Missouri Department of Natural Resources
Water Protection Program

Total Maximum Daily Load (TMDL)

for

Big Creek
Iron County, Missouri

Completed: December 22, 2005
Approved: February 17, 2006

Total Maximum Daily Loads (TMDLs)
For Big Creek
Pollutants: Metals

Name: Big Creek

Location: Near Chloride and Glover in Iron County, Missouri

Hydrologic Unit Code (HUC): 08020202-040001

Water Body Identification (WBID): 2916

Missouri Stream Class[1]**:** C – 0.5 mile; P – 32 miles

Beneficial Uses:
- Livestock and Wildlife Watering
- Protection of Warm Water Aquatic Life
- Protection of Human Health associated with Fish Consumption

Size of Impaired Segment: 4 miles

Location of Impaired Segment: From NE ¼ Section 27, T32N, R3E (downstream) to SW ¼ Section 2, T32N, R3E (upstream)

Pollutants: Metals

Pollutant Source: Glover Lead Smelter

Permit Number: Missouri State Operating Permits No. MO-0001121 and MO-0127434[2]

TMDL Priority Ranking: High

1. Background And Water Quality Problems

Geography:

Big Creek originates in Iron County south of Taum Sauk Mountain. It flows south and then east in Iron County, then it enters Wayne County where it turns south again to join the St. Francis River. The creek is 32.5 miles long and its watershed is about 194 square miles. The four-mile segment that is impaired is in the upper part of the watershed, ending about five miles north of Annapolis

[1] Class C streams may cease to flow in dry periods but maintain permanent pools which support aquatic life. Class P streams maintain permanent flow even in drought periods. See Missouri Water Quality Standards (WQS) 10 Code of State Regulations 20-7.031(1)(F). The WQS can be found at the following uniform resource locator (URL): http://www.dnr.mo.gov/env/wpp/rules/index.html#Chap7

[2] The state permitting system is Missouri's program for administering the National Pollution Discharge Elimination System (NPDES) program.

(see area map in Appendix A). State Highway 49 runs along most of the length of Big Creek in Iron County, starting at Des Arc and heading upstream. At its junction with Hwy 21, Hwy 49 turns away from the creek and Hwy 21 continues alongside it almost to the headwaters.

Area History[3]:

Iron County is in the geological area known as the St. Francois Mountains. These mountains are part of the oldest mountain range on our continent. Its age estimated in the billions of years. This area is also the only mountain range on the continent that runs roughly east to west. When Europeans came to the area, drawn largely by mining possibilities, there were many Native Americans. The Osage Indians had historically occupied southern Missouri and some of today's roads follow their ancient trails. One in particular, Springfield Road, ran from near Springfield to St. Louis, and traversed the northern part of Iron County. The first white settlers, William and Joseph Reed, arrived in Belleview Valley in 1798, before the Louisiana Purchase.

Iron County (named for the abundant iron ore) was established Feb. 17, 1857, by a special act of the Missouri Legislature. It was formed from parts of Washington, Wayne, St. Francois, Madison and Reynolds counties and has one of the oddest shapes of all counties in Missouri, an upside down L-shape. A large portion of Iron County lies in the Mark Twain National Forest, including almost its entire horizontal arm. There are many state parks, conservation areas and historical sites in the county, leading to its slogan: “Where every drive is scenic and every stop historic”.

The St. Louis and Iron Mountain Railroad was completed to Pilot Knob in Iron County in 1857. Up to this time, the Pilot Knob Iron Company had hauled its iron ore over the plank road to Ste. Genevieve. Great wagons pulled by oxen kept the road busy. The drovers made the trip one way in two days. After the railroad came, the job of cutting wood and making charcoal for the engines became a big business. The mining company bought many acres of timberland for this purpose. The terminus of the railroad remained at Pilot Knob until 1871.

During the Civil War, Missouri ranked only third to the states of Virginia and Tennessee in the number of battles and skirmishes in a single state, and Iron County saw its share of this action. Today, the Arcadia Valley in Iron County is a peaceful setting in one of Missouri's most scenic areas. But in 1864, the valley was the scene of one of the largest and most hard-fought battles waged on the state's soil - the Battle of Pilot Knob. Confederate Maj. Gen. Sterling Price invaded Missouri from Arkansas, leading an army of 12,000 men. On Sept. 26-27, 1864, while en route to the St. Louis area, Price attacked the weakly defended Union post of Fort Davidson at Pilot Knob. This proved to be a mistake. Fort Davidson was defended by a garrison of 1,450 men led by Gen. Thomas Ewing Jr., the brother-in-law of Gen. William Tecumseh Sherman. The Confederates lost nearly 1,000 men when they attacked the small earthen fort and its 11 cannons. They were delayed long enough to allow the Union forces to throw up a strong defense around St. Louis. If Price had taken the advice of [his colleague] General Shelby and bypassed Pilot Knob, going directly to St. Louis, history might have taken a different turn and the Civil War might have been prolonged.

[3] http://www.rootsweb.com/~moicgs/countyhistory.html

Land Use and Soils:
The soils in the bottomlands along Big Creek are of the Midco-Secesh-Viraton association. This association is found in long narrow stream valleys 200 to 2,000 feet wide. All of these soils are deep. The Midco cherty loam is found in the floodplain, has a slope of 0-4 percent and floods frequently. It is somewhat excessively drained with moderately rapid permeability. The Secesh silt loam has a 1-4 percent slope and is found on the stream terraces. It is well-drained with moderate permeability. The Viraton silt loam is similar to the Secesh with a slope of 3-9 percent and is found on the foot slopes. It has a fragipan at about 30 inches and the permeability is very slow below that. The Clarksville-Wilderness association is found on the uplands along Big Creek. The Clarksville very cherty silt loam is very steep with slopes of 25-50 percent. It is somewhat excessively drained with moderately rapid permeability and is found on the sides and side slopes of the stream valley. The Wilderness is also a very cherty silt loam and is deep like the Clarksville. It has slopes of 5-14 percent and is found on the ridgetops. The soil association in the headwaters of Big Creek (upstream of the impaired segment) is the Irondale-Killarney-Knobtop. This association is found on dome-shaped mountains and knobs with summits of 1,500 to 1722 feet high, in this case Taum Sauk, Russell and Hogan Mountains. It is largely very cobbly silt loams with slopes of 15-40 percent. Knobtop is a silt loam with 3-12 percent slopes.

Historical land use in the upper St. Francis River subbasin includes mining, timber harvesting, annual burning, upland row cropping, and livestock grazing. Land use in the Big Creek watershed is pasture, hay and woods with scattered chat piles. 2000 data (30 meter resolution) obtained from Thematic Mapper imagery was used to calculate land use statistics. According to that data, land use in the upper subbasin can be classified as 92 percent woodland, 7 percent grassland, 0.1 percent cropland, 0.4 percent barren (mine waste) and 0.5 percent other uses. See the Land Use Map in Appendix B.

Defining the Problem:
Four miles of Big Creek in the middle of lower Iron County is on the 303(d) list of impaired waters due to metals contamination. The metal smelter near Glover, Missouri, has contributed significant quantities of heavy metals to the creek and is listed as the source of this contamination. ASARCO Inc. (Asarco) owned and managed the Glover Smelter and Refinery from 1967 to 1998, when it sold its Missouri Lead Division operations to the Doe Run Company. Doe Run is a privately held natural resource company focused on mineral production, recycling and metals fabrication. Based in St. Louis, Doe Run is America's largest integrated lead producer and the second-largest total lead producer worldwide, employing more than 4,000 people. The company also produces zinc, copper, gold and silver. It has operations in Missouri, Washington and Arizona and South American operations in Peru.

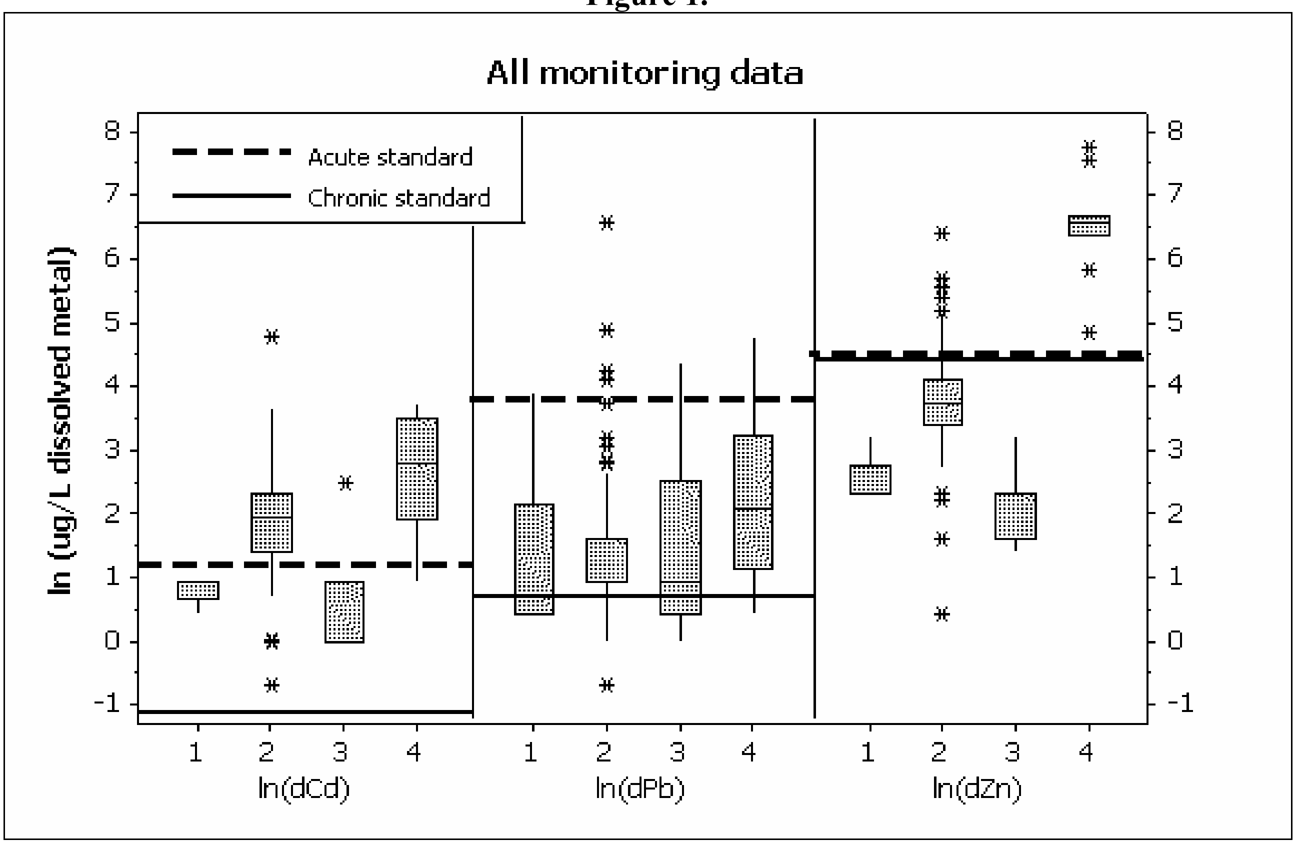
Big Creek is a gaining stream with inputs from groundwater and Scoggins Branch. Scoggins Branch is an unclassified tributary to Big Creek and runs through the Glover Smelter property. Concentrations of metals in Big Creek upstream of Scoggins Branch confluence do not exceed Missouri's Water Quality Standards. Concentrations of cadmium, lead, selenium, zinc and thallium in Scoggins Branch increase to exceed Aquatic Life Criteria or MCLs.

Although operations at Glover Smelter were indefinitely suspended in December 2003 (due to decreased United States demand for lead), Big Creek is still contaminated by heavy metals.

These metals found their way to the stream via fallout from smokestack emissions, fugitive dusts and drainage from smelter slag (waste) piles. Many of the airborne metal dusts that settled to the ground in the immediate smelter area were captured by a wastewater and storm water treatment system installed several years ago. The installation of this system significantly lowered the amounts of cadmium and lead entering Big Creek. Despite the construction and operation of this wastewater treatment system, some problems remain. The U.S. Geological Survey (USGS) has documented elevated levels of cadmium in fish in Big Creek, and the smelter was the only likely significant cadmium source in the watershed. Water quality monitoring has detected large amounts of zinc leaching from the slag pile and the Department of Natural Resources (the department) has documented potential toxicity to aquatic life in Big Creek.

Comparison of data collected above the smelter, both in Big Creek and Scoggins Branch, indicate the impact of the permitted facilities (Figure 1). Monitoring data collected in Big Creek from 1984 – 2004 for cadmium and lead were analyzed with a methodology that has a limit of detection above the new proposed criteria for lead and cadmium. That is, this method cannot detect numbers as low as the new criteria. The result is that the exact concentrations are unknown. When the test results were less that the limit of detection, the results were reported as a concentration approximately one-half the limit of detection. Because even this number is higher than the proposed criteria, the background box plots (Figure 1) indicate violation of water quality targets, when in fact the background may be in compliance. However, the distribution of the data does indicate that the smelter is the source of elevated concentrations in Big Creek. Results of monitoring data are given in Appendix E.

Figure 1.



To read the box plots: The box represents the 25th -75th quartiles and the middle line is the median of the data. The "whiskers" (lines outside the boxes) represent 1.5 times the interquartile range (you can use it to look at a rough distribution of the data). The asterisks are outliers.
These box plots show the monitoring data from left to right for the natural log (ln) dissolved cadmium (dCd), dissolved lead (dPb), and dissolved zinc (dZn) at monitoring points 1.) Big Creek above smelter, 2.) Big Creek below smelter, 3.) Scoggins Branch above slag piles, 4.) Scoggins Branch below slag piles.

In 2002 and 2003 the department conducted a study of the aquatic invertebrate animals in Big Creek in the vicinity of the smelter. Sampling points 0.1 mile and 0.5 miles downstream of the smelter showed impairment of the invertebrate community, especially mayflies, a group that is sensitive to metals pollution. A sampling point on Big Creek five miles below the smelter also showed impairment of the aquatic invertebrate community, but the pattern of impairment did not suggest metals pollution as the cause.

A final Remedy Work Plan for Glover Lead Facility was published in February 2001 with plans and schedules for dealing with the metals contamination in Scoggins Branch and Big Creek. As part of the transaction [sale] agreement between Asarco and Doe Run, Asarco is responsible for the closure of two inactive slag piles. Asarco also retained responsibility for investigation and remedial activities conducted on the Glover plant site as part of a Consent Agreement between Asarco and the department.

2. Description Of The Applicable Water Quality Standards And Numeric Water Quality Targets

Designated Uses[4]:
The designated uses of this section of Big Creek, WBID 2916, are:
- Livestock and Wildlife Watering
- Protection of Warm Water Aquatic Life
- Protection of Human Health associated with Fish Consumption

Use that is Impaired:
Protection of Warm Water Aquatic Life

Anti-degradation Policy:
Missouri's Water Quality Standards include the U. S. Environmental Protection Agency (EPA) "three-tiered" approach to anti-degradation, and may be found at 10 CSR 20-7.031(2).

Tier 1 – Protects existing uses and provides the absolute floor of water quality for all waters of the United States. Existing instream water uses are those uses that were attained on or after Nov. 29, 1975, the date of EPA's first Water Quality Standards Regulation, or uses for which existing water quality is suitable unless prevented by physical problems such as substrate or flow.

Tier 2 – Protects the level of water quality necessary to support propagation of fish, shellfish, and wildlife and recreation in and on the water in waters that are currently of higher quality than

[4] The designated uses may be found at 10 CSR 20-7.031 (1)(C) and Table H.

required to support these uses. Before water quality in Tier 2 waters can be lowered, there must be an antidegradation review consisting of: (1) a finding that it is necessary to accommodate important economical or social development in the area where the waters are located; (2) full satisfaction of all intergovernmental coordination and public participation provisions; and (3) assurance that the highest statutory and regulatory requirements for point sources and best management practices for nonpoint sources are achieved. Furthermore, water quality may not be lowered to less than the level necessary to fully protect the "fishable/swimmable" uses and other existing uses.

Tier 3 – Protects the quality of outstanding national resources, such as waters of national and state parks, wildlife refuges and waters of exceptional recreational or ecological significance. There may be no new or increased discharges to these waters and no new or increased discharges to tributaries of these waters that would result in lower water quality (with the exception of some limited activities that result in temporary and short-term changes in water quality).

Specific Criteria and Numeric Water Quality Target:
Missouri Water Quality Standards (WQS) for metals found in 10 CSR 20-7.031(4)(B)1 state:

> Water contaminants shall not cause the criteria in Tables A and B to be exceeded. Concentrations of these substances in bottom sediments or waters shall not harm benthic organisms and shall not accumulate through the food chain in harmful concentrations, nor shall state and federal maximum fish tissue levels for fish consumption be exceeded.

Numeric standards for metals are dependent on the hardness[5] of the water. The current specific WQS from Table A for cadmium (Cd), zinc (Zn) and lead (Pb) are as follows:

The chronic standards[6] for Big Creek, using a total hardness of 110 mg/L[7], are 1.1 μg/L Cd, 172 μg/L Zn and 9 μg/L Pb.

The standards for Scoggins Branch use acute criteria[8] because it is an unclassified stream (that is, it only flows when it rains). Based on a total hardness of 235 mg/L, they are 8.1 μg/L for Cd, 337 for Zn and 150 for Pb.

However, the most recent (2005) Missouri Water Quality Standards' revision proposes new metal criteria for cadmium, zinc, lead and other metals. The proposed new criteria determination is based on EPA's guidance (EPA820B96001). For the protection of aquatic life, the criteria for metals (other than mercury[9]) shall be expressed in μg/L of dissolved metal and go into effect Dec 31, 2005.

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[5] The amount of dissolved calcium and magnesium in the water.
[6] Chronic toxicity means conditions producing adverse effects on aquatic life or other wildlife following long-term exposure, but having no readily observable effect over a short time period. Numeric chronic criteria (standards) are maximum concentrations which protect again chronic toxicity. These criteria apply to classified waters only, with effects evident after 4 days of exposure. The criteria should be considered 4-day averages.
[7] mg/L = milligrams per liter or parts per million; μg/L = micrograms per liter or parts per billion
[8] Acute toxicity means conditions producing harm or death to aquatic life following short-term exposure. Acute criteria are maximum concentrations which protect against acutely toxic conditions. These criteria apply to classified waters in certain circumstances and apply to unclassified waters at all times, with effects evident after 1 hour of exposure.
[9] The criteria for mercury are expressed in total recoverable form.

Numeric Water Quality Target:
All three of the targeted metals have new proposed hardness-dependant standards as listed below (Table 1). This TMDL will target these new proposed criteria. Although these are not the current standards, the difference will be considered a conservative assumption for the margin of safety.

Table 1. Proposed water quality criteria used as targets in this TMDL

Metal, Dissolved	Chronic Standard (μg/L)
Cadmium	$e^{(0.7409*\ln(Hardness)-4.719948)} * (1.101672-(\ln(Hardness)*0.041838))$
Lead	$e^{(1.273*(\ln(Hardness)-4.704797)} * (1.46203- (\ln(Hardness)*0.145712))$
Zinc	$e^{(0.8473*\ln(Hardness)+0.785271)} * 0.986$
Metal, Dissolved	Acute Standard (ug/L)
Cadmium	$e^{(1.0166*\ln(Hardness)-3.062490)} * (1.136672-(\ln(Hardness)*0.041838))$
Lead	$e^{(1.273*(\ln(Hardness)-1.460448)} * (1.46203- (\ln(Hardness)*0.145712))$
Zinc	$e^{(0.8473*\ln(Hardness)+0.884211)} * 0.978$

3. Calculation of Load Capacity

Load Capacity (LC) is defined as the greatest amount of a pollutant a water body can assimilate without violating Missouri Water Quality Standards. This total load is then divided among a Wasteload Allocation (WLA) for point sources, a Load Allocation (LA) for nonpoint sources and a Margin of Safety (MOS).

LC = LA + WLA + MOS

The loading capacity is calculated for Big Creek at the monitoring site known as #004 in the Glover Smelter permit #MO-0001121. It is located at an old, broken-up low water bridge near the center of section 11, T32N, R3E in Iron County downstream from the confluence of Scoggins Branch, into which the permitted facility discharges.

TMDL Development:
The TMDL is determined by calculating the load that will result in reduction of the existing concentration to meet the criterion for each metal. The present load is depicted in load duration curves (Figures 2-4), which also give a graphical expression of the TMDL, both acute and chronic, at all percentiles of flow. A discussion of how Big Creek hydrology was related to the flow parameters used in this TMDL is given in Appendix C.

Figure 2. Load duration curve for dissolved cadmium

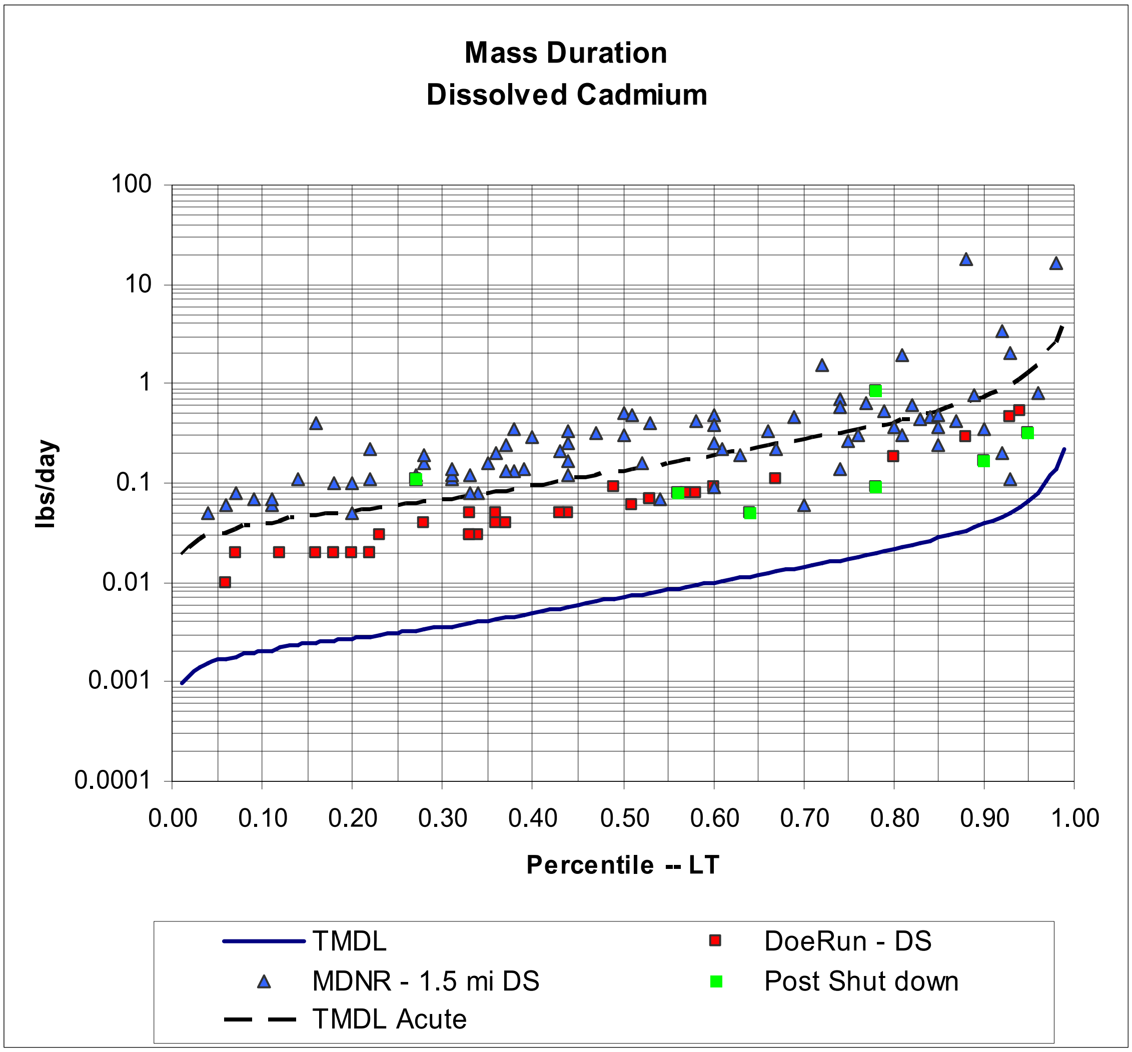


Figure 3. Load duration curve for dissolved lead

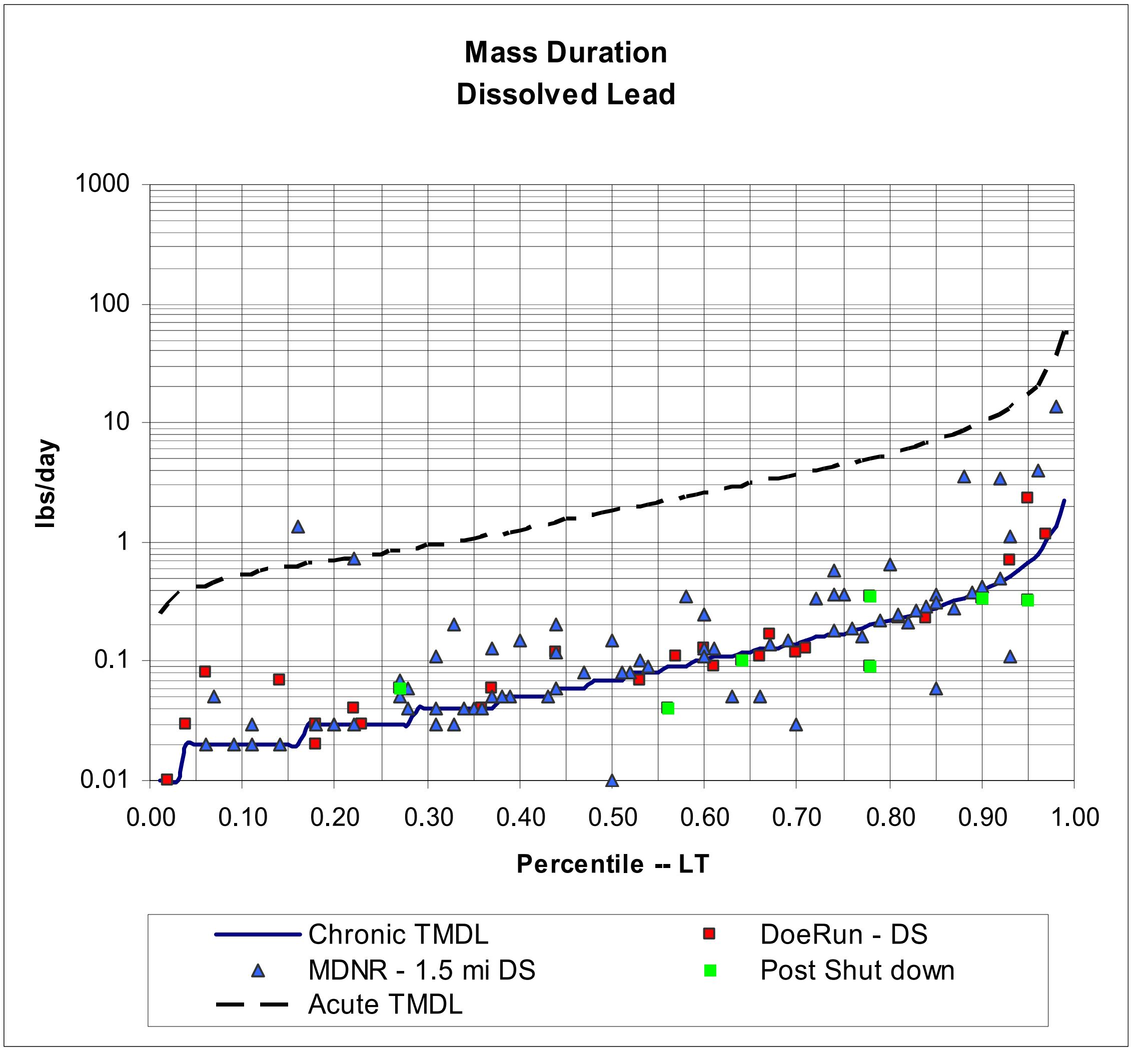
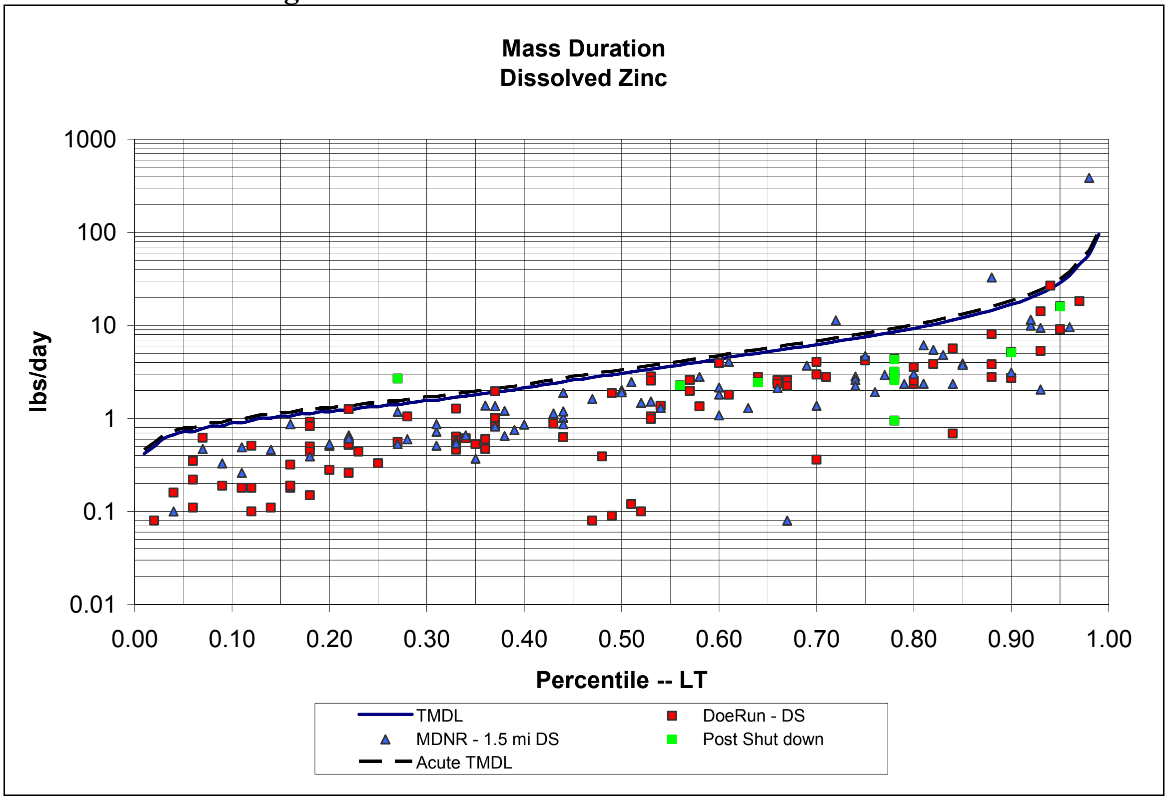


Figure 4. Load duration curve for dissolved zinc



4. Load Allocation (Nonpoint Source Load)

Load Allocation (LA) is the allowable amount of the pollutant that can be assigned to nonpoint sources. The background concentrations of dissolved cadmium, lead, and zinc measured in Big Creek upstream from the confluence of Scoggins Branch averaged below the 5 µg/L limit of detection. Because all background samples in Big Creek have been below the limit of detection, the load allocation for all three metals being addressed by this TMDL will be set at zero. Monitoring described later in this document will discuss using an appropriate analytical methodology to better characterize the background concentrations of dissolved metals in Big Creek. If nonpoint sources are found to cause violations of WQS for cadmium or lead these sources of load will be addresses in Phase II of this TMDL.

5. Waste Load Allocation (Point Source Loads)

The Wasteload Allocation (WLA) is the maximum allowable amount of the pollutant that can be assigned to point sources. The only known anthropogenic source of lead, zinc, and cadmium in the area is the Glover Smelter. This smelter operates a treatment facility (permit # MO-0001121) to process wastewater and sanitary wastewater from the facility which discharges to Scoggins Branch, an unclassified stream, which then flows to Big Creek. Associated with the smelter facility there are also waste piles which are regulated under a storm water permit (permit # MO-0127434).

Dry Weather WLA:
The design treatment capacity for the treatment facility is a volume of 288,000 gallons per day (0.288 MGD-million gallons per day or 0.45 cfs). Based on this flow and the 7Q10 flow in Big Creek[10], loads were calculated that would result in meeting water quality standards for all three metals in Big Creek (Appendix D). Calculations were based on the 25th percentile of hardness concentrations expressed as mg/L of $CaCO_3$ as per Missouri water quality standards. The resultant maximum calculated concentrations in the discharge, daily load and concentration in Big Creek are given in Table 2.

Table 2. Permit MO-0001121 present load and the load needed to meet WQS

Metal	Present Permit Limits (for total recoverable metals) daily/monthly	TMDL Effluent Concentration	TMDL Load	Resulting TMDL Big Creek Concentration (7Q10)
dissolved Cadmium	0.481/0.192 lbs/day	0.5 μg/L	0.001 lbs/day	0.2 μg/L
dissolved Lead	0.673/0.264 lbs/day	5 μg/L	0.012 lbs/day	2.4 μg/L
dissolved Zinc	2.452/0.745 lbs/day	213 μg/L	0.512 lbs/day	102 μg/L

Wet Weather WLA:
During wet weather the storm water permit provides an additional waste load to the stream. Storm water WLA calculations were made based on the capacity of Big Creek to assimilate additional load once the dry weather TMDL was taken into account. Calculations were performed in two steps. In step one, the final storm water effluent concentration reductions were made to conform with acute water quality targets (proposed standards) at the "end of pipe" (Table 3). This reduction would be protective of aquatic life from acute toxicity in Scoggins Branch (only acute criteria apply in Scoggins Branch because it is an unclassified stream). Step two calculated the capacity of Big Creek to assimilate storm water loads of the metals addressed in this TMDL and meet the chronic criteria (an analysis of flow stability and metals concentration showed chronic conditions applied even at high flow). To do this, dissolved metals concentrations in Big Creek were calculated with both the dry weather TMDL and the storm water load from the slag piles (Appendix F).

Table 3. Storm water permit maximum loads to meet acute targets at end of pipe

Metal	Storm water Concentration	Storm water Load
dissolved cadmium	4.5 μg/L	0.038 lbs/day
dissolved lead	61 μg/L	0.510 lbs/day
dissolved zinc	112 μg/L	0.930 lbs/day

[10] 7Q10 is the lowest average flow for seven consecutive days with a recurrence interval of ten years. This value was derived by the Missouri Department of Conservation for Big Creek at Des Arc, corrected to volume at sample point #004.

The result of this second set of calculations consists of a percent reduction needed from storm water loading after taking into account the required reductions to meet the dry weather TMDL. Table 4 shows the percent reduction needed to meet acute WQS in Scoggins Branch and chronic WQS in Big Creek. For each metal, a WLA is assigned based on the greater of the two required reductions listed.

Table 4. Storm water reductions to meet water quality targets

Metal	Required Reduction for Acute Targets in Scoggins Branch	Required Reduction for Chronic Targets in Big Creek
dissolved cadmium	95%	98%
dissolved lead	55%	46%
dissolved zinc	94%	58%

As a result of this two step process, the wet weather TMDL for the storm water permit (MO-0127434) is a reduction of 98 percent for dissolved cadmium (dCd), 55 percent for dissolved lead (dPb), and 94 percent for dissolved zinc (dZn). The WLA for the treatment plant (MO-0001121) remains the same as the dry weather TMDL (Table 5).

Table 5. Summary of Wet Weather TMDL reductions

Metal	Present Permit	New acute target	% reduction
dCd	68 μg/L	3.6 μg/L	98 %
dPb	104 μg/L	47 μg/L	55 %
dZn	1623 μg/L	92 μg/L	94%

WLA Summary:
Cadmium, dissolved
WLA_{dry} = 0.001 pounds per day (MO-0001121)

WLA_{wet} = 0.001 pounds per day (MO-0001121), 98 % reduction in load (MO-0127434)

Lead, dissolved
WLA_{dry} = 0.012 pounds per day (MO-0001121)

WLA_{wet} = 0.012 pounds per day (MO-0001121), 55 % reduction in load (MO-0127434)

Zinc, dissolved
WLA_{dry} = 0.512 pounds per day (MO-0001121)

WLA_{wet} = 0.512 pounds per day (MO-0001121), 94 % reduction in load (MO-0127434)

6. Margin Of Safety (MOS)

A Margin of Safety (MOS) is required in the TMDL calculation to account for uncertainties in scientific and technical understanding of water quality in natural systems. The MOS is intended to account for such uncertainties in a conservative manner. Based on EPA guidance, the MOS can be achieved through one of two approaches:

(1) Explicit - Reserve a numeric portion of the loading capacity as a separate term in the TMDL.
(2) Implicit - Incorporate the MOS as part of the critical conditions for the waste load allocation and the load allocation calculations by making conservative assumptions in the analysis.

The MOS for this TMDL is implicit through conservative assumptions in the analyses. These are expressed by meeting the new proposed water quality standards for these metals and in calculating the standard based on the lower 25^{th} percentile of the measured hardness concentrations. This latter assumption is conservative in that the hardness-dependant WQS result in lower concentrations when hardness is lower. For waste loads, the concentrations in the receiving stream tend to be highest at low flow periods in the creek, when hardness also tends to be high (and hardness derived WQS standards would be higher).

7. Seasonal Variation

The water quality data collected to this point represents all seasons. This TMDL addresses wet and dry weather specifically, the WLA and TMDL are applied to address all flow conditions, hence all seasons. Missouri water quality standards do not distinguish between summer and winter for these criteria.

8. Monitoring Plans

Sediment studies were conducted by the department in Big Creek below Glover Smelter in 2004 and 2005, with more scheduled for 2007. Fish tissue will be sampled in 2007. The U.S. Geological Survey maintains annual ambient water quality monitoring in Big Creek at Sam Baker State Park, about 25 miles downstream of the smelter. Monitoring is also included in the Remedy Work Plan, which is outlined below. Monitoring plans will include monitoring at lower limits of detection (LOD) to document the background loading. The monitoring requirements of the two state operating permits will be adjusted to reflect this new requirement. The presently identified monitoring sites with lower LODs will identify nonpoint sources of these metals. If it is found that nonpoint source loading results in violations of the applicable water quality standards, Phase II of this TMDL will reassign load allocations to address any changes in loading.

As with all of Missouri's TMDLs, if continued monitoring reveals that water quality standards are not being met, the TMDL will be reopened and re-evaluated accordingly. This TMDL will be incorporated into Missouri's Water Quality Management Plan.

9. Implementation

These TMDLs will be implemented through permit action. The permit for Doe Run-Glover Smelter (MO-0001121) expired November 2003. Even though the smelter closed in December 2003, a permit is needed to address residual issues at the site. The results from the TMDLs outlined in this document will be incorporated in the permit after the new metals standards go into effect. The storm water permit for the slag piles (MO-0127434) expires January 2008. That permit may be reopened to include the new limits as per the TMDLs.

Other actions to address metals contamination of Big Creek and Scoggins Branch involve a Consent Decree that was executed between ASARCO Incorporated (Asarco) and the department on September 6, 1994. The Decree required a series of investigations and remedial actions at Glover Smelter and Refinery at Glover, Missouri. The Site Assessment and Investigation of the Glover plant was finalized and submitted to the department Nov. 24, 1998. A Remedy Work Plan for Glover Lead Facility was published in February 2001. Actions dictated by the plan to improve water quality included:

- Construction of runoff and erosion control structures along Scoggins Creek
- Capping the two inactive slag piles and isolating them from the local hydrology

According to the slag pile capping design, the two piles were regraded and combined into one pile before capping. The existing side slopes were cut back to form a less steep angle of repose (3:1). To control surface runoff, benches were built into the side slopes to reduce slope length. Riprapped vee-ditches were built to collect and route runoff along the benches and around the north and south berms to the existing storm water catchment area east of the slag pile. From there, storm water drains to the storm water treatment area where it can be discharged (with or without treatment) to Scoggins Branch. This work was completed in 2001.

10. Reasonable Assurances

Reasonable assurances do not apply as there is no required reduction in load allocation to meet water quality standards. The department has the authority to write and enforce State Operating Permits. Inclusion of effluent limits (determined from the waste load allocations established by the modeling) into a state permit, and quarterly monitoring of the effluent reported to the department, will result in compliance with water quality standards being met.

11. Public Participation

This water quality limited segment is included on the approved 2002 303(d) list for Missouri. The department's Water Protection Program and the U.S. EPA developed this TMDL. The public notice period was from Nov. 18 to Dec. 18, 2005. Groups that received the public notice announcement included the Missouri Clean Water Commission, Doe Run, the Water Quality Coordinating Committee, Stream Team volunteers (17) in the watershed, appropriate legislators (2) and others that routinely receive the public notice of state operating (often called NPDES) permits. No comments were received.

12. Administrative Record and Supporting Documentation

An administrative record on the St. Francis River TMDL has been assembled and is being kept on file with the Missouri Department of Natural Resources. It includes the following:

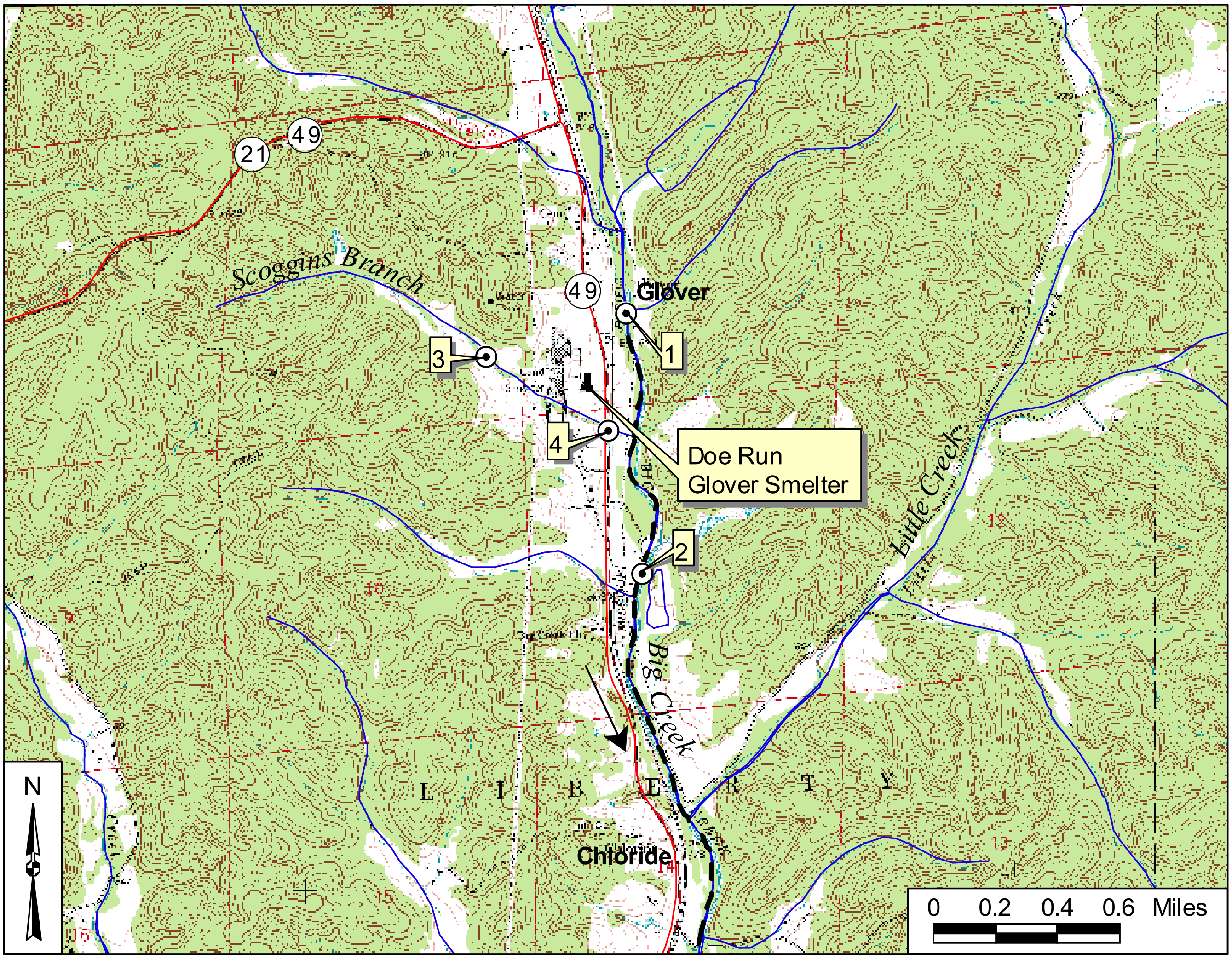
Biological Assessment Study, Big Creek, Iron County, 2002-2003 conducted by the Environmental Services Program
Remedy Work Plan for Glover Lead Facility, Glover, Missouri, February 2001
Glover Slag Pile Cap Design Analysis, Plans, and Specifications, May 2000 (Revised May and September 2001)
Glover Smelter permit # MO-0001121 (expired)
Glover Smelter permit # MO-0127434
Public Notice announcement
Big Creek Information Sheet

13. Appendices

Appendix A – Topographic map with the impaired segment of Big Creek and some sample sites
Appendix B – Land use map for Big Creek watershed
Appendix C – Hydrology
Appendix D – Dry weather TMDL load calculations
Appendix E – Glover Smelter Discharge Monitoring Report data
Appendix F – Calculations to determine storm water loads to Big Creek

Appendix A

Big Creek in Iron County, Missouri, showing the Impaired Segment and some Sampling Sites



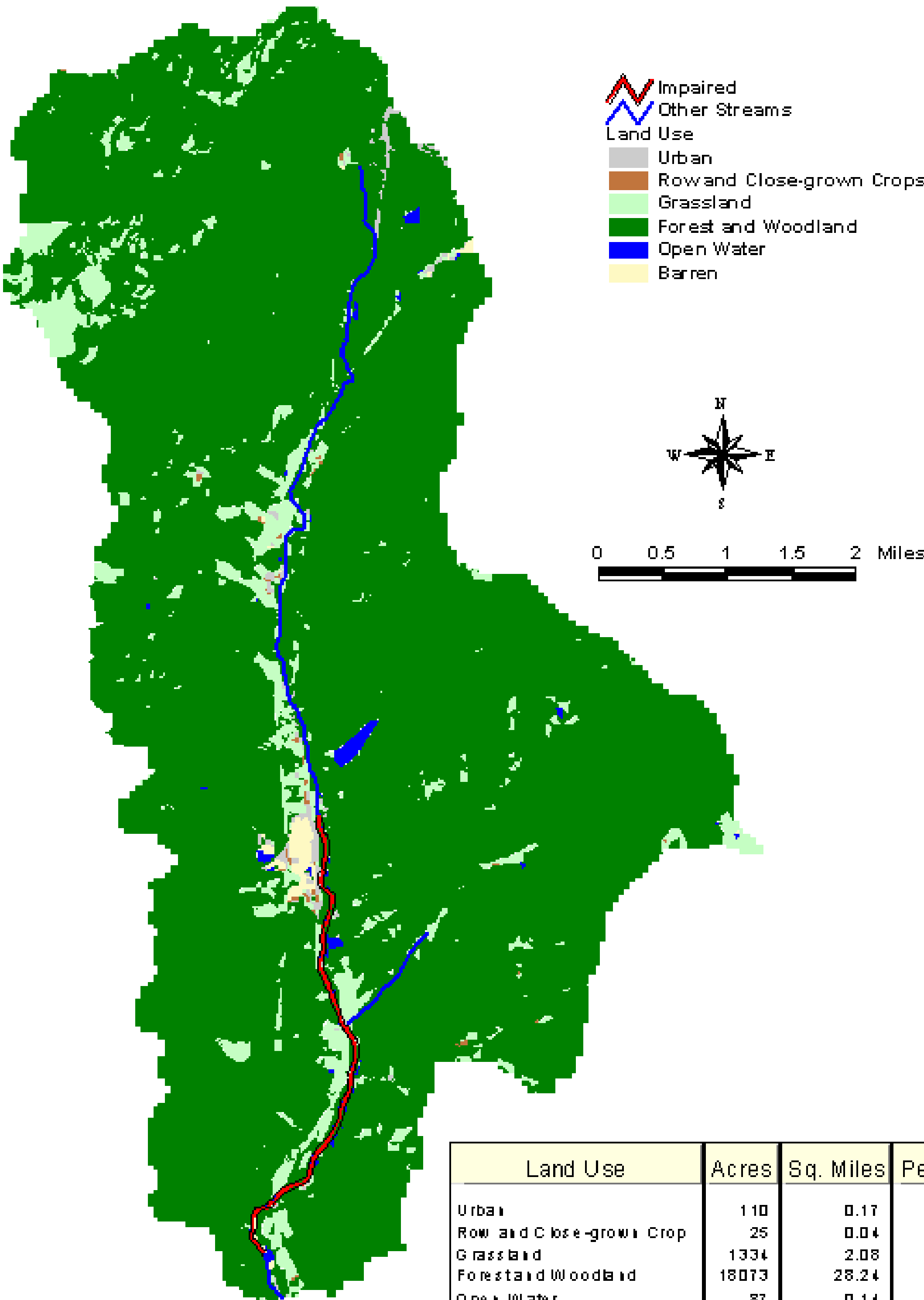
Impaired Segment **Direction of flow**

Site Index

1 – Big Creek 0.1 mile above Glover Smelter
2 – Big Creek 0.5 mile below Glover Smelter
3 – Scoggins Branch above Glover Smelter
4 – Scoggins Branch below Glover Smelter

Appendix B

Land Use in the Big Creek watershed in Iron County, Missouri



Land Use	Acres	Sq. Miles	Percentage
Urban	110	0.17	0.6
Row and Close-grown Crop	25	0.04	0.1
Grassland	1334	2.08	6.8
Forest and Woodland	18073	28.24	91.7
Open Water	87	0.14	0.4
Barren	83	0.13	0.4
Totals	19712	30.80	100.0

Appendix C. Hydrology

Big Creek is gaged at Des Arc (USGS 07037000, August 1983-September 1984 and October 2000-April 2004) and flow data was also taken in Big Creek at Chloride (USGS 07036940) during sampling episodes from 1967-1990. To relate the flow from this site to the monitoring site above the confluence of Little Creek near Chloride, Missouri, a Soil and Water Assessment Tool (SWAT) model was created with subbasins at points of importance for determining these TMDLs. The hydrological output from this model was compared to the measured flow record at Des Arc to ensure the model was accurately portraying flow at that point (Figure C-1 and C-2). The variation seen at high flow in Figure C-1 is the result of a lack of discharge measurements greater than the 85^{th} percentile in the Des Arc data. The missing observed flow in Figure C-2 for 1998 is due to the lack of USGS gage data for that time period.

The model developed a relationship between flow at Des Arc and at Chloride was used to determine a correction factor, which was then applied to the 7Q10 derived by the Missouri Department of Conservation (MDC) for Big Creek at Des Arc. This derived 7Q10 (0.48 cubic feet per second or 0.31 MGD) was used to calculate the low flow load of dissolved lead, dissolved zinc, and dissolved cadmium from the Glover Smelter permit #MO-0001121 at the design treatment plant flow (0.288 MGD).

Flow Relationship Equation

$$Q_{Chloride} = e^{(-2.32 + 1.01 * \ln(Q_{Des\ Arc}))}$$

Figure C-1. Comparison of modeled flow with measured flow

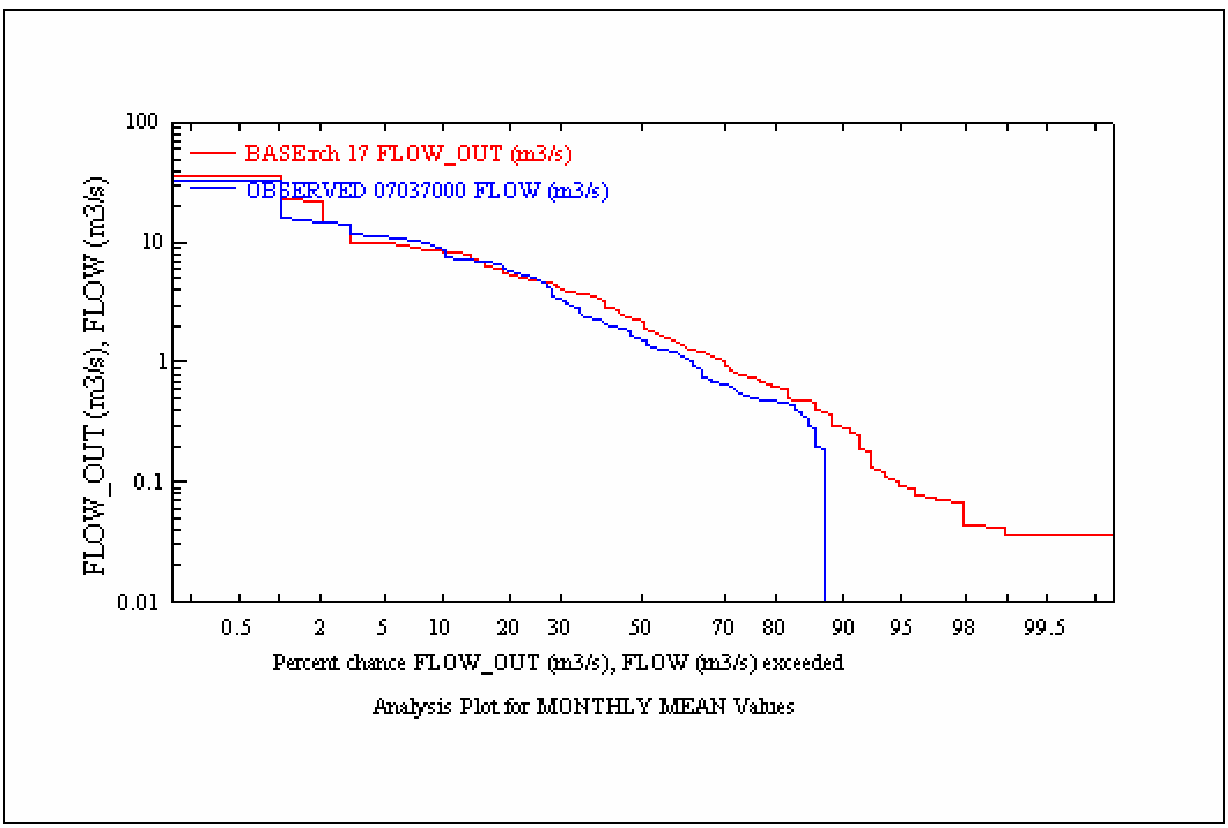
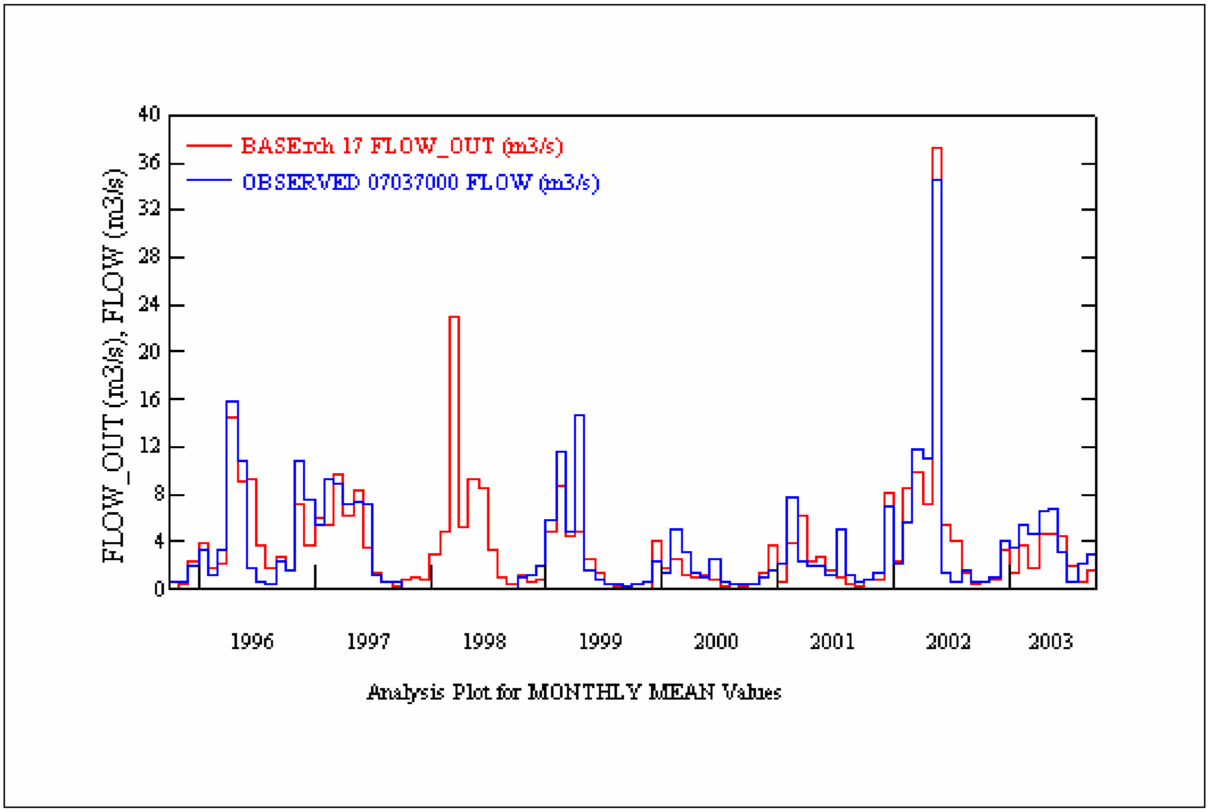


Figure C-2 Comparison of flow over time between model and measured



Appendix D. TMDL calculations for Big Creek Metals Dry Weather TMDL

*Formula used: flow in MGD*concentration in mg/L*conversion factor = pounds per day*

-------------------------------------- Cadmium---

0.288 MGD * 0.0002 mg/L * 8.34 = **0.03 lbs/day = Present WL**

load in Big Creek @ 7Q10 (proportional MDC value of 0.48 cfs (0.310 MGD))
using WQS at 25th percentile hardness of 95 mg/L as $CaCO_3$ = 0.0002mg/L

0.598 MGD * 0.0002 mg/L * 8.34 = **0.0012 lbs/day = TMDL**

back calculation to concentration in waste load stream

[dCd] = 0.0012 lbs/day * 1/8.34* 1/0.288MGD = 0.0005 mg/L

--Lead---

0.288 MGD * 0.027 mg/L * 8.34 = **0.06 lbs/day Present WL**

load in Big Creek @ 7Q10 (proportional MDC value of 0.48 cfs (0.310 MGD))
using WQS at 25th percentile hardness of 95 mg/L as $CaCO_3$ = 0.002mg/L

0.598 MGD * 0.004 mg/L * 8.34 = **0.012 lbs/day = TMDL**

back calculation to concentration in waste load stream

[dPb] = 0.012 lbs/day * 1/8.34* 1/0.288MGD = 0.005 mg/L

-- Zinc---

0.288 MGD * 0.34 mg/L * 8.34 = **0.82 lbs/day = Present WL**

load in Big Creek @ 7Q10 (proportional MDC value of 0.48 cfs (0.310 MGD))
using WQS at 25th percentile hardness of 95 mg/L as $CaCO_3$ = 0.084mg/L

0.598 MGD * 0.102 mg/L * 8.34 = **0.51 lbs/day = TMDL**

back calculation to concentration in waste load stream

[dZn] = 0.51 lbs/day * 1/8.34* 1/0.288MGD = 0.213 mg/L

Appendix E.

E-1. Discharge Monitoring Report (DMR) data from Glover Smelter
E-2. Missouri Department of Natural Resources monitoring data

E-1. DMR Data from Glover Smelter in Big Creek (1999 to 2004)

Note: Numbers in ***red*** exceed water quality targets in this TMDL;
** designate less than Limit of Detection results.

Date	dZn µg/L	dPb µg/L	dCd µg/L
1/22/1999	31	***8***	**
2/12/1999	23	**	**
3/4/1999	49	2	**
4/19/1999	37	**	**
5/4/1999	52	***3***	***2***
5/11/1999	40	**	**
6/17/1999	24	**	***2***
6/24/1999	22	**	***2***
7/19/1999	16	***12***	**
8/27/1999	15	**	***2***
11/15/1999	14	**	**
11/16/1999	18	**	**
11/17/1999	11	**	**
11/18/1999	21	**	**
12/10/1999	25	**	**
1/11/2000	31	2	***2***
1/19/2000	54	**	***2***
2/15/2000	36	**	***2***
2/27/2000	25	**	**
3/2/2000	32	2	**
3/14/2000	25	**	**
4/3/2000	30	**	***2***
4/11/2000	34	**	***2***
5/9/2000	26	5	***2***
6/5/2000	26	**	***3***
6/30/2000	41	**	**
7/26/2000	14	**	**
8/8/2000	31	**	***2***
9/1/2000	17	**	***2***
10/3/2000	15	2	**
10/23/2000	25	***4***	**
11/1/2000	11	***7***	**
12/23/2000	82	**	***2***
1/3/2001	65	**	***3***
1/18/2000	74	**	***3***
2/1/2001	56	**	**
3/6/2001	56	**	**
3/19/2001	45	**	**

4/2/2001	40	2	**
4/16/2001	3	**	**
5/1/2001	3	**	**
6/1/2001	4	**	***2***
7/2/2001	30	**	**
7/9/2001	43	**	***2***
8/3/2001	44	2	**
9/6/2001	50	**	***2***
10/1/2001	23	**	**
10/10/2001	18	**	**
11/13/2001	31	**	**
12/12/2001	3	**	**
1/8/2002	***105***	**	***2***
2/4/2002	44	***3***	**
3/5/2002	49	2	**
4/2/2002	6	**	**
5/6/2002	46	***3***	**
6/5/2002	40	**	***2***
7/23/2002	19	**	***2***
8/22/2002	55	**	**
9/4/2002	39	**	***2***
10/2/2002	28	**	***2***
11/21/2002	84	2	***2***
12/12/2002	76	**	**
1/2/2003	***103***	**	***2***
2/11/2003	78	**	***3***
3/3/2003	36	**	**
4/1/2003	65	**	**
5/5/2003	16	**	**
6/2/2003	68	**	**
7/2/2003	35	**	***2***
8/13/2003	33	2	***2***
9/3/2003	60	***3***	***2***
10/6/2003	35	2	***2***
11/6/2003	37	**	***2***
12/3/2003	***90***	***3***	***2***
1/5/2004	50	1	***1***
2/3/2004	30	2	***1***
3/1/2004	60	1	***2***
4/6/2004	50	2	***1***
5/4/2004	30	1	***10***
6/3/2004	50	***4***	***1***
7/7/2004	***190***	***4***	***8***
8/3/2004	33	**	**
9/8/2004	14	**	**
10/5/2004	**	**	**
11/4/2004	37	**	**
12/7/2004	11	**	**

E-2. Missouri Department of Natural Resources monitoring data

Site Name	Date	Hard	dCd	dPb	dZn
Big Cr. @Hwy 143, Sam Baker State Park	11/11/1992	140	0.499	0.499	29
Big Cr. @Hwy 143, Sam Baker State Park	1/20/1993	90	0.499	0.499	6
Big Cr. @Hwy 143, Sam Baker State Park	5/18/1993	110	0.499	0.499	12
Big Cr. @Hwy 143, Sam Baker State Park	1/7/1994	120	0.499	0.499	1.99
Big Cr. @Hwy 143, Sam Baker State Park	6/14/1994	140	0.499	0.499	1.99
Big Cr. @Hwy 143, Sam Baker State Park	1/23/1995	81	0.499	0.499	1.99
Big Cr. @Hwy 143, Sam Baker State Park	6/19/1995	120	0.499	1	1.99
Big Cr. @Hwy 143, Sam Baker State Park	1/29/1996	100	0.499	0.499	1.99
Big Cr. @Hwy 143, Sam Baker State Park	6/10/1996	120	0.499	0.499	0.499
Big Cr. @Hwy 143, Sam Baker State Park	1/21/1997	110	0.499	0.499	0.499
Big Cr. @Hwy 143, Sam Baker State Park	6/10/1997	110	0.499	0.499	0.499
Big Cr. @Hwy 143, Sam Baker State Park	12/31/1997	86	3.99	49.99	9.99
Big Cr. @Hwy 143, Sam Baker State Park	5/31/1998	110	3.99	49.99	9.99
Big Cr. @Hwy 143, Sam Baker State Park	12/31/1998	110	3.99	49.99	9.99
Big Cr. @Hwy 143, Sam Baker State Park	5/31/1999	140	3.99	49.99	8.3
Big Cr. @Hwy 143, Sam Baker State Park	10/31/1999	160	3.99	49.99	23
Big Cr. @Hwy 143, Sam Baker State Park	4/30/2000	140	3.99	49.99	20
Big Cr. @Hwy 143, Sam Baker State Park	11/13/2000	150	3.99	0.04	38
Big Cr. @Hwy 143, Sam Baker State Park	5/8/2001	130	3.99	0.09	
Big Cr. @Hwy 143, Sam Baker State Park	11/13/2001	160	0.0199	0.0399	4
Big Cr. @Hwy 143, Sam Baker State Park	5/14/2002	51	0.11	1.12	
Big Cr. @Hwy 143, Sam Baker State Park	11/19/2002	150	0.02	0.1	0.499
Big Cr. @Hwy 143, Sam Baker State Park	5/20/2003	110	0.02	0.04	0.499
Big Cr. 0.4 mi.bl. Annapolis Lead AML	11/18/1997	148	0.799	5.199	6.73
Big Cr. 0.5 mi.bl. Annapolis WWTP & GAF tailings	10/29/1974		0	2	40
Big Cr. 0.5 mi.bl. Annapolis WWTP & GAF tailings	1/8/1975		2	4	30
Big Cr. 0.5 mi.bl. Annapolis WWTP & GAF tailings	4/23/1975		0	2	0
Big Cr. 0.5 mi.bl. Annapolis WWTP & GAF tailings	7/30/1975		1	11	10
Big Cr. 0.5 mi.bl. Annapolis WWTP & GAF tailings	11/18/1997	147	0.599	5.199	1.99
Big Cr. 1.1 mi.ab. Glover Smelter	10/1/2002	109	0.499	0.99	4.99
Big Cr. 1.1 mi.ab. Glover Smelter	3/24/2003	57.5	0.499	0.99	4.99
Big Cr. 0.1 mi.ab. Glover Smelter	9/7/1984		1.499	50	24.99
Big Cr. 0.1 mi.ab. Glover Smelter	6/9/1996		2.499	1.499	9.99
Big Cr. 0.1 mi.ab. Glover Smelter	10/15/1996		2.499	1.499	9.99
Big Cr. 0.1 mi.ab. Glover Smelter	12/10/1996		2.499	1.499	9.99
Big Cr. 0.1 mi.ab. Glover Smelter	3/20/1997		2.499	1.499	9.99
Big Cr. 0.5 mi.bl. Glover Smelter	9/7/1984		18	700	24.99
Big Cr. 0.5 mi.bl. Glover Smelter	5/10/1993		2.3	2.499	52
Big Cr. 0.5 mi.bl. Glover Smelter	5/12/1993		0.99	2.499	46
Big Cr. 0.5 mi.bl. Glover Smelter	5/14/1993		0.99	2.499	59
Big Cr. 0.5 mi.bl. Glover Smelter	6/9/1996		2.499	3	120
Big Cr. 0.5 mi.bl. Glover Smelter	10/15/1996		2.499	6	260
Big Cr. 0.5 mi.bl. Glover Smelter	12/10/1996		2.499	1.499	62
Big Cr. 0.5 mi.bl. Glover Smelter	3/20/1997		2.499	1.499	9.99
Big Cr. 0.5 mi.bl. Glover Smelter	10/2/2002	164	3.9	0.99	67.9

Site Name	Date	Hard	dCd	dPb	dZn
Big Cr. 0.5 mi.bl. Glover Smelter	3/24/2003	75.2	0.499	0.99	45.6
Big Cr. 0.7 mi.bl. Glover Smelter	10/1/2002	163	2.98	0.99	53.9
Big Cr. 0.7 mi.bl. Glover Smelter	3/24/2003	73.2	0.499	0.99	42
Big Cr. 1.5 mi.bl. Glover Smelter	10/29/1974	128	16	14	180
Big Cr. 1.5 mi.bl. Glover Smelter	1/8/1975	74	13	41	30
Big Cr. 1.5 mi.bl. Glover Smelter	4/23/1975	62	4.99	70	30
Big Cr. 1.5 mi.bl. Glover Smelter	7/30/1975	158	14	14	20
Big Cr. 1.5 mi.bl. Glover Smelter	10/19/1982		10	2.499	20
Big Cr. 1.5 mi.bl. Glover Smelter	11/24/1982		4	2.499	80
Big Cr. 1.5 mi.bl. Glover Smelter	12/16/1982		5	2.499	40
Big Cr. 1.5 mi.bl. Glover Smelter	1/19/1983		6	2.499	30
Big Cr. 1.5 mi.bl. Glover Smelter	2/16/1983		4	6	20
Big Cr. 1.5 mi.bl. Glover Smelter	3/24/1983		0.99	2.499	4.99
Big Cr. 1.5 mi.bl. Glover Smelter	4/13/1983		14	6	42
Big Cr. 1.5 mi.bl. Glover Smelter	5/25/1983		7	2.499	10
Big Cr. 1.5 mi.bl. Glover Smelter	6/22/1983		9	16	180
Big Cr. 1.5 mi.bl. Glover Smelter	7/5/1983		8	2.499	290
Big Cr. 1.5 mi.bl. Glover Smelter	8/4/1983		8	2.499	18
Big Cr. 1.5 mi.bl. Glover Smelter	9/1/1983		6	2.499	20
Big Cr. 1.5 mi.bl. Glover Smelter	10/4/1983		10	6	62
Big Cr. 1.5 mi.bl. Glover Smelter	11/9/1983		17	5	68
Big Cr. 1.5 mi.bl. Glover Smelter	1/5/1984		13	2.499	44
Big Cr. 1.5 mi.bl. Glover Smelter	1/26/1984		14	2.499	78
Big Cr. 1.5 mi.bl. Glover Smelter	2/17/1984		20	2.499	63
Big Cr. 1.5 mi.bl. Glover Smelter	3/8/1984		6	2.499	27
Big Cr. 1.5 mi.bl. Glover Smelter	4/3/1984		0.99	2.499	50
Big Cr. 1.5 mi.bl. Glover Smelter	5/1/1984		4	2.499	20
Big Cr. 1.5 mi.bl. Glover Smelter	6/5/1984		9	2.499	21
Big Cr. 1.5 mi.bl. Glover Smelter	7/16/1984		7	0.499	15
Big Cr. 1.5 mi.bl. Glover Smelter	8/24/1984		18	60	55
Big Cr. 1.5 mi.bl. Glover Smelter	9/10/1984		39	130	84
Big Cr. 1.5 mi.bl. Glover Smelter	10/16/1984		17	17	57
Big Cr. 1.5 mi.bl. Glover Smelter	11/13/1984		1	0.499	22
Big Cr. 1.5 mi.bl. Glover Smelter	12/17/1984		4	3	32
Big Cr. 1.5 mi.bl. Glover Smelter	1/29/1985		10	0.499	64
Big Cr. 1.5 mi.bl. Glover Smelter	2/13/1985		5	3	91
Big Cr. 1.5 mi.bl. Glover Smelter	3/14/1985		2	0.499	33
Big Cr. 1.5 mi.bl. Glover Smelter	4/9/1985		4	7	33
Big Cr. 1.5 mi.bl. Glover Smelter	5/14/1985		6	6	51
Big Cr. 1.5 mi.bl. Glover Smelter	6/17/1985		26	21	600
Big Cr. 1.5 mi.bl. Glover Smelter	7/15/1985		18		63
Big Cr. 1.5 mi.bl. Glover Smelter	8/12/1985		11	4	42
Big Cr. 1.5 mi.bl. Glover Smelter	9/23/1985		9	3	36
Big Cr. 1.5 mi.bl. Glover Smelter	10/21/1985		120	24	220
Big Cr. 1.5 mi.bl. Glover Smelter	11/22/1985		9	0.499	41
Big Cr. 1.5 mi.bl. Glover Smelter	12/16/1985		6	2	53
Big Cr. 1.5 mi.bl. Glover Smelter	1/21/1986		9	2	49

Site Name	Date	Hard	dCd	dPb	dZn
Big Cr. 1.5 mi.bl. Glover Smelter	2/13/1986		10	8	40
Big Cr. 1.5 mi.bl. Glover Smelter	3/3/1986		12	3	45
Big Cr. 1.5 mi.bl. Glover Smelter	4/7/1986		3	2	
Big Cr. 1.5 mi.bl. Glover Smelter	5/12/1986		11	3	
Big Cr. 1.5 mi.bl. Glover Smelter	6/11/1986		5	2.499	
Big Cr. 1.5 mi.bl. Glover Smelter	7/14/1986		14	7	41
Big Cr. 1.5 mi.bl. Glover Smelter	8/13/1986		13	2.499	
Big Cr. 1.5 mi.bl. Glover Smelter	9/15/1986		9	2.499	
Big Cr. 1.5 mi.bl. Glover Smelter	10/20/1986		7	2.499	47
Big Cr. 1.5 mi.bl. Glover Smelter	11/14/1986		5	2.499	46
Big Cr. 1.5 mi.bl. Glover Smelter	12/11/1986		4	2.499	25
Big Cr. 1.5 mi.bl. Glover Smelter	1/6/1987		4	2.499	44
Big Cr. 1.5 mi.bl. Glover Smelter	2/3/1987		2	2.499	38
Big Cr. 1.5 mi.bl. Glover Smelter	3/2/1987		2	2.499	18
Big Cr. 1.5 mi.bl. Glover Smelter	4/3/1987		2	2.499	25
Big Cr. 1.5 mi.bl. Glover Smelter	5/5/1987		7	2.499	37
Big Cr. 1.5 mi.bl. Glover Smelter	6/4/1987		7	2.499	42
Big Cr. 1.5 mi.bl. Glover Smelter	7/15/1987		11	9	71
Big Cr. 1.5 mi.bl. Glover Smelter	8/5/1987		16	2.499	80
Big Cr. 1.5 mi.bl. Glover Smelter	9/9/1987		11	2.499	47
Big Cr. 1.5 mi.bl. Glover Smelter	10/16/1987		9	2.499	46
Big Cr. 1.5 mi.bl. Glover Smelter	11/10/1987		9	2.499	51
Big Cr. 1.5 mi.bl. Glover Smelter	12/2/1987		8	2.499	63
Big Cr. 1.5 mi.bl. Glover Smelter	1/6/1988		23	5	170
Big Cr. 1.5 mi.bl. Glover Smelter	2/3/1988		4	2.499	1.499
Big Cr. 1.5 mi.bl. Glover Smelter	3/2/1988		9	6	43
Big Cr. 1.5 mi.bl. Glover Smelter	4/6/1988		3	2.499	30
Big Cr. 1.5 mi.bl. Glover Smelter	5/11/1988		7	12	35
Big Cr. 1.5 mi.bl. Glover Smelter	6/8/1988		9	2.499	40
Big Cr. 1.5 mi.bl. Glover Smelter	7/13/1988		10	8	35
Big Cr. 1.5 mi.bl. Glover Smelter	8/3/1988		7	2.499	30
Big Cr. 1.5 mi.bl. Glover Smelter	9/9/1988		7	2.499	24
Big Cr. 1.5 mi.bl. Glover Smelter	10/13/1988		8	7	33
Big Cr. 1.5 mi.bl. Glover Smelter	11/4/1988		9	5	39
Big Cr. 1.5 mi.bl. Glover Smelter	12/15/1988		5	2.499	39
Big Cr. 1.5 mi.bl. Glover Smelter	1/13/1989		3.499	4.99	64
Big Cr. 1.5 mi.bl. Glover Smelter	2/8/1989		3	2.499	24
Big Cr. 1.5 mi.bl. Glover Smelter	3/9/1989		4	2.499	44
Big Cr. 1.5 mi.bl. Glover Smelter	4/14/1989		8	2.499	36
Big Cr. 1.5 mi.bl. Glover Smelter	5/17/1989		5	2	33
Big Cr. 1.5 mi.bl. Glover Smelter	6/6/1989		4	1	27
Big Cr. 1.5 mi.bl. Glover Smelter	7/17/1989		9	2	57
Big Cr. 1.5 mi.bl. Glover Smelter	8/1/1989		12	3	60
Big Cr. 1.5 mi.bl. Glover Smelter	9/14/1989		7	7	73
Big Cr. 1.5 mi.bl. Glover Smelter	10/13/1989		8	3	56
Big Cr. 1.5 mi.bl. Glover Smelter	11/13/1989		11	2	76
Big Cr. 1.5 mi.bl. Glover Smelter	12/7/1989		8	4	86

Site Name	Date	Hard	dCd	dPb	dZn
Big Cr. 1.5 mi.bl. Glover Smelter	1/16/1990		5	4.99	48
Big Cr. 1.5 mi.bl. Glover Smelter	2/15/1990		2	10	24
Big Cr. 1.5 mi.bl. Glover Smelter	3/23/1990		2	4.99	31
Big Cr. 1.5 mi.bl. Glover Smelter	4/12/1990		0.499	4.99	9
Big Cr. 1.5 mi.bl. Glover Smelter	5/10/1990		8	2	36
Big Cr. 1.5 mi.bl. Glover Smelter	6/7/1990		6	1	39
Big Cr. 4.9 mi.bl. Glover Smelter	10/2/2002	164	0.499	0.99	4.99
Big Cr. 4.9 mi.bl. Glover Smelter	3/25/2003	88	0.499	0.99	16.6
Glover Smelter Outfall 003	5/30/1995		0.99	14.99	4.3
Scoggins Br. ab. Glover Smelter	9/5/1984		12	80	24.99
Scoggins Br. ab. Glover Smelter	5/10/1993		0.99	2.499	4.99
Scoggins Br. ab. Glover Smelter	5/12/1993		0.99	2.499	4.99
Scoggins Br. ab. Glover Smelter	5/14/1993		0.99	2.499	10
Scoggins Br. ab. Glover Smelter	5/30/1995		0.99	60	5.6
Scoggins Br. ab. Glover Smelter	6/11/1996		2.499	1.499	9.99
Scoggins Br. ab. Glover Smelter	12/10/1996		2.499	1.499	9.99
Scoggins Br. ab. Glover Smelter	3/20/1997		2.499	1.499	9.99
Scoggins Br. ab. Glover Smelter	7/28/1998		0.99	0.99	4
Scoggins Br. bl. Glover Smelter	9/7/1984		42	120	340
Scoggins Br. bl. Glover Smelter	5/10/1993		35.2	2.499	787
Scoggins Br. bl. Glover Smelter	5/12/1993		29.5	5.78	785
Scoggins Br. bl. Glover Smelter	5/14/1993		23.7	8.7	737
Scoggins Br. bl. Glover Smelter	5/30/1995		6	14.99	127
Scoggins Br. bl. Glover Smelter	6/9/1996		2.499	1.499	650
Scoggins Br. bl. Glover Smelter	6/11/1996		11	30	1900
Scoggins Br. bl. Glover Smelter	10/15/1996		34	36	2300
Scoggins Br. bl. Glover Smelter	12/10/1996		2.499	1.499	670
Scoggins Br. bl. Glover Smelter	7/28/1998		10	9	567
Scoggins Br. bl. Glover Smelter	10/2/2002	236	23.6	6.7	586
Scoggins Br. bl. Glover Smelter	3/24/2003	236	11.1	7.37	774

mi. = mile; ab. = above; bl. = below

Appendix F. Calculations to determine storm water loads to Big Creek

Table F-1. Calculations for dissolved cadmium

pctile	Flow (cfs)	dCd (lbs/day)	TMDL	Available TMDL after plant removed	Excess actual load (lbs/day)	Percent above available	
0.0008	0.73	m	0.0009	0.001	0.0000	m	m
0.27	2.62	0.11	0.0034	0.002	0.0000	98.0%	0.002
0.56	6.97	0.08	0.0089	0.008	0.0000	90.4%	0.002
0.64	9.04	0.05	0.0116	0.010	0.0000	79.3%	0.001
0.78	16.00	0.89	0.0205	0.019	0.0000	97.8%	0.017
0.78	16.00	0.09	0.0205	0.019	0.0000	78.6%	0.002
0.78	16.00	m	0.0205	0.020	0.0000	m	m
0.78	16.00	m	0.0205	0.020	0.0000	m	m
0.9	31.84	0.17	0.0407	0.040	0.0000	76.7%	0.003
0.95	59.58	0.32	0.0762	0.075	0.0000	76.6%	0.006
					maximum	98.0%	
hardness							
25th percentile							
95							

Note: "m" = missing

Figure F-1. Wet weather TMDL Load Duration Curve – dissolved cadmium

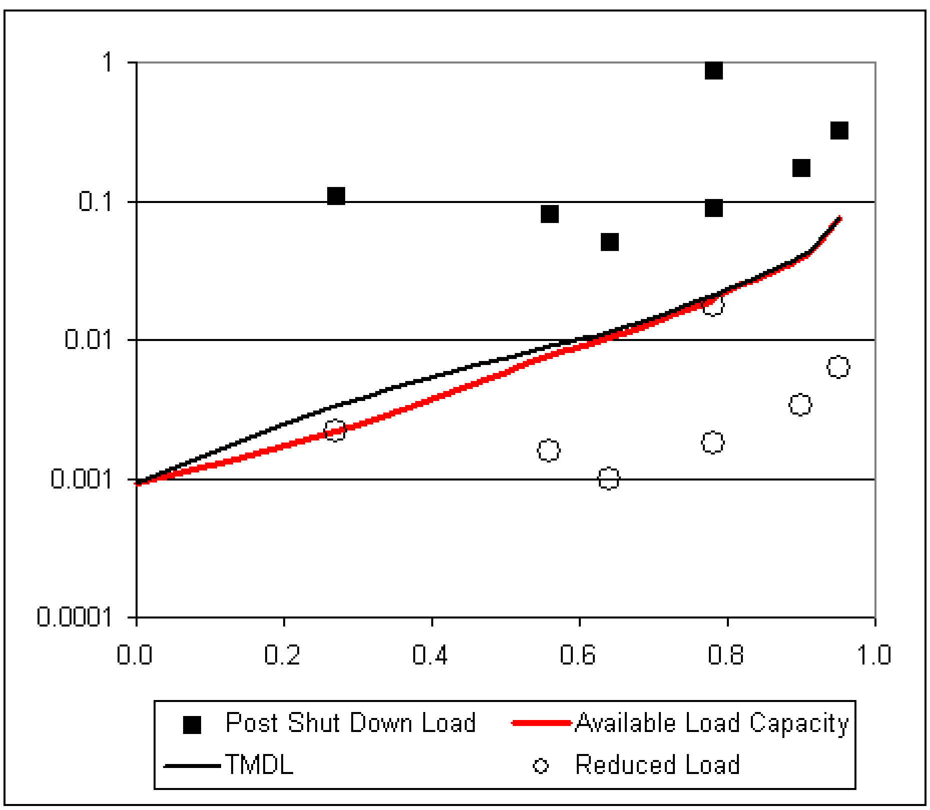


Table F-2. Calculations for dissolved lead

dPb (lbs/day)	TMDL	Available TMDL after plant removed	Excess Actual load (lbs/day)	Percent above available	Reduced by maximum
m	0.009	0.009	0.000	m	m
0.04	0.034	0.022	0.000	45.9%	0.022
0.10	0.090	0.077	0.000	22.5%	0.054
0.06	0.116	0.104	0.044	within WQS	0.032
0.09	0.205	0.193	0.103	within WQS	0.049
0.35	0.205	0.193	0.000	44.7%	0.189
m	0.205	0.205	0.000	m	m
m	0.205	0.205	0.000	m	m
0.34	0.409	0.397	0.057	within WQS	0.184
0.32	0.765	0.753	0.433	within WQS	0.173
			maximum	45.9%	

Note: "m" = missing

Figure F-2. Wet weather TMDL load duration curve – dissolved lead

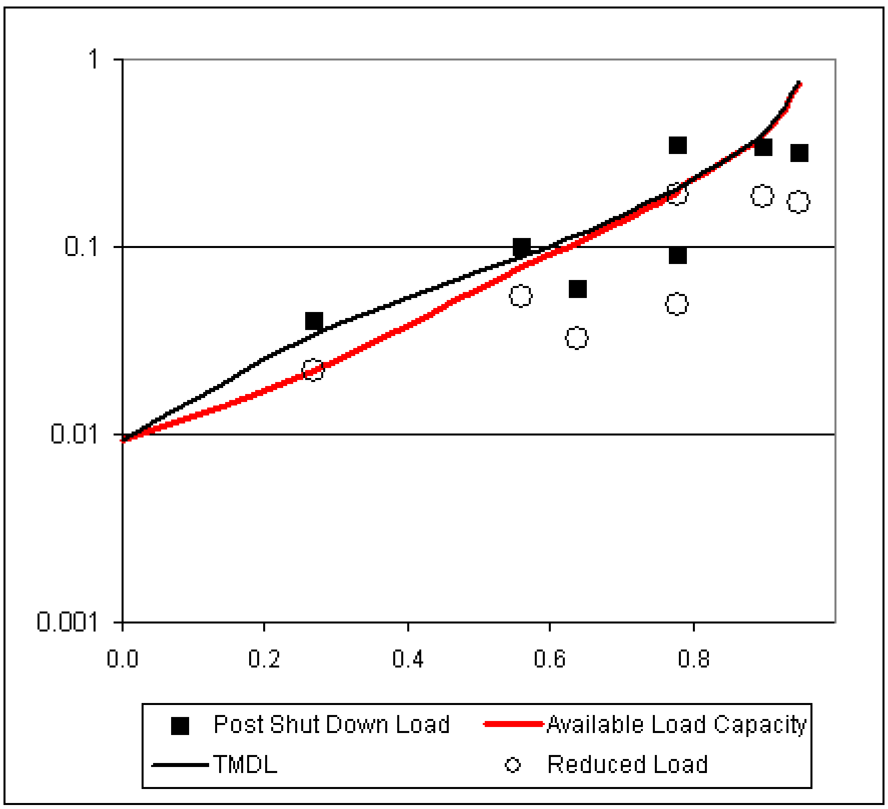


Table F-3. Calculations for dissolved zinc

dZn (lbs/day)	TMDL	Available TMDL after plant removed	Excess actual load (lbs/day)	Percent above available	Reduced by Maximum
0.06	0.404	0.40	0.344	within WQS	0.025
2.26	1.449	0.94	0.000	58.5%	0.937
2.44	3.854	3.85	1.414	within WQS	1.012
2.68	4.998	5.00	2.318	within WQS	1.111
2.59	8.846	8.85	6.256	within WQS	1.074
4.32	8.846	8.85	4.526	within WQS	1.791
3.19	8.846	8.85	5.656	within WQS	1.323
0.95	8.846	8.85	7.896	within WQS	0.394
5.15	17.604	17.60	12.454	within WQS	2.135
16.07	32.941	32.94	16.871	within WQS	6.662
			maximum	58.5%	

Figure F-3. Wet weather TMDL load duration curve – dissolved zinc