ambient monitoring report at [http://portal.ncdenr.org/c/document\\_library/get\\_file?uuid=33ee0e2b-76bc-46a1-9e26-1082a40aab62&groupId=38364](http://portal.ncdenr.org/c/document_library/get_file?uuid=33ee0e2b-76bc-46a1-9e26-1082a40aab62&groupId=38364).

<sup>12</sup> For more information, see <http://portal.ncdenr.org/web/wq/ess/bau>.

## Total and Dissolved Metals in North Carolina Surface Waters: RAMS Data Exploration

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**Table 4. Total and dissolved metals standards; numbers of stations with results over standards, and numbers of those stations demonstrating biological integrity**

Parameter	Type of Standard	Standard	# Stations with Results over Standard**	# Stations with Overages Attaining Biological Integrity***
<b>Arsenic, Total</b>	Current	50 µg/L (Aquatic Life)	0	-
<b>Arsenic, Total</b>	Current & Future	10 µg/L (Human Health)	1	NA
<b>Arsenic, Dissolved</b>	Proposed	150 µg/L (Chronic)	0	-
<b>Arsenic, Dissolved</b>	Proposed	340 µg/L (Acute)	0	-
<b>Beryllium, Total</b>	Current	6.5 µg/L (Aquatic Life)	0	-
<b>Beryllium, Dissolved</b>	Proposed	6.5 µg/L (Chronic)	0	-
<b>Beryllium, Dissolved</b>	Proposed	65 µg/L (Acute)	0	-
<b>Cadmium, Total</b>	Current	2 µg/L (Aquatic Life)	0	-
<b>Cadmium, Total</b>	Current	0.4 µg/L (Tr)	0	-
<b>Cadmium, Dissolved</b>	Proposed	0.15-0.82* µg/L (Chronic)	0	-
<b>Cadmium, Dissolved</b>	Proposed	0.82-5.9* µg/L (Acute)	0	-
<b>Cadmium, Dissolved</b>	Proposed	0.51-3.7* µg/L (Acute, Tr)	0	-
<b>Chromium, Total</b>	Current	50 µg/L (Aquatic Life)	0	-
<b>Chromium VI, Dissolved</b>	Proposed	11 µg/L (Chronic)	0	-
<b>Chromium VI, Dissolved</b>	Proposed	16 µg/L (Acute)	0	-
<b>Chromium III, Dissolved</b>	Proposed	24-153* µg/L (Chronic)	0	-
<b>Chromium III, Dissolved</b>	Proposed	180-1173* µg/L (Acute)	0	-
<b>Copper, Total</b>	Current	7 µg/L (Aquatic Life)	7	3
<b>Copper, Dissolved</b>	Proposed	2.7-19.0* µg/L (Chronic)	12	3
<b>Copper, Dissolved</b>	Proposed	3.6-30.8* µg/L (Acute)	6	2
<b>Lead, Total</b>	Current	25 µg/L (Aquatic Life)	0	-
<b>Lead, Dissolved</b>	Proposed	0.54-6.5* µg/L (Chronic)	2	0
<b>Lead, Dissolved</b>	Proposed	14-166* µg/L (Acute)	0	-
<b>Mercury, Total</b>	Current & Future	0.012 µg/L (Aqu Life)	35	NA
<b>Nickel, Total</b>	Current	88 µg/L (Aquatic Life)	0	-
<b>Nickel, Total</b>	Current & Future	25 µg/L (Water Supply)	2	NA
<b>Nickel, Dissolved</b>	Proposed	16-110* µg/L (Chronic)	0	-
<b>Nickel, Dissolved</b>	Proposed	145-987* µg/L (Acute)	0	-
<b>Selenium, Total</b>	Current & Future	5 µg/L (Aquatic Life)	0	-
<b>Zinc, Total</b>	Current	50 µg/L (Aquatic Life)	7	0
<b>Zinc, Dissolved</b>	Proposed	36.5-249* µg/L (Chronic)	5	1
<b>Zinc, Dissolved</b>	Proposed	36.2-247* µg/L (Acute)	5	1

**Notes:**

\* Formula-based dissolved metals standards vary depending upon instream hardness. Water Quality Metals standard values here are ranges calculated using a minimum hardness value of 25 mg/L (per proposed standards) to the maximum RAMS hardness of 242 mg/L. In practice, calculated standards could be higher with hardness up to 400 mg/L.

\*\* Count of stations with results over standards based on any/all of 3 assessment methods (see next table): >10% of results over standard, >10% over with ≥90% confidence, **and/or** > 1 result over standard in 3 years.

\*\*\* Biological Integrity = # of Stations with Results over Standard that attained Biological Integrity. This field = NA when biology would not be considered per the proposed standards language (i.e. for total mercury and selenium standards, and any standards based on Human Health).

## Total and Dissolved Metals in North Carolina Surface Waters: RAMS Data Exploration

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Table 5. RAMS stations with results over current and proposed total and dissolved metals standards

Station	# Samples	Total As (10 µg/L Human Health)	Total Cu (7 µg/L Aquatic Life)	Diss Cu (Chronic, formula- based)	Diss Cu (Acute, formula- based)	Diss Pb (Chronic, formula- based)	Total Zn (50 µg/L Aquatic Life)	Diss Zn (Chronic & Acute, formula- based)
B0410000	6		• 17% over	• 17% over	• 17% over	• 17% over	• 17% over	
B1972000	6			• 17% over				
B2970000	24		• 17% over • >1 in 3				• 38% over • ≥90% • >1 in 3	• >1 in 3
B5231000	22			• >1 in 3				
B5565000	6		• 17% over	• 33% over • >1 in 3	• 33% over • >1 in 3			
B7616000	16	• 13% over • >1 in 3					• 19% over • >1 in 3	• 19% over • >1 in 3
C3851000	25		• >1 in 3					
C9085000	24		• 35% over • ≥90% • >1 in 3					
D4206000	6			• 17% over	• 17% over			
D9515000	24							• >1 in 3
E8140000	6		• 33% over • >1 in 3					
G5300000	6			• 17% over	• 17% over			
I5380000	19							• 11% over • >1 in 3
I8990000	24						• >1 in 3	
J6750000	6			• 17% over				
K9560000	6			• 17% over	• 17% over			
M6930000	6			• 17% over				
O4805000	13			• 31% over • ≥90% • >1 in 3	• 15% over • >1 in 3		• 31% over • ≥90% • >1 in 3	• 31% over • ≥90% • >1 in 3
O9759000	24						• >1 in 3	
Q2688000	6		• 17% over	• 17% over		• 17% over	• 17% over	
Q3452000	6			• 17% over				
Q6613000	24	• 29% over • ≥90% • >1 in 3						
<b>NOTES:</b>								
Three assessment methods were considered & noted above if applicable for each station-parameter combination:								
• > 10% of results over standard (noted as **% over)								
• > 10% of results over standard with ≥ 90% confidence								
• > 1 result over standard in 3 years ( <b>Note: Due to the consideration of some small sample sizes (e.g. 6 results) in this evaluation, it is possible to have &gt;10% of results over a standard, but only 1 result over the standard in 3 years.</b> )								
Biological integrity attained								
Biological assessment Fair or Poor								
Biological communities not rated								

## INDIVIDUAL METALS DETAILS

### DISSOLVED METALS, NOT HARDNESS-DEPENDENT (Arsenic, Beryllium)

#### *Arsenic*

Current Aquatic Life standard: 50 µg/L total arsenic

Current Water Supply & Human Health (fish consumption) standards: 10 µg/L total arsenic

Proposed chronic standard: 150 µg/L dissolved arsenic

Proposed acute standard: 340 µg/L dissolved arsenic

Future Water Supply & Human Health (fish consumption) standards (unchanged): 10 µg/L total arsenic

Lab Practical Quantitation Limit (PQL): 2 µg/L

RAMS results:

No stations had greater than 10% of results or more than 1 result in 3 years above the current Aquatic Life 50 µg/L total arsenic standard or above the proposed chronic and acute dissolved arsenic standards.

Total arsenic results were above the Human Health standard (10 µg/L total arsenic) at 2 RAMS stations (Table 6). Biological ratings would have no bearing on potential surface water use assessment decisions based on Human Health standards.

**Table 6. RAMS total arsenic results over the 10 µg/L total arsenic Human Health standard and biological ratings, 2007-2013**

Station	Location	County	Total As (Range: <2 – 26 µg/L)			Benthos	Fish
			% > 10 µg/L	≥ 90% confid?	> 1 over in 3 years?	Biological Rating	Biological Rating
B7616000	UT to Locks Creek at US-301 near Fayetteville	Cumberland	12.5	No	Yes (2)*	Not Rated	Not Rated
Q6613000	UT to Uwharrie River off SR 1311 near Motleta	Randolph	29.2	Yes	Yes (7)*	Good	Not Rated

\*Number in ( ) indicates number of results over the standard.

#### *Beryllium*

Current Aquatic Life standard: 6.5 µg/L total beryllium

Proposed chronic standard: 6.5 µg/L dissolved beryllium

Proposed acute standard: 65 µg/L dissolved beryllium



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## Total and Dissolved Metals in North Carolina Surface Waters: RAMS Data Exploration

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Lab PQL: 5 µg/L

RAMS results: No results were detected above the PQL, current standard or proposed standard → no results over current total beryllium or proposed chronic or acute dissolved beryllium standards.

### DISSOLVED METALS, HARDNESS-DEPENDENT (Cadmium, Copper, Lead, Nickel, Zinc)

#### Cadmium

Current Aquatic Life standard: 2 µg/L total cadmium

Current Trout waters standard: 0.4 µg/L total cadmium

Proposed chronic standard: 0.15\* µg/L to 0.82\* µg/L dissolved cadmium

Proposed acute standard: 0.82\* µg/L to 5.9\* µg/L dissolved cadmium

Proposed acute (Tr) standard: 0.51\* µg/L to 3.7\* µg/L dissolved cadmium

*\*Formula-based standards will vary. The range presented here is based on RAMS hardness values of ≤ 25 to 242 mg/L; actual standards could be higher based on hardness up to ≥ 400 mg/L.*

Lab PQL: 1.0 µg/L

RAMS results: No results were detected above the PQL, current standards or proposed standards → no results over current total cadmium or proposed chronic or acute dissolved cadmium standards.

#### Copper

Current Aquatic Life standard: 7 µg/L total copper

Proposed chronic standard: 2.7\* µg/L to 19.0\* µg/L dissolved copper

Proposed acute standard: 3.6\* µg/L to 30.8\* µg/L dissolved copper

*\*Formula-based standards will vary. The range presented here is based on RAMS hardness values of ≤ 25 to 242 mg/L (Figure 2); actual standards could be higher based on hardness up to ≥ 400 mg/L.*

Lab PQL: 2.0 µg/L

RAMS results:

## Total and Dissolved Metals in North Carolina Surface Waters: RAMS Data Exploration

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Eighteen RAMS stations returned results over the current total copper standard between 1 and 8 times (4 – 35% of samples). The remaining 102 RAMS stations returned no results over the 7 µg/L total copper standard.

Six of these stations had results over the 7 µg/L total copper standard greater than 10% of the time; one of these with ≥90% confidence. Three of these stations, plus one additional station with less than 10% of results over the standard, had results over the 7 µg/L total copper standard more than once in 3 years (Table 7, Figure 3). Of these 7 stations with results over the current total copper standard through one or more of the three evaluation methods, attainment of biological integrity was demonstrated in 3 cases in which **all** biological communities were rated Good-Fair, Good or Excellent (Table 7, Figure 4, Report Notes regarding Biological ratings).

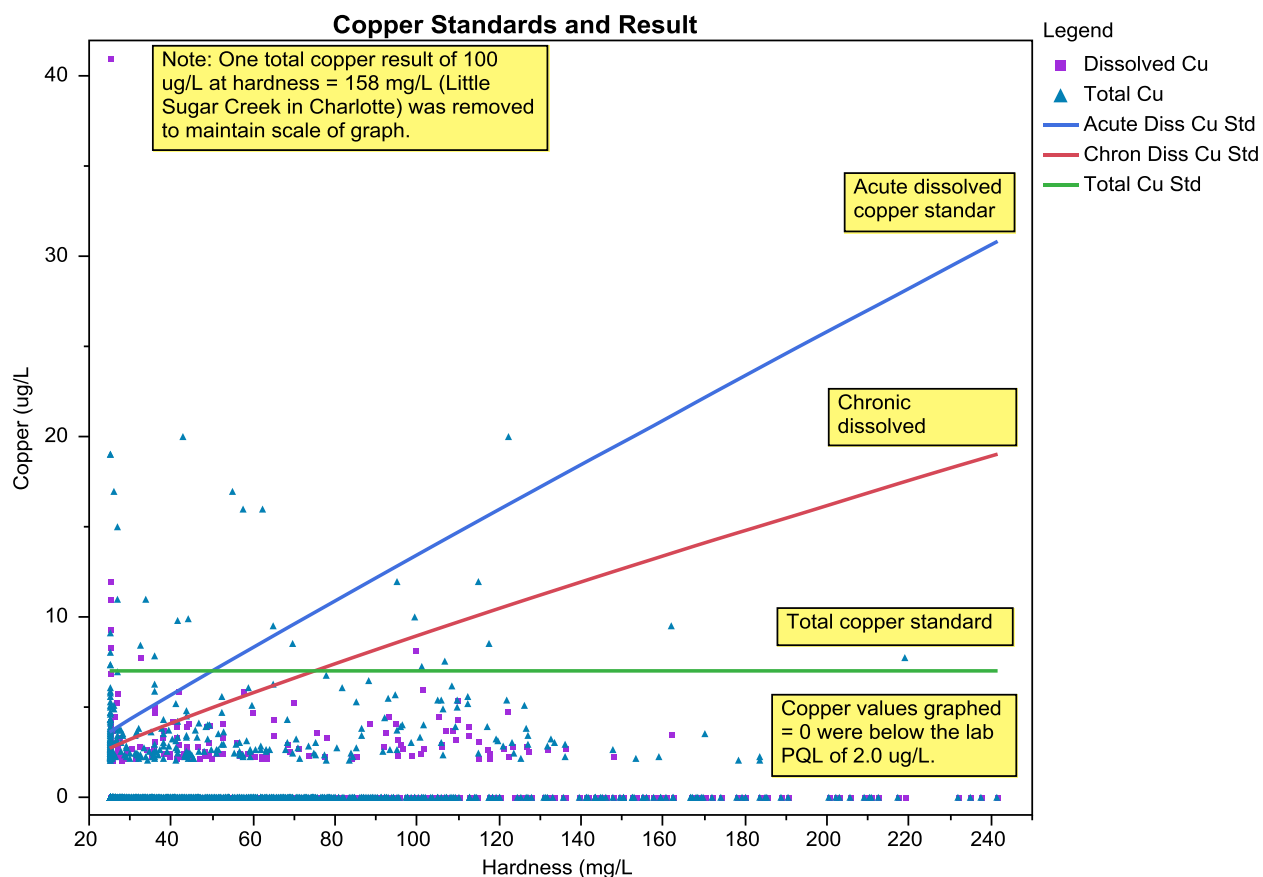


Figure 2. Total and dissolved copper standards and RAMS results, 2007-2013

## Total and Dissolved Metals in North Carolina Surface Waters: RAMS Data Exploration

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Table 7. RAMS stations with results over the 7 µg/L total copper standard and biological ratings, 2007-2013

Station	Location	County	Total Cu (Range of Results: <2 – 100 µg/L)			Benthos Biological Rating	Fish Biological Rating
			% > 7 µg/L	≥ 90% confid?	> 1 over in 3 yrs?		
B0410000	North Buffalo Creek at W Friendly Ave at Greensboro	Guilford	17	No	No	Fair	Good- Fair
B2970000	Third Fork Creek at NC- 55 at Durham	Durham	17	No	Yes (4)*	NR	NR
B5565000	McLendons Creek at SR 1006 near Glendon	Moore	17	No	No	NR	Excellent
C3851000	Leepers Creek at SR 1404 near Mariposa	Lincoln	8	NA	Yes (2)*	NR	Excellent
C9085000	Little Sugar Creek at East Morehead Street at Charlotte	Mecklen- burg	35	Yes	Yes (8)*	Poor	Fair
E8140000	Lily Branch off SR 1170 near Boonford	Mitchell	33	No	Yes (2)*	Good- Fair	NR
Q2688000	UT to Leak Creek at Derende Street near Winston-Salem	Forsyth	17	No	No	NR	NR

\*Number in ( ) indicates number of results over the standard.

# Total and Dissolved Metals in North Carolina Surface Waters: RAMS Data Exploration

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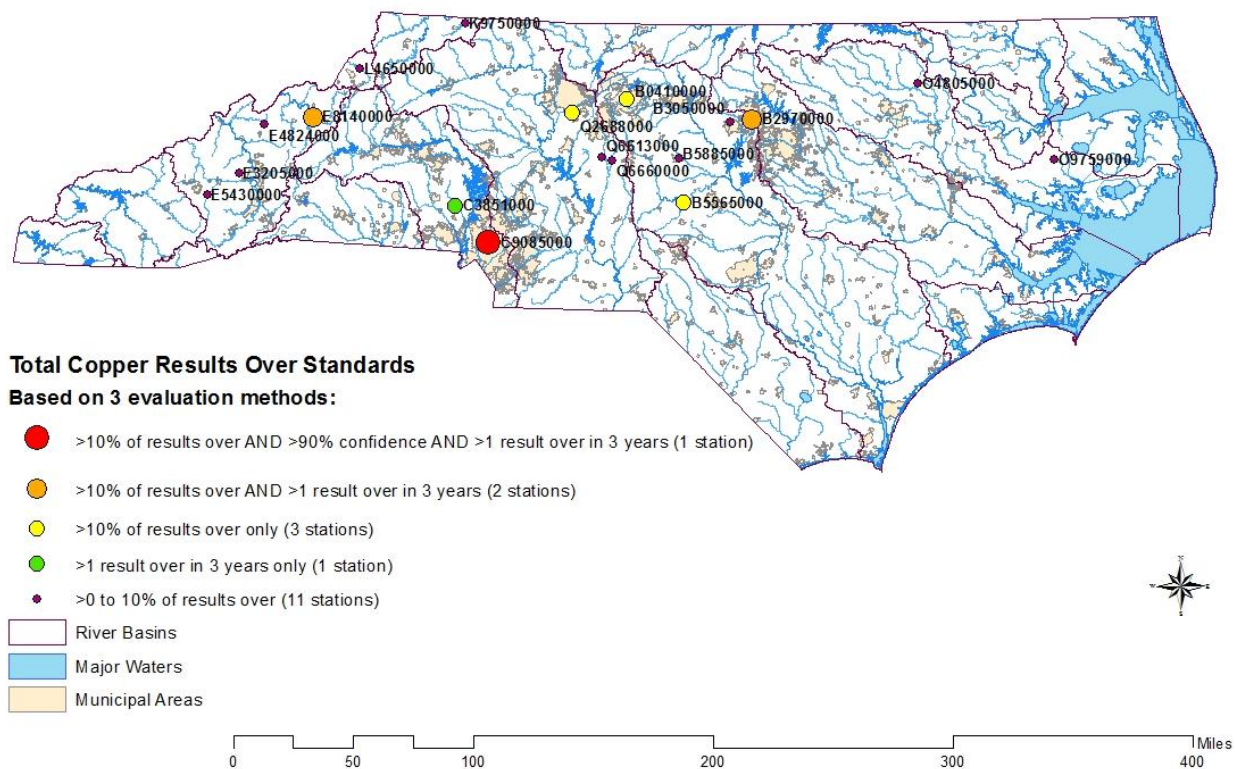


Figure 3. RAMS stations with results over the total copper standard, 2007-2013

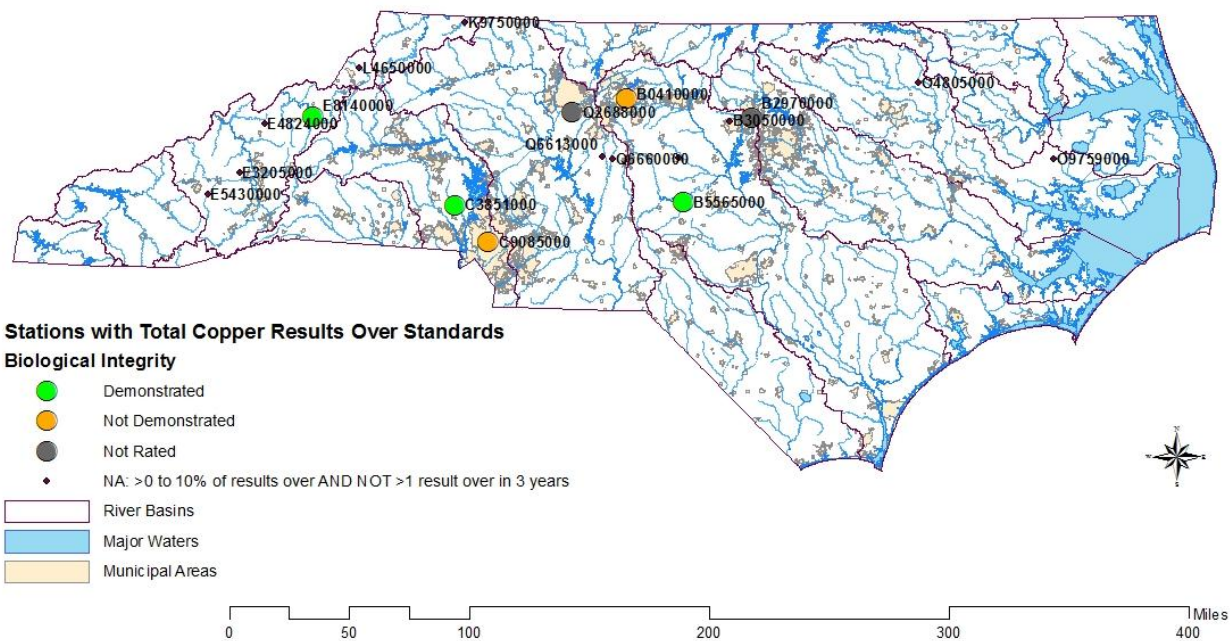


Figure 4. Biological assessments at RAMS stations with results over the total copper standard, 2007-2013

## Total and Dissolved Metals in North Carolina Surface Waters: RAMS Data Exploration

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Twenty-seven stations returned results over the proposed calculated hardness-dependent chronic dissolved copper standards between 1 and 4 times (4 – 33% of samples). Eleven of these stations had results over the proposed hardness-based chronic dissolved copper standard > 10% of the time; one of these with ≥ 90% confidence. Two of these stations, plus one additional station with less than 10% of results above the standard, had results over the chronic dissolved copper standard more than once in 3 years (Table 8, Figure 5). Of these 12 stations with results over proposed chronic dissolved copper standards through one or more evaluation methods, attainment of biological integrity was demonstrated at 4 stations at which **all** biological communities were rated Good-Fair, Good or Excellent (Table 8).

Twelve stations returned results over the proposed calculated hardness-dependent acute dissolved copper standards between 1 and 2 times (4 – 33% of samples). Six of these stations had results over the hardness-based acute dissolved copper standard > 10% of the time; none with ≥ 90% confidence. Two of these stations had results over the acute dissolved copper standards more than once in 3 years (Table 8, Figure 6). Of these 6 stations with results over acute dissolved copper standards through one or more evaluation methods, attainment of biological integrity was demonstrated at 2 stations at which **all** biological communities were rated Good-Fair, Good or Excellent (Table 8).

The remaining 93 RAMS stations returned no results over proposed calculated hardness-based chronic and acute dissolved copper standards.

Table 8. RAMS stations with results over proposed dissolved copper standards and biological ratings, 2007-2013

Station	Dissolved Cu (Range of Results: <2 – 41 µg/L)						Benthos	Fish
	Chronic			Acute			Biological Rating	Biological Rating
	% > Chronic	≥ 90% confid?	> 1 over in 3 years?	% > Acute	≥ 90% confid?	> 1 over in 3 years?		
B0410000	17	NA	No	17	No	No	Fair	Good-Fair
B1972000	17	No	No	0	NA	No	Good	Good
B5231000	9	NA	Yes (2)*	0	NA	No	Good	NR
B5565000	33	No	Yes (2)*	33	No	Yes (2)*	NR	Excellent
D4206000	17	No	No	17	No	No	NR	NR
G5300000	17	No	No	17	No	No	NR	NR
J6750000	17	No	No	0	NA	No	NR	NR
K9560000	17	No	No	17	NA	No	Excellent	NR
M6930000	17	No	No	0	NA	No	NR	NR
O4805000	31	Yes	Yes (4)*	15	No	Yes (2)*	NR	NR
Q2688000	17	No	No	0	NA	No	NR	NR
Q3452000	17	No	No	0	NA	No	NR	NR

\*Number in ( ) indicates number of results over the standard.

# Total and Dissolved Metals in North Carolina Surface Waters: RAMS Data Exploration

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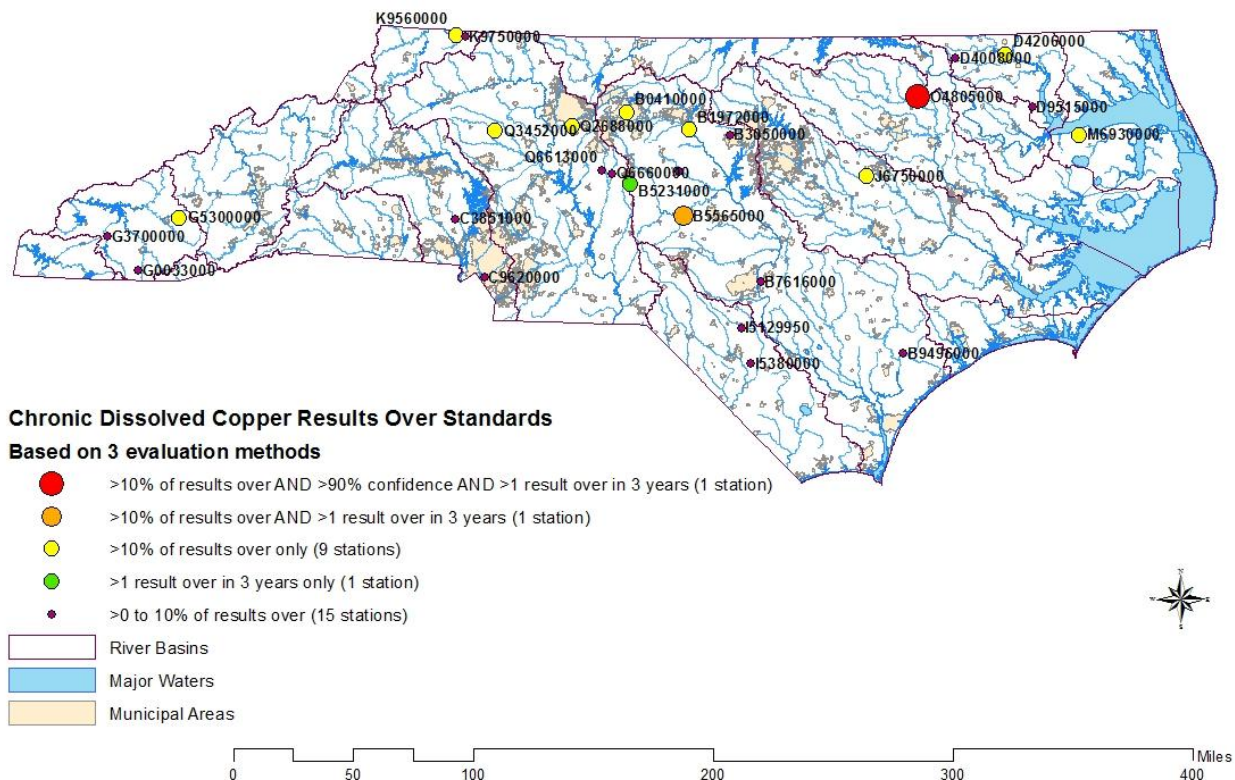


Figure 5. RAMS stations with results over proposed chronic dissolved copper standards, 2007-2013

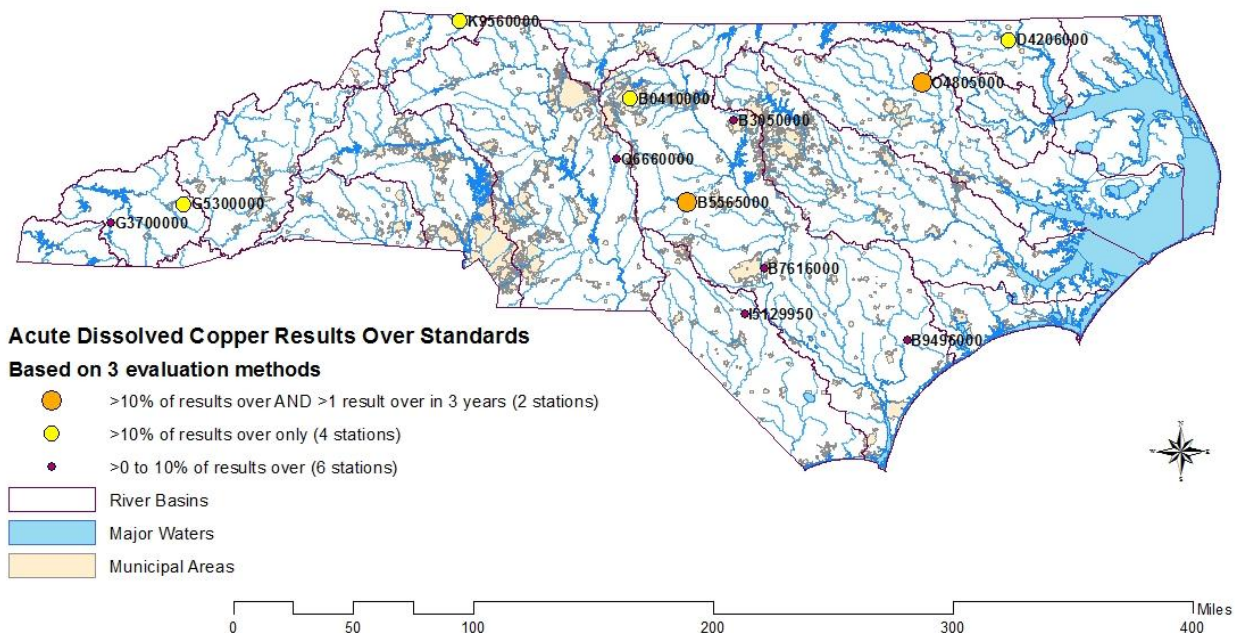


Figure 6. RAMS stations with results over proposed acute dissolved copper standards, 2007-2013

## Total and Dissolved Metals in North Carolina Surface Waters: RAMS Data Exploration

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### Lead

Current Aquatic Life standard: 25 µg/L total lead

Proposed chronic standard: 0.54\* µg/L to 6.5\* µg/L dissolved lead

Proposed acute standard: 14\* µg/L to 166\* µg/L dissolved lead

*\*Formula-based standards will vary. The range presented here is based on RAMS hardness values of ≤ 25 to 242 mg/L (Figure 7); actual standards could be higher based on hardness up to ≥ 400 mg/L.*

Lab PQL: 2 or 10 µg/L (varied during RAMS timeframe)

RAMS results:

No stations had greater than 10% of results or more than 1 result in 3 years above the current Aquatic Life 25 µg/L total lead standard. One station had one individual result (out of 24 results) at one station over the 25 µg/L total lead standard (Table 9, Figure 7).

1. C9085000, Little Sugar Creek at East Morehead Street at Charlotte, Mecklenburg County, class C

Two RAMS stations had single results over proposed calculated hardness-dependent chronic dissolved lead standards. Each station returned a result over the standard in 1 out of 6 results (Table 9). **NOTE: Sample sizes < 10 were used in this report for illustrative purposes, but would not be adequate for surface water use assessments.**

1. B0410000, North Buffalo Creek at W Friendly Ave at Greensboro, Guilford County, class WS-V NSW
2. Q2688000, UT to Leak Creek at Derende Street near Winston-Salem, Forsyth County, class C

Biological assessments did not demonstrate attainment of biological integrity at any of the stations with a result over a lead standard.

No stations had greater than 10% of results or more than 1 result in 3 years over the proposed calculated hardness-dependent acute dissolved lead standard.

**Table 9. RAMS stations with results over total and proposed chronic dissolved lead standards, biological ratings, 2007-2013**

	Total Pb (Range of Results: <2-110 µg/L)			Dissolved Pb (Range of Results: <2-7.5 µg/L)			Benthos	Fish
	% > 25 µg/L	≥ 90% confid?	> 1 over in 3 years?	% > Chronic	≥ 90% confid?	> 1 over in 3 years?	Biological Rating	Biological Rating
C9085000	4.3	NA	No	0	0	NA	Poor	Fair
B0410000	0	NA	NA	16.7	No	No	Fair	Good-Fair
Q2688000	0	NA	NA	16.7	No	No	NR	NR

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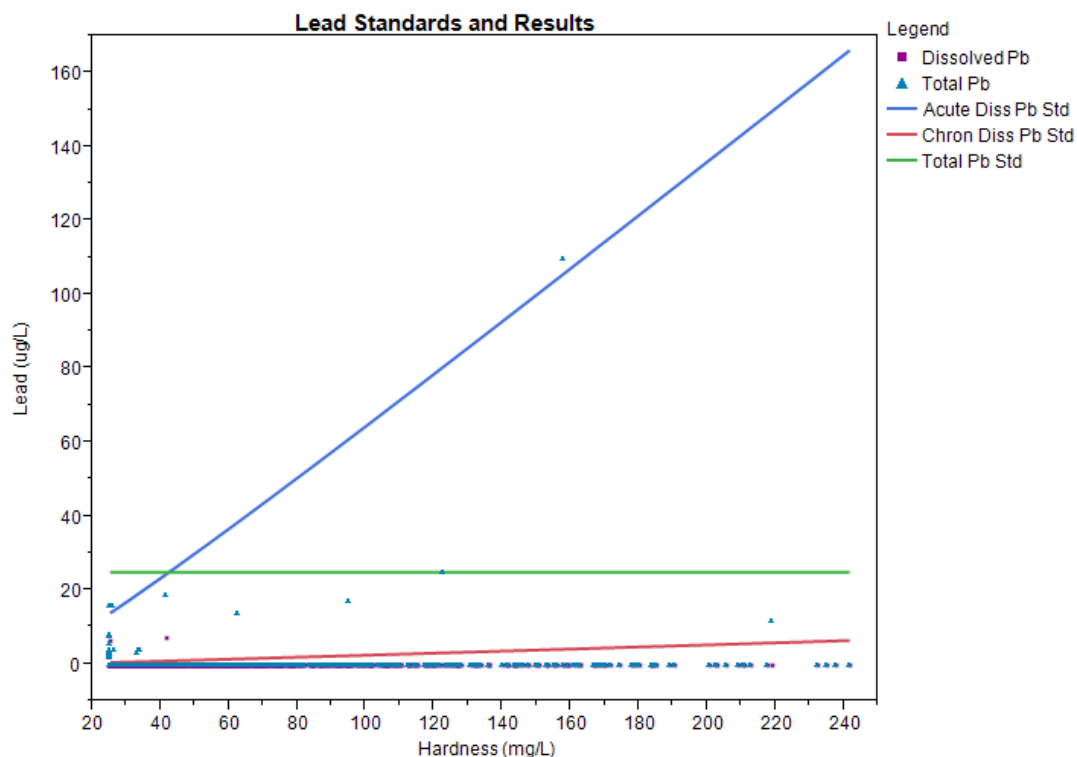


Figure 7. Total and dissolved lead standards and RAMS results, 2007-2013

### Nickel

Current Aquatic Life standard: 88 µg/L total nickel

Current Water Supply standard: 25 µg/L total nickel

Proposed chronic standard: 16\* µg/L to 110\* µg/L dissolved nickel

Proposed acute standard: 145\* µg/L to 987\* µg/L dissolved nickel

*\*Formula-based standards will vary. The range presented here is based on RAMS hardness values of ≤ 25 to 242 mg/L (Figure 8); actual standards could be higher based on hardness up to ≥ 400 mg/L.*

Future Water Supply standard (unchanged): 25 µg/L total nickel

Lab PQL: 10 µg/L

RAMS results:

There were no results over the current Aquatic Life 88 µg/L total nickel standard. There were no results over the 25 µg/L total nickel standard in waters classified as Water Supply.



## Total and Dissolved Metals in North Carolina Surface Waters: RAMS Data Exploration

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No stations had greater than 10% of results or more than 1 result in 3 years above the proposed calculated hardness-dependent chronic dissolved nickel standards. There was one individual result (out of 24 results) at one station over the chronic dissolved nickel standard (Figure 8).

- 18990000, Wet Ash Swamp at SR 1300 near Ash, Brunswick County, class C Sw

There were no results over proposed calculated hardness-dependent acute dissolved nickel standards (Figure 8).

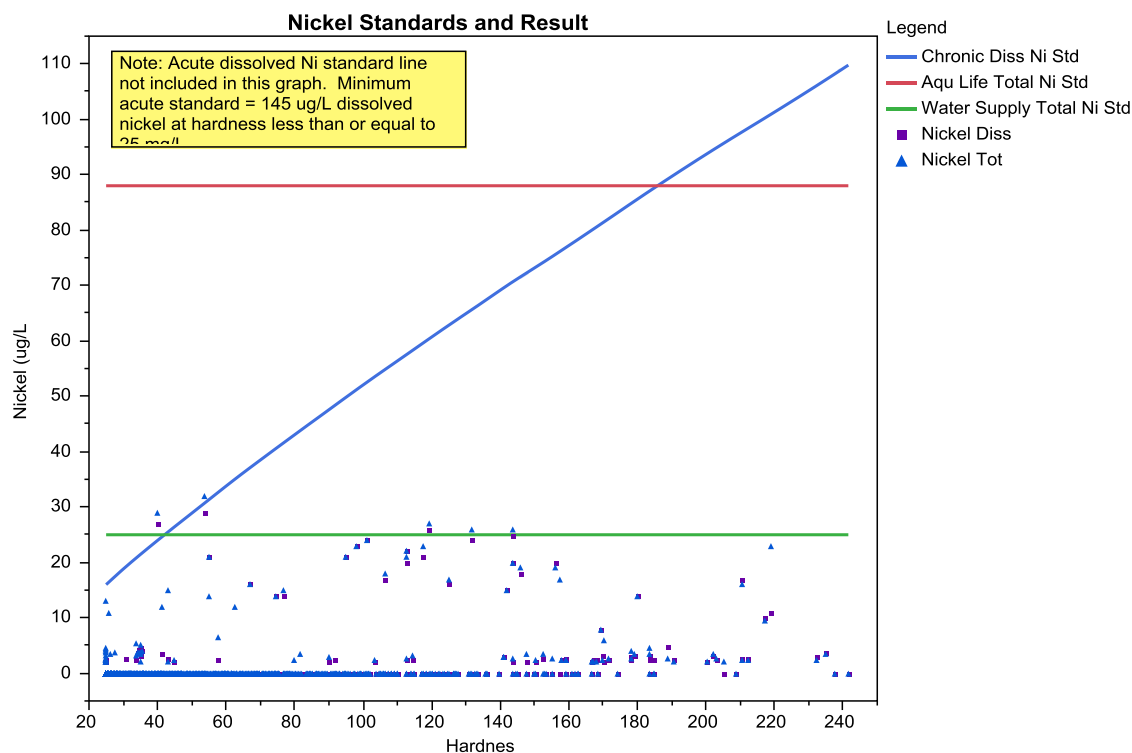


Figure 8. Total and dissolved nickel standards and RAMS results, 2007-2013

### Zinc

Current Aquatic Life standard: 50 µg/L total zinc

Proposed chronic standard: 36.5\* µg/L to 249\* µg/L dissolved zinc

Proposed acute standard: 36.2\* µg/L to 247\* µg/L dissolved zinc

*\*Formula-based standards will vary. The proposed formulas for calculation of chronic and acute dissolved zinc standards<sup>13</sup> produce similar standards, even at high instream hardness values (Figure 9).*

<sup>13</sup> See proposed standards, available via link from <http://portal.ncdenr.org/web/emc/november-13-2014>

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## Total and Dissolved Metals in North Carolina Surface Waters: RAMS Data Exploration

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The range presented here is based on RAMS hardness values of  $\leq 25$  to 242 mg/L (Figure 9); actual standards could be higher based on hardness up to  $\geq 400$  mg/L.

Lab PQL: 10  $\mu\text{g/L}$

RAMS results:

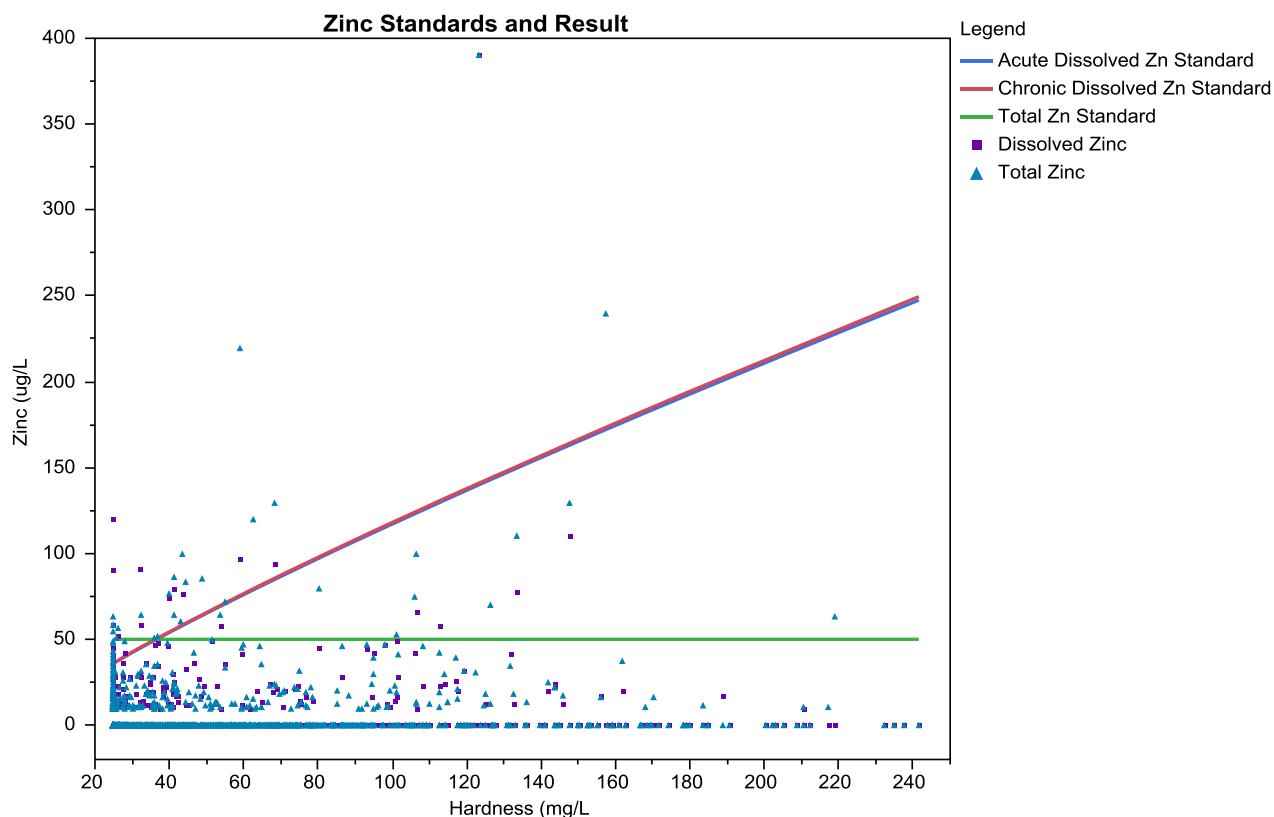


Figure 9. Total and dissolved zinc standards and RAMS results, 2007-2013

Fifteen RAMS stations returned results over the current total zinc standard between 1 and 9 times (4 – 38% of samples). Five of these stations had results over the 50  $\mu\text{g/L}$  total zinc standard  $> 10\%$  of the time; two of these with  $\geq 90\%$  confidence. Three of these, plus 2 additional RAMS stations with less than 10% of results over the standard, had results over the 50  $\mu\text{g/L}$  total zinc standard more than once in 3 years (Table 10).

The remaining 105 RAMS stations had no results over the 50  $\mu\text{g/L}$  total zinc standard.

RAMS stations showed equal numbers and percentages of results over proposed hardness-based chronic and acute dissolved zinc standards. Nine stations had results over the proposed calculated dissolved zinc standards between 1 and 4 times (4 – 31% of samples). Three of these stations had results over the calculated chronic and acute dissolved zinc standards greater than 10% of the time; one

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of these with  $\geq 90\%$  confidence. These 3 stations, plus 2 additional RAMS stations with less than 10% of results over the standards, had results over the proposed dissolved zinc standards more than once in 3 years. Of these 5 stations, attainment of biological integrity was demonstrated at 1 station at which **all** biological communities were rated Good-Fair, Good, Excellent or Moderate<sup>14</sup> (Table 10).

The remaining 111 RAMS stations had no results over proposed calculated hardness-dependent dissolved zinc standards.

**Table 10. RAMS stations with results over total and proposed dissolved zinc standards and biological ratings, 2007-2013**

Station	Total Zn (Range of Results: <10 – 390 µg/L)			Dissolved Zn (Range of Results: <10 – 390 µg/L)			Benthos	Fish
	% > 50 µg/L	≥ 90% confid?	> 1 over in 3 years?	% > Dissolved Standard	≥ 90% confid?	> 1 over in 3 years?	Biological Rating	Biological Rating
B2970000	38	Yes	Yes (9)*	8	NA	Yes (2)*	NR	NR
O4805000	31	Yes	Yes (4)*	31	Yes	Yes (4)*	NR	NR
B7616000	19	No	Yes (3)*	19	No	Yes (3)*	NR	NR
B0410000	17	No	No	0	NA	No	Fair	Good-Fair
Q2688000	17	No	No	0	NA	No	NR	NR
I8990000	8	NA	Yes (2)*	4	NA	No	NR	NR
O9759000	9	NA	Yes (2)*	0	NA	No	NR	NR
I5380000	0	NA	No	11	No	Yes (2)*	NR	NR
D9515000	0	NA	No	8	NA	Yes (2)*	Moderate	NR
B3050000	4	NA	No	0	NA	No	NR	NR
B5885000	4	NA	No	0	NA	No	NR	Good
C3851000	4	NA	No	0	NA	No	NR	Excellent
C9085000	4	NA	No	0	NA	No	Poor	Fair
E3205000	4	NA	No	0	NA	No	NR	NR
E4824000	4	NA	No	0	NA	No	NR	NR
J5403000	4	NA	No	0	NA	No	NR	NR
L4650000	4	NA	No	0	NA	No	Good	NR
B9496000	0	NA	No	4	NA	No	NR	NR
J7810000	0	NA	No	4	NA	No	NR	NR
O2650000	0	NA	No	4	NA	No	NR	NR

\*Number in ( ) indicates number of results over the standard.

<sup>14</sup> The moderate biological community rating is applicable in Swamp waters.

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### PARAMETERS WITHOUT DATA FOR METALS SPECIES (Chromium III, Chromium VI)

Current Aquatic Life standard: 50 µg/L total chromium

Proposed chronic standard: 11 µg/L dissolved chromium VI

Proposed acute standard: 16 µg/L dissolved chromium VI

Proposed chronic standard: 24\* µg/L to 153\* µg/L dissolved chromium III

Proposed acute standard: 180\* µg/L to 1173\* µg/L dissolved chromium III

*\*Formula-based standards will vary. The range presented here is based on RAMS hardness values of ≤ 25 to 242 mg/L; actual standards could be higher based on hardness up to ≥ 400 mg/L.*

Lab PQL: 10 µg/L chromium, total

RAMS results:

Chromium species were not differentiated in RAMS analyses. Therefore, total and dissolved chromium results were compared to current total chromium and proposed dissolved chromium VI and chromium III standards.

No stations had greater than 10% of results or more than 1 result in 3 years above the 50 µg/L total chromium standard. There was one individual result (out of 23 total chromium results) at one station over the current total chromium standard.

- C9085000, Little Sugar Creek at East Morehead Street at Charlotte, Mecklenburg County, class C.

There were no dissolved chromium results detected above the PQL or the minimum proposed dissolved standards. It is inferred that there would have been no results over the proposed chronic or acute dissolved chromium VI or chromium III standards.

### PARAMETERS WITHOUT DATA (Silver)

#### *Silver*

Current Aquatic Life standard: 0.06 µg/L total silver

Proposed standard (chronic): 0.06 µg/L dissolved silver

Proposed standard (acute): 0.30\* µg/L to 15\* µg/L dissolved silver

*\*Formula-based standards will vary. The range presented here is based on RAMS hardness values of ≤ 25 to 242 mg/L; actual standards could be higher based on hardness up to ≥ 400 mg/L.*

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Lab PQL: 5 µg/L

RAMS results:

Because the PQL is higher than the current standard, RAMS samples were not analyzed for silver concentration. No results were available for comparison with current or proposed standards.

### TOTAL METALS, NOT HARDNESS-DEPENDENT (Mercury, Selenium)

Total mercury and selenium have been analyzed previously, and no changes in type or value of standards are proposed for these metals. Very brief summaries of RAMS results are provided below.

#### Mercury

Current Aquatic Life standard: 0.012 µg/L total mercury

Proposed chronic standard (unchanged): 0.012 µg/L total mercury

Lab PQL (trace level): 1.00 ng/L (=0.001 µg/L) total mercury

RAMS results:

- 2185 results
- 619 non-detects
- 1566 results detected  $\geq$  PQL
- 35 results were over the current total mercury standard

#### Selenium

Current Aquatic Life standard: 5 µg/L total selenium

Proposed chronic standard (unchanged): 5 µg/L total selenium

Lab PQL: 5 µg/L

RAMS results:

No results were detected above the PQL or the current standard → no results over current chronic total selenium standards.

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## REPORT NOTES

### *Sampling methods and result handling*

- RAMS samples were not collected specifically for the purpose of evaluating proposed chronic and acute dissolved metals standards. RAMS results do not meet the sampling requirements for chronic (average of four samples taken on consecutive days, or as a 96-hour average) or acute (average of two or more samples collected within one hour) standards evaluation.
- In most cases, one sample result was available for each total metal and each dissolved metal per sampling day. During some sampling events, duplicate samples were collected and analyzed; therefore, two results were available for some sampling dates. Regardless of the number of samples collected, the maximum detected result per parameter per station per day was used in this exploration.
- Non-detects (i.e. results below the laboratory PQL) were recorded as zero (0) values for this exploration. No averaging of results was done. Non-detects can be seen as zero values in graphs within this report.

### *Hardness*

- Hardness samples (i.e. total calcium and total magnesium) for use in this exploration were collected concurrently with each collection of total and dissolved instream metals samples.
- Hardness was calculated<sup>15</sup> using the instream total calcium and total magnesium results from each station on each sampling day:
  - Total hardness equation:
$$2.497 * Total\ Calcium \left( \frac{mg}{L} \right) + 4.118 * Total\ Magnesium \left( \frac{mg}{L} \right) = Total\ Hardness \left( \frac{mg}{L} \text{ as } CaCO_3 \right)$$
- Proposed hardness-dependent standards were calculated using:
  - The actual hardness value if total hardness  $\geq$  25 mg/L, **OR**
  - 25 mg/L if the actual hardness was less than 25 mg/L.
  - Note: no RAMS hardness values exceeded 400 mg/L.

### *Sample size*

- All sample sizes, ranging from 5 to 24 results per parameter per station, were considered in this analysis. There were 24 results for most station-parameter combinations.
- Surface water assessment decisions based on percentages of standard exceedances generally require at least 10 samples<sup>16</sup>.
- Possible overage percentage errors
  - During RAMS sampling, total metals and dissolved metals are collected at each RAMS site visit. In approximately 1% of sampling events, issues may occur that prevent results

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<sup>15</sup> Hardness calculator available at <http://portal.ncdenr.org/web/wq/lab/ops/supp-tech-safety>

<sup>16</sup> Link to 2014 303(d) Listing Methodology from <http://portal.ncdenr.org/web/wq/ps/mtu/assessment>.

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from being generated for total and/or dissolved metals. Such issues include incorrect preservation, hold time exceedances, broken sample containers, or failed quality assurance checks.

- This analysis was based on all RAMS site visits, and it was assumed that there were the same number of results for total metals and dissolved metals. There may be a small number of percentage errors in this report due to a sample count (n) that was inflated by one because it did not account for situations in which a total OR dissolved metals sample was lost due to one of the issues mentioned above.

***Biological ratings may be considered in the context of proposed Aquatic Life standards.***

- When possible, biological communities (fish and/or benthic macroinvertebrates) were evaluated at RAMS stations. For this report, demonstration of biological integrity was indicated when **all** of the biological communities that were assessed at a given station achieved a rating of Good-Fair, Good or Excellent (Moderate or above in the case of Swamp waters). If any biological community assessment resulted in a Poor or Fair rating at a given station, then biological integrity was not attained at that station.
- Note that biological ratings should not be considered in the context of Human Health and Water Supply standards.