UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION III
1650 Arch Street
Philadelphia, Pennsylvania 19103-2029

Metals, pH, and Fecal Coliform TMDLs for the Guyandotte River Watershed, West Virginia

__/s/ ____________
Jon M. Capacasa, Director
Water Protection Division

Date: __3-30-04______

Metals, pH, and Fecal Coliform TMDLs for the Guyandotte River Watershed, West Virginia

FINAL REPORT

U.S. Environmental Protection Agency
Region 3
1650 Arch Street
Philadelphia, PA

March 2004

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION III
1650 Arch Street
Philadelphia, Pennsylvania 19103-2029

Ms. Allyn Turner, Director
Division of Water and Waste Management
West Virginia Department of Environmental Protection
414 Summers Street
Charleston, West Virginia 25301

Dear Ms. Turner:

According to the Consent Decree (entered by the United States District Court for the southern District of West Virginia on July 9, 1997) and Settlement Agreement for the case OVEC Inc.,et al., V. Browner, et al., the U.S. Environmental Protection Agency (EPA) has established final Total Maximum Daily Loads (TMDLs) for 66 waterbodies including the Upper and Lower Guyandotte River and 64 tributaries. For this TMDL report, the Lower Guyandotte River and Upper Guyandotte River watersheds were combined into a single watershed called the Guyandotte River watershed. The TMDLs are for mine drainage and fecal coliform bacteria impaired waterbodies in the Guyandotte River watershed. EPA has established these TMDLs to satisfy its obligation of Joint Notice of Modification of Consent Decree to extend deadline entered into and filed in September 2002.

In accordance with Federal regulations found in 40 CFR §130.7, a TMDL must: (1) be designed to meet water quality standards, (2) include, as appropriate, both wasteload allocations for point sources and load allocations for nonpoint sources, (3) consider the impacts of background pollutant contributions, (4) take critical stream conditions into account (the conditions when water quality is most likely to be violated), (5) consider seasonal variations, (6) include a margin of safety (which accounts for any uncertainties in the relationship between pollutant loads and instream water quality), (7) reasonable assurance that the TMDLs can be met and, (8) be subject to public participation. The TMDLs for the Guyandotte River watershed satisfy all statutory and regulatory requirements.

Following the establishment of these TMDLs, the West Virginia Department of Environmental Protection shall incorporate these TMDLs into the State's Water Quality Management Plan pursuant to 40 CFR §130.7(d)(2). As you know, any new or revised National Pollution Discharge Elimination System permits, with applicable effluent limits, must be consistent with the TMDL's wasteload allocation pursuant to 40 CFR §122.44(d)(1)(vii)(B)(2). Any such permit should be submitted to EPA for review consistent with EPA's letter dated October 1, 1998.

Enclosed, please find the final TMDL report for the Guyandotte River watershed, copies of comment letters, and a responsiveness summary. A compact disk with the final TMDLs is also included. The final TMDLs will also be available on our web site at http:/www.epa.gov/reg3wapd/tmdl/.

If you have any questions concerning the final TMDLs, please contact Ms. Jennifer Sincock, West Virginia TMDL Coordinator at (215) 814-5766 or Mr. Thomas Henry, TMDL Program Manager at (215) 814-5752.

Sincerely,

/s/ 3-30-04

Jon M. Capacasa, Director
Water Protection Division

Enclosures

cc: Ms. Evelyn S. MacKnight, EPA
Mr. Patrick Campbell, WVDEP
Ohio Valley Environmental Coalition
West Virginia Highlands Conservancy
Appalachian Research and Defense Fund, Inc.
Ms. Ryan Alexander, Esquire
Mr. David L. Yaussy, Esquire
Mr. David M. Flannery, Esquire
Mr. Jeffrey K. Towner, U.S. Fish and Wildlife Services
Mr. Daniel Ramsey, U.S. Fish and Wildlife Services
Mr. Alan Vicory, Ohio River Valley Sanitation Commission
Mr. Jason Heath, Ohio River Valley Sanitation Commission

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION III- OFFICE OF COMMUNICATIONS AND GOVERNMENT RELATIONS
1650 Arch Street Philadelphia, Pennsylvania 19103-2029
Phone - 215/814-5100 Fax - 215/814-5102

EPA Environmental News

Contact: Roy Seneca (215) 814-5567
March 31, 2004

EPA establishes clean-up plans for Guyandotte River watershed

PHILADELPHIA – The U.S. Environmental Protection Agency has established final plans to improve water quality on 66 impaired water bodies within the Upper and Lower Guyandotte River watersheds in West Virginia.

The plans, which were developed by EPA in coordination with the West Virginia Department of Environmental Protection, establish more than 180 "pollution budgets," known as Total Maximum Daily Loads (TMDLs), that set the maximum amount of specific pollutants that can be introduced into the river and its tributaries.

"Through a teamwork approach with West Virginia, we have produced plans that we believe will dramatically improve the environmental health of the Guyandotte River and its tributaries," said Donald S. Welsh, regional administrator for EPA's mid-Atlantic region.

When a water body does not meet its water quality standards for a particular pollutant, the federal Clean Water Act requires the state to include the water body on its list of impaired waters. West Virginia has listed the Lower and Upper Guyandotte River and its tributaries as impaired by pollutants including pH, aluminum, iron, manganese, selenium, fecal coliform bacteria and/or biological impairment.

Once the water body is impaired, a TMDL must be developed to set the maximum amount of a specific pollutants that an estuary, lake or river can receive. After that load amount is calculated, all sources of that pollutant in the watershed are required to reduce their contributions of the contaminant to specified levels.

EPA developed these TMDLs to meet the requirements under a court order to resolve a civil suit.

The final TMDLs can be reviewed on the EPA Region 3 website at http://www.epa.gov/reg3wapd/tmdl/ .

Responses to Comments on the Draft Guyandotte TMDL (3/30/04)

Guyandotte TMDL Comment Letter #1

January 16, 2004 letter from David Densmore at U.S. Fish and Wildlife Service (FWS) to Allyn Turner at WVDEP regarding the FWS selenium survey in fish, water, and sediments in various waterbodies in southern West Virginia.

This letter describes the selenium survey and provides data results.

Response in regards to the Guyandotte TMDL:

Thank you for providing data from Fish and Wildlife Service's (FWS) selenium survey in fish, water, and sediments in various waterbodies in southern West Virginia that was conducted during the spring and summer of 2003. EPA, in partnership with West Virginia Department of Environmental Protection, has developed TMDLs in the Guyandotte River watershed for aluminum, iron, manganese, selenium, pH, and fecal coliform. Selenium TMDLs were developed for the Upper Mud River, Stanley Fork, and Sugartree Branch within the Guyandotte River watershed. EPA developed the selenium TMDLs using water quality data from the EPA Mountaintop Mining Environmental Impact Study (2001) as well as additional water quality data collected by EPA during the fall of 2003. The selenium TMDLs were developed to meet applicable water quality standards for selenium, which is 5 ug/L for chronic aquatic life, 20 ug/L for acute aquatic life, and 10 ug/L for human health.

EPA reviewed the data provided in the FWS letter dated January 16, 2004 to determine if any data was applicable to the selenium TMDL development. FWS listed water quality data from EPA's Mountaintop Mining Environmental Impact Study (utilized during TMDL development). However, the sediment and fish tissue data collected by the FWS on the Mud River, Stanley Fork, and Sugartree Branch was not applicable to the TMDL development because West Virginia does not have selenium fish tissue or sediment criteria. There is also no established method for back calculating selenium water column information from fish tissue or sediment data. Therefore, EPA was not able directly to utilize the selenium fish tissue and sediment data collected by FWS for the selenium TMDL development. We note that FWS's data appears to support the data and conclusions of the selenium TMDLs for the Mud River, Stanley Fork, and Sugartree Branch.

Guyandotte TMDL Comment Letter #2

"Summary Analytical Results, Upper Guyandotte River and Tributaries" hand-delivered from Acculab, Inc. to EPA at the February 24, 2004 public meeting at Logan High School in Logan, West Virginia.

Response:

Thank you for submitting these analytical results for Division of Mining and Reclamation's (DMR) trend stations in the Guyandotte River watershed. The Guyandotte

River watershed TMDL was developed using water quality data obtained from numerous sources including this DMR trend station data that was submitted by Acculab, Inc.

Guyandotte TMDL Comment Letter #3

February 27, 2004 email from Ken Johnson at CONSOL Energy, Inc.

Comment No. 1a

CONSOL found a great disparity between water quality in the samples it has collected under the NPDES program for its permitted facilities and the assertion that these same streams are impaired for water quality. For most if not all of the streams in the Guyandotte River basin that CONSOL samples, average levels of iron, manganese and aluminum and pH are consistently better than water quality standards. These data are listed in Table 1, and the raw data are given in the attached Excel spreadsheets.

Response:

In West Virginia, a water is determined to be impaired if it exceeds applicable water quality standards that are discussed in Section 2. On West Virginia's 2002 Section 303(d) list of impaired waters, West Virginia listed waters where more than 10 percent of samples exceeded the numeric water quality standards. Averages of data results are not applicable to West Virginia's listing methodology.

Comment No. 1b

In addition, it should be more clearly explained in Tables 3a, 3b, 3c and 3d of Appendix A-1 the meaning of the "WQ Station" instead of simply using nomenclature that the reader is totally unfamiliar with. It would be helpful to know which stream corresponds to each "WQ Station". It would also be helpful to know that the data CONSOL submits to the WVDEP and EPA is included in the TMDL analysis process. We see no evidence that any of our data was considered or utilized. The amount of data submitted by CONSOL was substantial.

Response:

All available data was used in the development of the Guyandotte TMDLs. As stated in Section 3 (pages 3-2 & 3-3), WVDEP requested that mining companies submit in-stream water quality monitoring data upstream and downstream of all discharging NPDES outlets in electronic format. This request was issued by WVDEP on March 30, 2003 with a submission deadline of April 28, 2003. Monitoring data were received from ten mining operations in the Guyandotte River watershed. The water quality data submitted by CONSOL was received after model calibration was complete (December 16, 2003). However, the water quality data was used to further adjust the calibration of the MDAS model for TMDL development.

Comment No. 2

The TMDL modeling method does not seem to take into account the fact that many metals do not behave conservatively in flowing stream water. Aluminum, for example, quickly precipitates at progressively higher pH, so it is unclear how reducing aluminum flux from one or more selected sources can contribute significantly to the overall health of the stream. Rather, reductions need to be more focused on the largest sources of pollution rather than on a large number of relatively small sources.

Response:

As stated in Section 4, it was necessary to link the watershed model (MDAS) with the Dynamic Equilibrium in-Stream Chemical reactions model (DESC) to appropriately address dissolved aluminum TMDLs in the Guyandotte River watershed. To establish this linkage, the MDAS model was first set up and calibrated to simulate in-stream concentrations of total metals (iron, aluminum, and manganese). The MDAS calibration process is discussed in detail in Section 4.6. Once calibration was complete, the time series flow and water quality output from MDAS was entered in the DESC to dynamically simulate dissolved metals behavior. DESC was then calibrated to further refine the simulation of dissolved metals. DESC is capable of simulating water quality in a multiple watershed setting by routing flow from upstream to downstream while simulating the transformation of in-stream water quality constituents. The model fully connects all chemical reactions with the transport routine and pollutants are routed from upstream to downstream allowing for loading inputs from landuses. The model supports all major chemical reactions and some kinetic reactions that need to be considered in the mining-affected stream. Examples of these reactions include:

- *Adsorption of metals onto iron oxide included on the surface of clay or other soil particles*
- *Adsorption of metals onto aluminum oxide*
- *Saturation calculations with dissolved and precipitated conditions within the water column and sediment*
- *Kinetic photo iron reduction*
- *Microbial iron oxidation*
- *Homogeneous oxidation processes*

As described in Section 5.4.1, the larger, most significant sources of metals were reduced first prior to reducing the smaller contributing sources. The methodology is described below:

- *For watersheds with AMLs but no permitted point sources, AMLs were reduced first, until in-stream water quality criteria were met or to conditions no less than those of undisturbed forest. If further reductions were required, then the sediment sources (Harvested Forest, Burned Forest, Oil and Gas operations, and Roads) were reduced until water quality criteria were met.*

- *For watersheds with AMLs and point sources, point sources were set at the precipitation induced load defined by the permit limits and AMLs were subsequently reduced. AMLs and revoked mining permits were reduced (point sources were not reduced) until in-stream water quality criteria were met, if possible. If further reduction was required once AMLs and revoked mines were reduced, sediment sources were then* *reduced. If even further reduction was required, the point source discharge limits were then reduced.*

C *For watersheds where dissolved aluminum TMDLs were developed, source allocations for total iron and manganese were developed first since their total in-stream concentrations (primarily iron) significantly reduce pH and consequently increase dissolved aluminum concentrations. If the dissolved aluminum TMDL endpoint was not attained after source reductions to iron and manganese, the total aluminum sources were reduced based on the methodology described above.*

Comment No. 3
The TMDL modeling method only calibrates results (hydrology and water quality, both) with field data for the Guyandotte River itself, and not for any of its tributaries. One would think that with all the flow and water quality data that is available from DMRs and other NPDES data for tributaries of the Guyandotte that they could have run more calibrations at some of these locations. This is a concern to CONSOL, because many of our permitted discharges occur in these tributaries, and CONSOL is concerned that the modeling results may not be accurate for these tributaries.

<u>Response:</u>
The MDAS model was calibrated for both hydrology and water quality using data from multiple locations throughout the Guyandotte watershed, including the Guyandotte River and its tributaries. Calibration could only be conducted where observed data were available. For hydrology calibration, locations with multiple years of daily USGS stream flow data were necessary. The MDAS model was first calibrated at locations where daily stream flow data were available for the smaller tributaries. The model parameters were then used for areas of the watershed where daily stream flow data were unavailable. The model was then calibrated to the available daily stream flow data for the Guyandotte mainstem. See Section 4.6:

In order to best represent hydrologic variability throughout the watershed, three locations with daily flow monitoring data were selected for calibration. The stations were USGS 03204000 Guyandotte at Branchland, USGS 03203600 Guyandotte at Logan, and USGS 03202750 Clear Fork at Clear Fork. The model was calibrated at these three locations for water years 1994 and 1995 by running the model over a calibration time period of 10/1/1993 - 9/30/1995. Flow-frequency curves, temporal comparisons (daily and monthly), and comparisons of high flows and low flows were developed to support calibration. The calibration involved adjustment of infiltration, subsurface storage, evapotranspiration, surface runoff, and interception storage parameters.

After adjusting the appropriate parameters within acceptable ranges, good correlations were found between model results and observed data for the comparisons made. Flow-frequency curves and temporal analyses are presented in Appendix F. Hydrology calibration statistics are shown in Table 4-11.

Parameter values were validated for an independent, extended time period (10/1/1983 through 9/30/1993) after calibrating parameters at the stations. The station chosen for validation was USGS 0320400 Guyandotte at Branchland. Validation involved comparison of model results and flow observations without further adjustment of parameters. The validation comparisons also showed a good correlation between modeled and observed data. Figure 4-4 presents a monthly summary of validation results. Refer to Appendix F for more detailed validation results.

For water quality calibration, see Section 4.6.2

The approach taken to calibrate water quality focused on matching trends identified during the water quality analysis. The water quality calibration period was 1994-2001. Daily average in-stream concentrations from the model were compared directly to observed data. Observed data were obtained from EPA's STORET database as well as from WVDEP Division of Water and Waste Management, and data submitted by various mining companies throughout the watershed. All data were obtained through WVDEP. The objective was to best simulate low flow, mean flow, and storm peaks at representative water quality monitoring stations. Representative stations were selected based on both location (distributed throughout the Guyandotte watershed) and loading source type. Locations and results of the water quality calibration are presented in Appendix F.

Comment No. 4a

The TMDL results in Appendix A-1 suggest a strong bias in enforcing metals load reductions in AMLs (abandoned mine lands) as compared to other sources of pollution. There is a rather large amount of pollution contributed by "Other nonpoint sources" (Tables 5a, b, c), and it is rare to see any reductions enforced for these sources. These sources need to be identified and contributors to this pollution held accountable. This is not to say that AMLs should in any way be exempt from cleanup, but that other industries and landowners should do their fair share as well.

Response:

As stated in Section 5.2, the MDAS model was run for baseline conditions using hourly precipitation data for a representative 6-year time period. The precipitation experienced over this period was applied to the landuses and pollutant sources as they existed at the time of this TMDL development. Predicted in-stream concentrations were compared directly to the TMDL endpoints. This comparison allowed evaluation of the expected magnitude and frequency of exceedances under a range of hydrologic and environmental conditions, including dry periods, wet periods, and average periods.

The various source contributions of metals can occur during periods of both high flow and low flow. During high flow or storm events, the nonpoint sources of metals (primarily sediment sources) will dominate the overall loading to the stream. However, during low flow periods, the point sources and/or continuous flow sources such as AML will dominate the overall loading to the stream. In order to be compliant with water quality criteria, the TMDL endpoints must be achieved during both high flow and low *flow conditions. For some waterbodies, the critical conditions may occur at high flow, others may occur at low flow, and still others may occur at both high and low flow.*

The Other Nonpoint Sources category includes the nonpoint sources of Forest, Wetland, Agriculture, Pasture, Urban Pervious and Urban Impervious, which contribute metals loadings during storm events and do not contribute metals under low flow conditions. However, these loadings are not significant and did not cause exceedances of the TMDL endpoints. Furthermore, the source allocations presented in Appendices A-1 through A-14 are shown in terms of average annual loads (lb/yr). Therefore, the average annual loading from Other Nonpoint Sources are shown to be higher, but do not cause exceedances of the TMDL endpoint during high flow conditons. Conversely, AMLs were shown to cause exceedances of the TMDL endpoint during low flow conditions and required reduction.

Tables 5a, b, c have been updated to indicate that Other Nonpoint Sources include Forest, Wetland, Agriculture, Pasture, Urban Pervious and Urban Impervious.

Comment No. 4b

In addition, the way the results are presented in Tables 4 and 5 of Appendix A-1 and in the main body text of the report, it is unclear regarding the rationale behind the reductions in load that are proposed. In other words, there is no explanation of priority as to which sources should be reduced first, second, third, etc., and how the modelers decided on certain proposed reductions. Since most NPDES permittees discharge well below technology based permit limits and in many cases below water quality standards (and they sample on regular basis to ensure compliance), they are usually not as much of a problem to pollution as unregulated discharges. Therefore, it would seem that unregulated discharges should be more aggressively targeted in this TMDL (and others) than permitted discharges. This prioirity is not explained clearly.

Response:

The allocation strategy employed in this TMDL is clearly stated in Section 5.4.1 and discussed briefly in the response to Comment No. 3.

Comment No. 5

In Appendix A-1 in Tables 4a, 4b, and 4c, there are several instances in which the allocation (in mg/l) of a particular metal is a negative number. See results for Region 2 as an example. What does a negative number mean, that the permittee is required to remove metals from the stream at this location??

Response:

The negative numbers in Tables 4a, 4b, and 4c of Appendix A-1 were typographical errors. Tables 4a, 4b, and 4c have been updated to reflect the correct allocations in terms of concentration.

Comment No. 6
CONSOL feels it should be more clear in Appendix A-1 that proposed load reductions in metals only apply to streams that are listed as impaired in the 2002 303d list. Because this is not clear, CONSOL is concerned that load reductions are being applied to streams that are in compliance with water quality standards. As an example, one can see a proposed reduction in Region 7 for SWS (sub watershed) 1092 (Tables 4a, 4b, 4c), but this is not listed as an SWS that contributes to pollution according to Table 1.

CONSOL believes that streams that are in compliance should not have reductions in metals load imposed on them.

Response:
In order to address impairments to the main stem Guyandotte River and to the listed tributaries, the TMDL provides allocations to sources both in the listed waters and in waters that are not identified on West Virginia's Section 303(d) list. EPA's decision to include allocations to unimpaired waters is authorized by the Clean Water Act (CWA) and its implementing regulations. This TMDL addresses the Guyandotte River main stem and the tributaries in the Guyandotte River watershed that are listed under section 303(d)(1)(A) because they are impaired by mine drainage (iron, manganese, aluminum, selenium, and pH) and/or fecal coliform bacteria. Under section 303(d)(1)(C) of the CWA, the TMDL for the listed waters must be developed "at levels necessary to implement the applicable water quality standard." In this case, EPA has determined that reducing loads only from sources discharging directly to the Guyandotte River main stem and listed tributaries will not result in attaining applicable water quality standards in the listed waters. Accordingly, EPA may look at other sources of acid mine drainage and fecal coliform loadings to the listed waters. A WLA assigned to an upstream point source on an unlisted tributary is encompassed within the regulatory definition of "wasteload allocation." The term "wasteload allocation" is defined as "[t]he portion of a receiving water's loading capacity that is allocated to one of its existing or future point sources of pollution." 40 C.F.R. § 130.2(h). In this definition, the "receiving water" is not the unlisted tributary, but rather the downstream impaired water. The phrase "its existing or future point sources" includes point sources contributing loadings to the receiving water, irrespective of their location. The same rationale applies to nonpoint source loadings and load allocations. See 40 C.F.R. § 130.2(g)(similar language in the definition of "load allocation"). This interpretation is consistent with 40 CFR 122.4(d), which requires permits to include limits that meet downstream water quality standards.

Acknowledgments

This study was developed and prepared by Tetra Tech, Inc., in Fairfax, Virginia, under U.S. Environmental Protection Agency (EPA) Contract Number 68-C-02-108, Task Order 2003-12. The EPA Regional Coordinator was Thomas Henry of EPA Region 3. The EPA Work Assignment Manager was Francis Mulhern of EPA Region 3. Additional EPA Region 3 support was provided by Jennifer Sincock and Mary Beck. Completion of this study also depended on the generous support of various groups that provided data and other information. The following people especially are acknowledged:

Mary Beck	United States Environmental Protection Agency, Region 3
Pat Campbell	West Virginia Department of Environmental Protection, Division of Water and Waste Management
Angela Dorsey	West Virginia Department of Environmental Protection, Division of Mining and Reclamation
Debbie Martin	West Virginia Department of Environmental Protection, Division of Mining and Reclamation
Thomas Henry	U.S. Environmental Protection Agency, Region 3
Ken Politan	West Virginia Division of Environmental Protection, Division of Mining and Reclamation
Steve Stutler	West Virginia Department of Environmental Protection, Division of Water and Waste Management
David Vande Linde	West Virginia Division of Environmental Protection, Division of Mining and Reclamation
Dave Montali	West Virginia Department of Environmental Protection, Division of Water and Waste Management
Frank Borsuk	U.S. Environmental Protection Agency, Region 3, Wheeling, West Virginia
Lou Reynolds	U.S. Environmental Protection Agency, Region 3, Wheeling, West Virginia
Jim Green	U.S. Environmental Protection Agency, Region 3, Wheeling, West Virginia
John Wirts	West Virginia Department of Environmental Protection, Division of Water and Waste Management
Maryellen Schultz	U.S. Environmental Protection Agency, Region 3, Fort Meade, Maryland

Contents

Executive Summary

The Guyandotte River watershed, located in southwestern West Virginia, is part of the Ohio River basin. The heavily forested area drained by the Guyandotte River is approximately 1,680 square miles and lies within portions of the following counties: Raleigh, Wyoming, Logan, Mingo, Boone, Lincoln, Putnam, and Cabell. The largest tributaries of the Guyandotte River are Mud River, Clear Fork, and Island Creek. A large portion of the Guyandotte River basin lies in the southern coalfields of West Virginia, where extensive coal deposits are the most economically valuable mineral resource in the area. Forestry is another major industry in the Guyandotte watershed.

West Virginia's 1996, 1998, and 2002 Section 303(d) lists include 123 waterbodies in the Guyandotte River watershed because of fecal coliform bacteria, metals (total aluminum, iron, manganese, and selenium), pH, and/or biological impairments. Total Maximum Daily Loads (TMDLs) were developed for the 66 segments in the Guyandotte River watershed that are impaired relative to total iron, manganese and selenium, dissolved aluminum, pH, fecal coliform bacteria and/or biological impairments. TMDLs for the remaining 57 segments listed for biological impairment only will be established within 8-13 years of their initial listing.

Requirements Governing West Virginia Water Quality Standards, West Virginia Code of State Rules, Title 46, Series 1 defines total iron and pH numeric criteria under the Aquatic Life and the Human Health use designation categories. Total manganese and fecal coliform bacteria have numeric criteria under the Human Health designation category. Recently, EPA approved revisions to certain water quality standards in West Virginia including an aquatic life protection change to aluminum criteria from total recoverable to dissolved. The listed waterbodies in the Guyandotte River watershed have been designated as having an Aquatic Life and a Human Health use.

The Guyandotte River watershed was divided into 14 regions representing hydrologic units. Each region was further divided into subwatersheds for modeling purposes; a total of 369 for the entire watershed. The 14 regions and their respective subwatersheds provided a basis for georeferencing pertinent source information and monitoring data, and for presenting TMDLs. The Mining Data Analysis System (MDAS) was used to represent the source-response linkage in the Guyandotte River watershed for total aluminum, manganese, iron and fecal coliform bacteria. The MDAS is a comprehensive data management and modeling system that is capable of representing loads from nonpoint and point sources found in the watershed and simulating in-stream processes. MDAS was linked with the Dynamic Equilibrium In-stream Chemical Reactions model (DESC) to appropriately address dissolved aluminum TMDLs in the watershed. Based on a pollutant flow analysis, a low flow critical condition was identified and using modeled flow from MDAS the low flow 7Q10 was determined to be 0 cfs. The MINTEQ modeling system was used to represent the source-response linkage in the Guyandotte River watershed for pH.

Primary sources contributing to metals and pH impairments include an array of nonpoint or diffuse sources as well as discrete point sources/permitted discharges. Most of the point sources with metals permits in the watershed are mining-related. The unpermitted and nonpoint sources include abandoned mines (AMLs), revoked permits, burned forest, harvested forest, oil and gas operations and roads.

The unpermitted and nonpoint fecal coliform sources within the Guyandotte River watershed include urban and residential runoff, leaking sanitary sewers, failing septic systems and straight pipe discharges, grazing livestock, runoff from cropland, and wildlife.

West Virginia's numeric water quality criteria and an explicit margin of safety (MOS) were used to identify endpoints for TMDL development.

The following general methodology was used when allocating to sources of metals for the Guyandotte River watershed TMDLs.

- For watersheds with AMLs but no permitted point sources, AMLs were reduced first, until in-stream water quality criteria were met or to conditions no less than those of undisturbed forest. If further reductions were required, then the sediment sources (Harvested Forest, Burned Forest, Oil and Gas operations, and Roads) were reduced until water quality criteria were met.
- For watersheds with AMLs and point sources, point sources were set at the precipitation induced load defined by the permit limits and AMLs were subsequently reduced. AMLs and revoked mining permits were reduced (point sources were not reduced) until in-stream water quality criteria were met, if possible. If further reduction was required once AMLs and revoked mines were reduced, sediment sources were then reduced. If even further reduction was required, the point source discharge limits were then reduced.
- For watersheds where dissolved aluminum TMDLs were developed, source allocations for total iron and manganese were developed first since their total in-stream concentrations (primarily iron) significantly reduce pH and consequently are associated with increased dissolved aluminum concentrations. If the dissolved aluminum TMDL endpoint was not attained after source reductions to iron and manganese, the total aluminum sources were reduced based on the methodology described above.
- Since the primary sources contributing to selenium impairments are the point sources at a low flow 7Q10 condition of 0 cfs, the nonpoint source contributions of selenium were considered to be negligible. Therefore, the TMDLs were based on wasteload allocations assigned at water quality criteria for selenium (5 ug/L) at the end of pipe for the surface mining discharging upstream of the 7Q10 condition of 0cfs (Upton Branch).

The following general methodology was used when allocating to sources for the Guyandotte River fecal coliform bacteria TMDL:

- All point sources in the Guyandotte River watershed were set at permit limits (200 counts/100mL monthly average) and all illicit, non-disinfected discharges of human waste (i.e., straight pipes and failing septic systems) were eliminated. If further reduction was necessary, source loadings from residential areas and agricultural lands were subsequently reduced until in-stream water quality criteria were met.

Tables 1, 2, and 3 show the baseline and allocated loads, along with the margin of safety (MOS) and percent reduction impaired segment. Figure 1 shows the Guyandotte River watershed and its 14 regions.

Table 1. Aluminum Baseline and Allocated Loads by Impaired Segment

Parameter	DNRCODE	DNRN	Region	Baseline LA	LA	Baseline WLA	WLA	MOS	TMDL	% Red.
Aluminum	OG-100	Clear Fork (OGC)	11	460,464	121,115	66,410	59,338	9,498	189,951	66
Aluminum	OG-134	Slab Fork	14	18,936	10,598	2,543	2,543	692	13,833	39
Aluminum	OG-138	Winding Gulf	14	160,013	31,576	14,270	14,270	2,413	48,259	74
Aluminum	OG-49	Big Creek	5	27,641	13,793	1,026	1,026	780	15,599	48
Aluminum	OG-51	Crawley Creek	1	4,348	4,348	0	0	229	4,577	0
Aluminum	OG-61	Buffalo Creek	1	18,040	4,006	0	0	211	4,217	78
Aluminum	OG-65	Island Creek	6	950,883	82,883	109,637	109,637	10,133	202,652	82
Aluminum	OG-65-B	Copperas Mine Fork	6	103,302	17,750	59,827	59,827	4,083	81,660	52
Aluminum	OG-75	Buffalo Creek	8	50,985	12,409	80,003	60,806	3,853	77,068	44
Aluminum	OG-89	Gilbert Creek	7	27,811	7,855	29,029	27,912	1,882	37,649	37
Aluminum	OG-96	Big Cub Creek	7	27,050	6,278	10,780	10,780	898	17,956	55

Table 2. Iron Baseline and Allocated Loads by Impaired Segment

Parameter	DNRCODE	DNRN	Region	Baseline LA	LA	Baseline WLA	WLA	MOS	TMDL	% Red.
Iron	O-4	Guyandotte River	1	760,790	421,132	710,685	515,830	49,314	986,276	36
Iron	OG-100	Clear Fork (OGC)	11	96,785	44,298	66,783	58,120	5,390	107,808	37
Iron	OG-108	Little Cub Creek/Upper Guyandotte River	7	2,185	763	0	0	40	804	65
Iron	OG-10-A	Right Fork/Merritt Creek	1	272	272	0	0	14	286	0
Iron	OG-110	Indian Creek	12	7,812	6,703	40,586	28,130	1,833	36,666	28
Iron	OG-110-A	Brier Creek/Indian Creek	12	394	394	153	153	29	575	0
Iron	OG-110-A-2	Marsh Fork/Brier Creek	12	70	70	109	109	9	189	0
Iron	OG-124	Pinnacle Creek	13	25,744	8,827	50,291	43,092	2,733	54,651	32
Iron	OG-124-D	Smith Branch/Pinnacle Creek	13	497	497	240	240	39	775	0
Iron	OG-124-H	Laurel Branch/Pinnacle Creek	13	55	55	809	606	35	696	23
Iron	OG-124-I	Spider Creek	13	285	285	34	34	17	336	0
Iron	OG-127	Cabin Creek	7	861	861	331	331	63	1,255	0
Iron	OG-128	Joe Branch	7	2,787	483	791	791	67	1,341	64
Iron	OG-129	Long Branch	7	1,539	317	1,606	1,606	101	2,024	39
Iron	OG-130	Still Run	7	4,711	1,820	1,136	1,136	156	3,111	49
Iron	OG-131	Barkers Creek	14	17,532	11,597	5,840	5,840	918	18,355	25
Iron	OG-131-B	Hickory Branch/Barkers Creek	14	351	351	0	0	18	370	0
Iron	OG-131-F	Gooney Otter Creek	14	8,785	3,341	4,559	4,559	416	8,316	41
Iron	OG-131-F-1	Jims Branch/Gooney Otter Creek	14	389	160	0	0	8	169	59
Iron	OG-131-F-2	Noesman Branch	14	1,301	530	573	573	58	1,161	41
Iron	OG-134	Slab Fork	14	10,630	8,317	2,489	2,489	569	11,374	18
Iron	OG-134-D	Measle Fork	14	124	124	0	0	7	130	0
Iron	OG-135-A	Left Fort/Allen Creek	14	2,652	564	0	0	30	594	79

Parameter	DNRCODE	DNRN	Region	Baseline LA	LA	Baseline WLA	WLA	MOS	TMDL	% Red.
Iron	OG-137	Devils Fork	14	4,519	4,519	0	0	238	4,757	0
Iron	OG-138	Winding Gulf	14	46,604	16,604	13,966	13,966	1,609	32,179	50
Iron	OG-139	Stonecoal Creek	14	14,328	5,279	3,460	3,460	460	9,199	51
Iron	OG-48	Limestone Branch	1	294	268	0	0	14	282	9
Iron	OG-49-A	Ed Stone Branch/Big Creek	5	73	73	0	0	4	77	0
Iron	OG-49-A-1	North Branch/ Ed Stone Branch	5	26	26	0	0	1	28	0
Iron	OG-53	Godby Branch	1	56	56	0	0	3	59	0
Iron	OG-61	Buffalo Creek	1	3,149	847	0	0	45	892	73
Iron	OG-65-A	Coal Branch/Island Creek	6	960	366	0	0	19	386	62
Iron	OG-65-B	Copperas Mine Fork	6	30,340	13,410	58,552	41,575	2,894	57,879	38
Iron	OG-65-B-1	Mud Fork	6	13,107	6,131	0	0	323	6,454	53
Iron	OG-65-B-1-A	Lower Dempsey Branch	6	1,434	516	0	0	27	544	64
Iron	OG-65-B-1-B	Ellis Branch/Mud Fork	6	2,049	829	0	0	44	872	60
Iron	OG-65-B-1-E	Upper Dempsey Branch	6	435	166	0	0	9	175	62
Iron	OG-65-B-4	Trace Fork/Copperas Mine Fork	6	6,679	1,030	13,877	8,326	492	9,848	54
Iron	OG-75-C.5	Proctor Hollow/Buffalo Creek	8	956	341	3,127	1,626	104	2,070	52
Iron	OG-76	Huff Creek	9	22,634	14,366	36,286	25,815	2,115	42,296	32
Iron	OG-76-L	Toney Fork/Huff Creek	9	3,319	1,068	6,083	3,954	264	5,286	47
Iron	OG-77-A.5	Oldhouse Branch/Rockhouse Creek	7	396	137	47	47	10	194	58
Iron	OG-92-I	Muzzle Creek	10	1,750	1,343	0	0	71	1,414	23
Iron	OG-92-K	Buffalo Creek/Little Huff Creek	10	1,338	534	112	112	34	680	55
Iron	OG-92-K-1	Kezee Fork	10	65	65	0	0	3	69	0
Iron	OG-92-K-2	Mudlick Fork/Buffalo Creek	10	16	16	0	0	1	16	0
Iron	OG-92-Q	Pad Fork	10	4,310	1,497	506	506	105	2,109	58
Iron	OG-92-Q-1	Righthand Fork/Pad Fork	10	872	383	380	380	40	804	39
Iron	OG-96-A	Sturgeon Branch	7	34	34	0	0	2	36	0
Iron	OG-96-B	Road Branch	7	1,571	948	2,928	2,196	166	3,310	30
Iron	OG-96-C	Elk Trace Branch/Big Cub Creek	7	1,793	402	0	0	21	424	78
Iron	OG-96-F	Toler Hollow	7	305	145	443	310	24	480	39
Iron	OG-96-H	McDonald Fork	7	836	293	2,595	1,817	111	2,221	39
Iron	OG-99	Reedy Branch	7	2,153	2,153	4,211	2,948	268	5,369	20
Iron	OGC-12	Lower Road Branch	11	1,995	732	3,753	2,064	147	2,944	51
Iron	OGC-16	Laurel Fork	11	52,779	25,096	23,899	20,476	2,399	47,971	41
Iron	OGC-16-M	Milam Branch	11	2,076	1,706	0	0	90	1,796	18
Iron	OGC-16-P	Trough Fork	11	4,624	2,916	3,699	3,560	341	6,817	22
Iron	OGC-19	Toney Fork/Clear Fork	11	3,013	2,169	4,062	4,062	328	6,560	12
Iron	OGC-26	Crane Fork	11	8,033	1,678	2,779	2,779	235	4,692	59

Table 3. Manganese Baseline and Allocated Loads by Impaired Segment

Parameter	DNR Code	DNR Name	Region	Baseline LA	LA	Baseline WLA	WLA	MOS	TMDL	% Red.
Manganese	OG-108	Little Cub Creek/Upper Guyandotte River	7	3,130	3,130	0	0	165	3,294	0

Parameter	DNR Code	DNR Name	Region	Baseline LA	LA	Baseline WLA	WLA	MOS	TMDL	% Red.
Manganese	OG-110	Indian Creek	12	30,722	24,590	16,341	14,338	2,049	40,978	17
Manganese	OG-110-A	Brier Creek/Indian Creek	12	5,129	4,516	93	93	243	4,852	12
Manganese	OG-110-A-2	Marsh Fork/Brier Creek	12	1,744	1,509	67	67	83	1,658	13
Manganese	OG-124	Pinnacle Creek	13	100,870	39,944	20,961	20,961	3,206	64,110	50
Manganese	OG-124-D	Smith Branch/Pinnacle Creek	13	3,918	1,470	127	127	84	1,680	61
Manganese	OG-124-H	Laurel Branch/Pinnacle Creek	13	381	381	334	334	38	753	0
Manganese	OG-124-I	Spider Creek	13	7,365	5,691	18	18	300	6,009	23
Manganese	OG-127	Cabin Creek	7	4,636	4,636	202	202	255	5,093	0
Manganese	OG-128	Joe Branch	7	15,779	1,749	451	451	116	2,316	86
Manganese	OG-129	Long Branch	7	8,414	808	892	892	89	1,789	82
Manganese	OG-130	Still Run	7	28,861	12,187	691	691	678	13,556	56
Manganese	OG-131	Barkers Creek	14	63,506	45,677	3,271	3,271	2,576	51,524	27
Manganese	OG-131-B	Hickory Branch/Barkers Creek	14	2,627	1,379	0	0	73	1,452	47
Manganese	OG-131-F	Gooney Otter Creek	14	39,513	22,932	2,531	2,531	1,340	26,803	39
Manganese	OG-131-F-1	Jims Branch/Gooney Otter Creek	14	1,962	1,061	0	0	56	1,117	46
Manganese	OG-131-F-2	Noesman Branch	14	6,652	3,548	345	345	205	4,098	44
Manganese	OG-134	Slab Fork	14	56,987	38,163	1,482	1,482	2,087	41,732	32
Manganese	OG-134-D	Measle Fork	14	3,831	2,473	0	0	130	2,603	35
Manganese	OG-135-A	Left Fort/Allen Creek	14	11,751	3,538	0	0	186	3,725	70
Manganese	OG-137	Devils Fork	14	119,838	31,407	0	0	1,653	33,060	74
Manganese	OG-138	Winding Gulf	14	124,932	80,793	6,919	6,919	4,616	92,329	33
Manganese	OG-139	Stonecoal Creek	14	74,493	34,337	1,891	1,891	1,907	38,135	53
Manganese	OG-48	Limestone Branch	1	1,658	1,058	0	0	56	1,113	36
Manganese	OG-49-A	Ed Stone Branch/Big Creek	5	1,674	1,674	0	0	88	1,762	0
Manganese	OG-49-A-1	North Branch/ Ed Stone Branch	5	936	936	0	0	49	985	0
Manganese	OG-53	Godby Branch	1	1,248	968	0	0	51	1,019	22
Manganese	OG-61	Buffalo Creek	1	12,972	3,621	0	0	191	3,812	72
Manganese	OG-65-A	Coal Branch/Island Creek	6	4,742	4,742	0	0	250	4,991	0
Manganese	OG-65-B	Copperas Mine Fork	6	121,049	121,049	24,521	24,521	7,662	153,232	0
Manganese	OG-65-B-1	Mud Fork	6	58,792	58,792	0	0	3,094	61,886	0
Manganese	OG-65-B-1-A	Lower Dempsey Branch	6	7,071	7,071	0	0	372	7,443	0
Manganese	OG-65-B-1-B	Ellis Branch/Mud Fork	6	10,550	10,550	0	0	555	11,105	0
Manganese	OG-65-B-1-E	Upper Dempsey Branch	6	2,022	2,022	0	0	106	2,128	0
Manganese	OG-65-B-4	Trace Fork/Copperas Mine Fork	6	29,229	29,229	5,818	5,818	1,845	36,892	0
Manganese	OG-75-C.5	Proctor Hollow/Buffalo Creek	8	3,140	933	1,369	1,369	121	2,424	49
Manganese	OG-76	Huff Creek	9	106,061	56,120	16,761	16,761	3,836	76,717	41
Manganese	OG-76-L	Toney Fork/Huff Creek	9	16,431	5,688	3,172	3,172	466	9,327	55
Manganese	OG-77-A.5	Oldhouse Branch/Rockhouse Creek	7	1,931	827	28	28	45	900	56
Manganese	OG-92-I	Muzzle Creek	10	35,436	6,966	0	0	367	7,333	80
Manganese	OG-92-K	Buffalo Creek/Little Huff Creek	10	11,247	6,344	68	68	337	6,749	43
Manganese	OG-92-K-1	Kezee Fork	10	3,518	771	0	0	41	812	78
Manganese	OG-92-K-2	Mudlick Fork/Buffalo Creek	10	253	253	0	0	13	266	0
Manganese	OG-92-Q	Pad Fork	10	22,826	9,472	279	279	513	10,264	58
Manganese	OG-92-Q-1	Righthand Fork/Pad Fork	10	5,054	2,938	202	202	165	3,306	40
Manganese	OG-96-A	Sturgeon Branch	7	299	280	0	0	15	294	7
Manganese	OG-96-B	Road Branch	7	11,277	4,536	1,069	1,069	295	5,899	55

Parameter	DNR Code	DNR Name	Region	Baseline LA	LA	Baseline WLA	WLA	MOS	TMDL	% Red.
Manganese	OG-96-C	Elk Trace Branch/Big Cub Creek	7	9,034	2,279	0	0	120	2,399	75
Manganese	OG-96-F	Toler Hollow	7	1,494	445	208	208	34	687	62
Manganese	OG-96-H	McDonald Fork	7	4,041	4,041	1,432	1,432	288	5,761	0
Manganese	OG-99	Reedy Branch	7	15,276	6,229	1,513	1,513	407	8,149	54
Manganese	OGC-12	Lower Road Branch	11	9,935	3,946	1,943	1,943	310	6,199	50
Manganese	OGC-16	Laurel Fork	11	210,752	91,108	11,736	11,736	5,413	108,257	54
Manganese	OGC-16-M	Milam Branch	11	15,531	7,260	0	0	382	7,642	53
Manganese	OGC-16-P	Trough Fork	11	17,774	11,449	1,967	1,967	706	14,122	32
Manganese	OGC-19	Toney Fork/Clear Fork	11	119,520	17,956	2,153	1,292	1,013	20,261	84
Manganese	OGC-26	Crane Fork	11	45,844	1,739	1,566	1,566	174	3,479	93

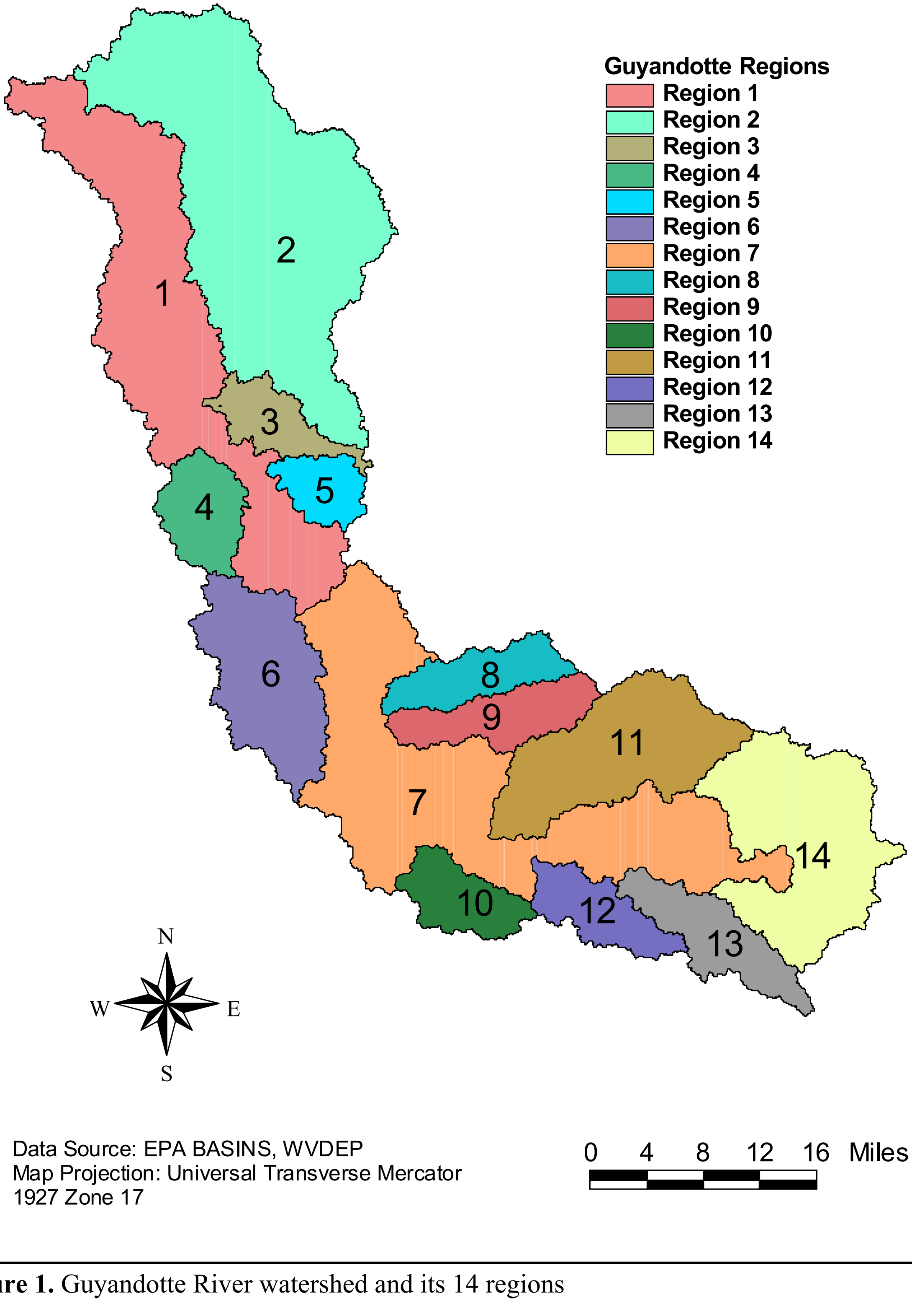
Table 4. Fecal coliform Baseline and Allocated Loads by Major Tributary

Drainage	DNR Code	DNR Name	Baseline LA	LA	Baseline WLA	WLA	MOS	TMDL	% Red.
Mainstem	O-4	Guyandotte River	1.28e+16	1.30e+15	2.15e+11	2.15e+11	6.87e+13	1.37e+15	90
Direct Drainage	OG-1	Russell Creek	2.92e+13	1.01e+13	1.07e+09	1.07e+09	5.32e+11	1.06e+13	65
Direct Drainage	OG-10	Merritt Creek	5.28e+13	1.05e+13	1.07e+09	1.07e+09	5.51e+11	1.10e+13	80
Direct Drainage	OG-100	Clear Fork	6.78e+14	9.68e+13	8.94e+08	8.94e+08	5.10e+12	1.02e+14	86
Direct Drainage	OG-108	Little Cub Creek	2.09e+13	1.78e+12	0.00e+00	0.00e+00	9.37e+10	1.87e+12	91
Direct Drainage	OG-11	Cavill Creek	2.35e+13	4.33e+12	8.94e+08	8.94e+08	2.28e+11	4.56e+12	82
Direct Drainage	OG-110	Indian Creek	1.63e+14	2.01e+13	0.00e+00	0.00e+00	1.06e+12	2.11e+13	88
Direct Drainage	OG-118	Turkey Creek	3.19e+13	3.41e+12	0.00e+00	0.00e+00	1.79e+11	3.59e+12	89
Direct Drainage	OG-119	Skin Fork	1.93e+13	3.92e+12	0.00e+00	0.00e+00	2.07e+11	4.13e+12	80
Direct Drainage	OG-123	Rockcastle Creek	5.48e+13	2.14e+13	0.00e+00	0.00e+00	1.13e+12	2.26e+13	61
Direct Drainage	OG-124	Pinnacle Creek	2.39e+14	3.31e+13	0.00e+00	0.00e+00	1.74e+12	3.48e+13	86
Direct Drainage	OG-127	Cabin Creek	5.60e+13	1.39e+13	0.00e+00	0.00e+00	7.33e+11	1.47e+13	75
Direct Drainage	OG-128	Joe Branch	6.73e+12	1.37e+12	0.00e+00	0.00e+00	7.20e+10	1.44e+12	80
Direct Drainage	OG-129	Long Branch	4.48e+12	7.12e+11	0.00e+00	0.00e+00	3.74e+10	7.49e+11	84
Direct Drainage	OG-130	Still Run	3.11e+13	4.99e+12	0.00e+00	0.00e+00	2.63e+11	5.25e+12	84
Direct Drainage	OG-131	Barkers Creek	1.72e+14	3.56e+13	0.00e+00	0.00e+00	1.87e+12	3.75e+13	79
Direct Drainage	OG-134	Slab Fork	2.06e+14	3.22e+13	0.00e+00	0.00e+00	1.70e+12	3.39e+13	84
Direct Drainage	OG-135	Allen Creek	4.50e+13	5.00e+12	0.00e+00	0.00e+00	2.63e+11	5.26e+12	89
Direct Drainage	OG-136	Big Branch	1.43e+13	3.07e+12	0.00e+00	0.00e+00	1.61e+11	3.23e+12	79
Direct Drainage	OG-137	Devils Fork	1.44e+14	1.93e+13	0.00e+00	0.00e+00	1.02e+12	2.03e+13	87
Direct Drainage	OG-138	Winding Gulf	6.14e+14	5.24e+13	0.00e+00	0.00e+00	2.76e+12	5.51e+13	91
Direct Drainage	OG-2	Mud River	2.64e+15	2.79e+14	1.14e+11	1.14e+11	1.47e+13	2.93e+14	89
Direct Drainage	OG-20	Twomile Creek	1.16e+13	7.67e+12	1.07e+09	1.07e+09	4.04e+11	8.07e+12	34
Direct Drainage	OG-22	Falls Creek	2.78e+13	6.86e+12	0.00e+00	0.00e+00	3.61e+11	7.22e+12	75
Direct Drainage	OG-23	Onemile Creek	2.17e+13	4.90e+12	0.00e+00	0.00e+00	2.58e+11	5.16e+12	77
Direct Drainage	OG-24	Twomile Creek	1.53e+13	3.76e+12	0.00e+00	0.00e+00	1.98e+11	3.95e+12	75
Direct Drainage	OG-27	Fourmile Creek	1.47e+14	2.20e+13	0.00e+00	0.00e+00	1.16e+12	2.32e+13	85
Direct Drainage	OG-29	Sixmile Creek	1.58e+13	2.33e+12	0.00e+00	0.00e+00	1.23e+11	2.46e+12	85
Direct Drainage	OG-3	Davis Creek	8.99e+13	1.60e+13	6.43e+09	6.43e+09	8.42e+11	1.68e+13	82
Direct Drainage	OG-31	Ninemile Creek	3.20e+13	5.19e+12	0.00e+00	0.00e+00	2.73e+11	5.47e+12	84
Direct Drainage	OG-32	Tenmile Creek	7.33e+13	8.66e+12	1.07e+09	1.07e+09	4.56e+11	9.12e+12	88

Drainage	DNR Code	DNR Name	Baseline LA	LA	Baseline WLA	WLA	MOS	TMDL	% Red.
Direct Drainage	OG-33	Furnett Creek	7.25e+12	6.49e+11	0.00e+00	0.00e+00	3.42e+10	6.83e+11	91
Direct Drainage	OG-34	Fourteenmile Creek	9.07e+13	1.05e+13	2.14e+09	2.14e+09	5.50e+11	1.10e+13	88
Direct Drainage	OG-35	Aarons Creek	7.15e+12	9.98e+11	0.00e+00	0.00e+00	5.25e+10	1.05e+12	86
Direct Drainage	OG-38	Big Ugly Creek	1.39e+14	1.22e+13	0.00e+00	0.00e+00	6.41e+11	1.28e+13	91
Direct Drainage	OG-4	Booten Creek	1.95e+13	3.04e+12	0.00e+00	0.00e+00	1.60e+11	3.20e+12	84
Direct Drainage	OG-40	Sand Creek	2.27e+13	1.01e+12	0.00e+00	0.00e+00	5.33e+10	1.07e+12	96
Direct Drainage	OG-42	Little Harts Creek	4.06e+13	2.97e+12	0.00e+00	0.00e+00	1.56e+11	3.13e+12	93
Direct Drainage	OG-44	Big Harts Creek	3.35e+14	2.01e+13	1.97e+09	1.97e+09	1.06e+12	2.12e+13	94
Direct Drainage	OG-45	Green Shoals Branch	1.39e+13	9.73e+11	0.00e+00	0.00e+00	5.12e+10	1.02e+12	93
Direct Drainage	OG-48	Limestone Branch	9.65e+12	6.54e+11	2.14e+09	2.14e+09	3.45e+10	6.91e+11	93
Direct Drainage	OG-49	Big Creek	1.98e+14	1.05e+13	0.00e+00	0.00e+00	5.51e+11	1.10e+13	95
Direct Drainage	OG-51	Crawley Creek	1.19e+14	5.85e+12	1.07e+09	1.07e+09	3.08e+11	6.16e+12	95
Direct Drainage	OG-53	Godby Branch	9.66e+12	5.77e+11	0.00e+00	0.00e+00	3.04e+10	6.08e+11	94
Direct Drainage	OG-59	Mill Creek	4.29e+13	1.97e+12	0.00e+00	0.00e+00	1.04e+11	2.07e+12	95
Direct Drainage	OG-6	Mill Creek	3.89e+13	8.41e+12	1.97e+09	1.97e+09	4.43e+11	8.85e+12	78
Direct Drainage	OG-61	Buffalo Creek	3.51e+13	1.26e+12	0.00e+00	0.00e+00	6.65e+10	1.33e+12	96
Direct Drainage	OG-65	Island Creek	2.38e+15	5.06e+13	2.90e+10	2.90e+10	2.66e+12	5.32e+13	98
Direct Drainage	OG-68	Dingess Run	1.25e+14	7.06e+12	0.00e+00	0.00e+00	3.72e+11	7.43e+12	94
Direct Drainage	OG-70	Rum Creek	6.90e+13	6.89e+12	0.00e+00	0.00e+00	3.63e+11	7.25e+12	90
Direct Drainage	OG-73	Rich Creek	6.57e+13	2.77e+12	0.00e+00	0.00e+00	1.46e+11	2.92e+12	96
Direct Drainage	OG-75	Buffalo Creek	1.65e+14	2.82e+13	0.00e+00	0.00e+00	1.49e+12	2.97e+13	83
Direct Drainage	OG-76	Huff Creek	2.98e+14	2.11e+13	0.00e+00	0.00e+00	1.11e+12	2.22e+13	93
Direct Drainage	OG-77	Rockhouse Creek	4.59e+13	1.90e+12	0.00e+00	0.00e+00	9.98e+10	2.00e+12	96
Direct Drainage	OG-78	Sandlick Creek	2.22e+13	1.03e+12	0.00e+00	0.00e+00	5.40e+10	1.08e+12	95
Direct Drainage	OG-8	Lower Tom Creek	4.62e+13	9.34e+12	0.00e+00	0.00e+00	4.92e+11	9.83e+12	80
Direct Drainage	OG-80	Elk Creek	8.78e+13	3.85e+12	0.00e+00	0.00e+00	2.03e+11	4.05e+12	96
Direct Drainage	OG-82	Spice Creek	1.80e+13	4.87e+11	0.00e+00	0.00e+00	2.57e+10	5.13e+11	97
Direct Drainage	OG-89	Gilbert Creek	2.60e+14	1.29e+13	0.00e+00	0.00e+00	6.81e+11	1.36e+13	95
Direct Drainage	OG-9	Heath Creek	5.77e+13	9.82e+12	8.94e+08	8.94e+08	5.17e+11	1.03e+13	83
Direct Drainage	OG-92	Little Huff Creek	2.36e+14	1.92e+13	0.00e+00	0.00e+00	1.01e+12	2.02e+13	92
Direct Drainage	OG-96	Big Cub Creek	1.42e+14	7.06e+12	0.00e+00	0.00e+00	3.72e+11	7.43e+12	95
Direct Drainage	OG-97	Long Branch	1.46e+13	6.20e+11	0.00e+00	0.00e+00	3.26e+10	6.53e+11	96
Direct Drainage	OG-98	Big Branch	2.15e+13	1.02e+12	0.00e+00	0.00e+00	5.37e+10	1.07e+12	95
Direct Drainage	OG-99	Reedy Branch	1.78e+13	6.38e+11	0.00e+00	0.00e+00	3.36e+10	6.72e+11	96

Table 5. Selenium Baseline and Allocated Loads by Major Tributary

DNR Code	Stream Name	TMDL (ug/L)	MOS	WLA (ug/L)	LA(ug/L)
WVOG-2	Mud River upstream of Upton Fork	5.0	Implicit	5.0	NA
WVOGM-47	Sugar Tree Branch	5.0	Implicit	5.0	NA
WVOGM-48	Stanley Fork	5.0	Implicit	5.0	NA



Data Source: EPA BASINS, WVDEP
Map Projection: Universal Transverse Mercator
1927 Zone 17

Figure 1. Guyandotte River watershed and its 14 regions

Figures

Tables

1. Problem Understanding

The Clean Water Act at Section 303(d) and its implementing regulations (*Water Quality and Planning and Management Regulations)* at 40 CFR 130 require that a Total Maximum Daily Load (TMDL) be developed for those waterbodies identified by the state as to which technology-based and other required controls are not sufficient to achieve applicable water quality standards. Under the consent decree entered in *Ohio Valley Environmental Coalition, Inc., et al. v. Browner, et al.*, No. 2:95-0329 (S.D.W.Va. July 9, 1997), a TMDL for the Lower Guyandotte River was scheduled for completion by September 30, 2002, and TMDLs for acid mine drainage (AMD) impaired waters (including many tributaries to the Upper and Lower Guyandotte River) were scheduled for completion by March 30, 2008. EPA and the plaintiffs agreed to a modification of the consent decree for the Lower Guyandotte River. That modification effectively extended the date for TMDL development for the Lower Guyandotte watershed by 18 months to March 30, 2004. The modification provided EPA sufficient time to simultaneously develop TMDLs for both the Lower Guyandotte River and the Upper Guyandotte River and tributaries in both watersheds impaired by AMD and/or fecal coliform bacteria. This is consistent with EPA’s view that, where possible, it is preferable to develop TMDLs on a watershed basis. The extended time frame, however, did not allow sufficient time for the data collection and analysis necessary to develop TMDLs for waters listed as biologically impaired, but as to which no impairing pollutant has been identified. It is EPA’s expectation that WVDEP will establish TMDLs for those waters in accordance with the Watershed Management Framework.

For this TMDL report, the Lower Guyandotte and the Upper Guyandotte watersheds were combined into a single watershed called the Guyandotte River watershed. The objective of this study was to develop TMDLs for waterbodies impaired by AMD and fecal coliform bacteria in the Guyandotte River watershed, West Virginia. As a result, TMDLs are being developed for the mainstem Upper and Lower Guyandotte River and waters in the Guyandotte watershed that have been listed on West Virginia’s 1996, 1998 and 2002 Section 303(d) lists as impaired by AMD and/or fecal coliform bacteria.

1.1 Watershed Description

The Guyandotte River is in southwestern West Virginia. Its drainage area is approximately 1,680 square miles (1,075,691 acres) and is represented by the Guyandotte River watershed (Figure 1-1). The Guyandotte River watershed lies entirely in the Appalachian Plateau Physiographic Providence. From its headwaters in Raleigh County, the Guyandotte River flows westerly through Wyoming County; then northwesterly through Logan, Lincoln, and Cabell counties, with tributaries entering from Mingo, Putnam, and Boone counties; to its confluence with the Ohio River northwest of Pea Ridge for a total of approximately 102 miles (Figure 1-2). The largest tributaries of the Guyandotte are Mud River, Clear Fork, and Island Creek, which have drainage areas of 359, 129, and 105 square miles, respectively. Big Ugly Creek, Big Creek, Indian Creek, Pinnacle Creek, Barkers Creek, Slab Fork, Winding Gulf, and Stonecoal Creek are also significant tributaries to the Guyandotte River. The Guyandotte River watershed comprises extremely narrow valley floors that rise quickly to form steep and rugged mountain walls. The elevations of the ridges range from 3,400 feet in the upper portion of the watershed to a maximum of 1,000 feet in the lower portion of the watershed. As the watershed approaches the Ohio River, it becomes less rugged; the valleys are wider, and the mountains tend to be more rolling. (WVDNR, 1987)

The Guyandotte River watershed lies in Raleigh, Wyoming, Logan, Mingo, Boone, Lincoln, Putnam, and Cabell counties and adjacent to Mercer, McDowell, Wayne, Kanawha, and Lawrence (Ohio) counties, as shown in Figure 1-2. Most of the population resides in the northwest corner of the watershed, in western Cabell County near the cities of Pea Ridge and Barboursville. Two areas of higher population density lie in Logan County to the east and north of the city of Mount Gay. The rest of the watershed is sparsely populated. Population estimates (based on 2000 census data) for Pea Ridge, Barboursville, Culloden, and Mount Gay and the counties in and near the watershed are given in Table 1-1. Note that only portions of some of these counties lie within the Guyandotte River watershed. Since 1990 the entire region has experienced a very slight decline in population (Table 1-1).

1.2 Economy

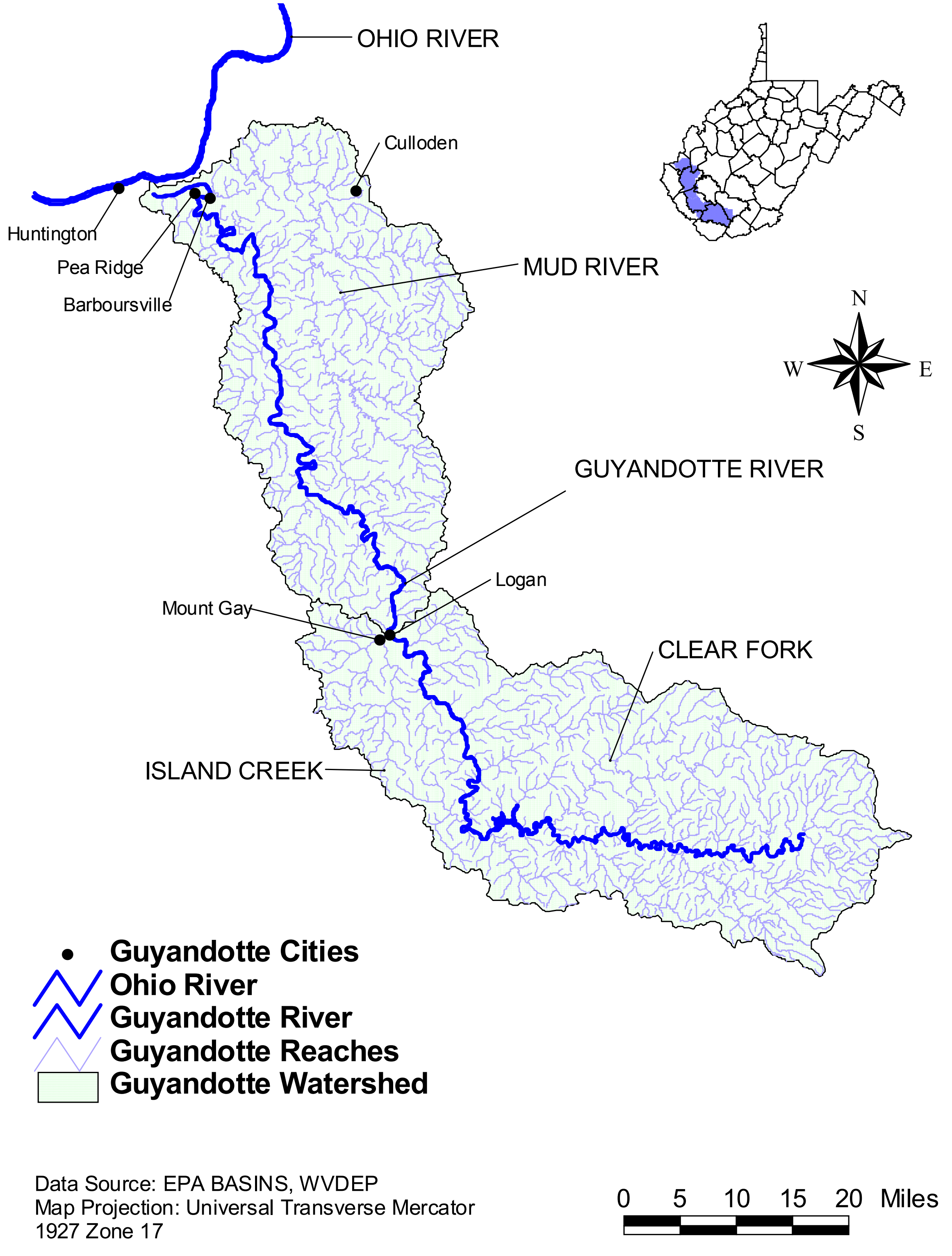
1.2.1 Mining

Historically, coal has been the most economically valuable mineral resource in the Guyandotte River watershed. There are extensive deposits of low-sulfur coal in all three formations of the Pottsville group. These formations (Kanawha, New River, and Pocahontas) include large mineable beds in Logan, Mingo, Wyoming, and Raleigh counties. Smaller coal seams are present in the lower basin in Cabell and Lincoln counties. There has been continuous mining in the basin since the completion of the Norfolk and Western Railroad in the late 1800s. In the 1970s, approximately 90 percent of the coal was produced from underground mines and the remaining 10 percent came from surface mining. Surface mining activities have significantly increased since then (WVGES, 1998). The increase in surface mining is due to the increased demand for production of low-sulfur coal. Table 1-2 presents the total amount of coal produced in 2002.

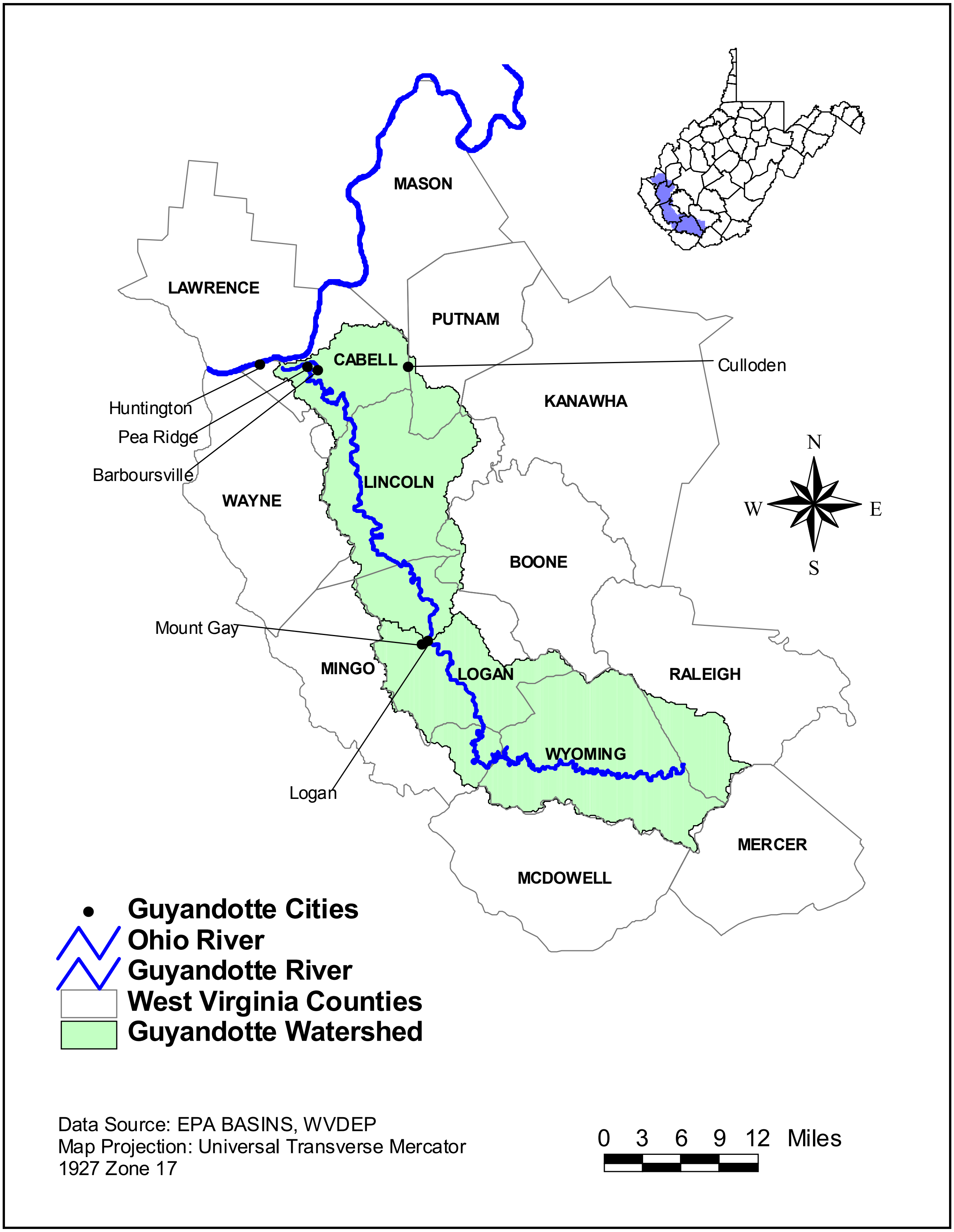
1.2.2 Forestry

Forestry is another major industry in the Guyandotte River watershed. According to the U.S. Forest Service Forest Inventory and Analysis Database Retrieval System, there are more than 2,900 square miles (approximately 1.9 million acres) of forestland in the eight counties in and around the Guyandotte River watershed. Table 1-3 shows the estimated area of forested land (in square miles) for each of the counties in or adjacent to the Guyandotte River watershed.

Figure 1-1. Location of the Guyandotte River watershed.



Data Source: EPA BASINS, WVDEP
Map Projection: Universal Transverse Mercator
1927 Zone 17



Data Source: EPA BASINS, WVDEP
Map Projection: Universal Transverse Mercator
1927 Zone 17

Figure 1-2. Counties in and around the Guyandotte River watershed.

Table 1-1. Population estimates for the Guyandotte River watershed

Location	1990 Population Estimate	2000 Population Estimate	1990-2000 Numeric Population Change	1990-2000 Percent Population Change
State of West Virginia	1,793,477	1,808,344	14867	0.8
Boone County	25,870	25,535	-355	-1.4
Cabell County	96,827	96,784	-43	0.0
Lincoln County	21,382	22,108	726	3.4
Mingo County	33,739	28,253	-5486	-16.3
Putnam County	42,835	51,589	8754	20.4
Raleigh County	76,819	79,220	2401	3.1
Wyoming County	28,990	25,708	-3282	-11.3
Total of all Counties	**326,462**	**329,197**	**2715**	**-2.14**
City of Pea Ridge	6,535	6,363	-172	-2.6
City of Barboursville	2,774	3,183	409	14.7
City of Culloden	2,907	2,940	33	1.1
City of Mount Gay	3,377	2,623	-754	-22.3

Source: U.S. Census Bureau, Washington D.C., Population Division, Population Estimates Program.

Table 1-2. Total coal production in West Virginia for 2002

Location	Total Employees	Underground Production (tons)	Surface Production (tons)	Total Production (tons)
State of West Virginia	15,377	100,600,258	63,296,632	163,896,890
Boone County	3,044	15,980,343	15,837,475	31,817,818
Cabell County[a]	N/A	N/A	N/A	N/A
Lincoln County	76	192,036	1,088,388	1,280,424
Logan County	1,296	4,496,716	7,179,543	11,676,259
Mingo County	1,545	10,258,614	9,736,582	19,995,196
Putnam County[a]	N/A	N/A	N/A	N/A
Raleigh County	845	7,962,508	905,883	8,868,391
Wyoming County	1,100	5,226,310	2,970,089	8,196,399
Total of Counties	1,945	13,188,818	3,875,972	17,064,790

[a] No data available for 2002.

Source: West Virginia Geologic and Economic Survey, 2002.

Table 1-3. Forested area in and near the Guyandotte River watershed

County	All Land (mi^2)	Total Forest (mi^2)	Timberland (mi^2)	Nonforest Land (mi^2)
Boone	503	423	423	80
Cabel	282	194	194	87
Lincoln	438	370	370	68
Logan	454	387	387	67
Mingo	423	360	360	63
Putnam	346	263	263	83
Raleigh	607	499	462	108
Wyoming	501	434	434	67
Total	**3,553**	**2,930**	**2,894**	**623**

Source: U.S. Forest Service, 2000.

1.3 Section 303(d) Listed Waterbodies

West Virginia's 1996, 1998, and 2002 Section 303(d) lists include 123 waterbodies in the Guyandotte River watershed (Upper and Lower Guyandotte River watersheds combined) because of fecal coliform bacteria, metals (total aluminum, iron, manganese, and selenium), pH, and/or biological impairments. The impaired waterbodies include the Upper and Lower Guyandotte River which comprise the main stem of the Guyandotte River and 121 additional stream segments in the watershed. Table 1-4 shows the 66 stream segments listed for fecal coliform bacteria, metals, and/or pH. Table 1-5 lists those streams from Table 1-4 that also have biological impairments. The pH and metals impairments, which include iron, aluminum, and manganese, have been attributed to AMD. The cause of the fecal coliform bacteria, selenium, and biological impairments was unknown at the time of listing. The objective of this study is to develop TMDLs for the 66 waters in the Guyandotte River watershed that are impaired relative to total iron, manganese, selenium, dissolved aluminum, pH, and fecal coliform bacteria.

It is assumed that the implementation of these metals TMDLs likely will resolve the biological impairment. The iron, pH and dissolved aluminum TMDLs address aquatic life protection criteria and call for significant reductions of existing loads. It is reasonable to assume that the achievement of these reductions will have a positive biological impact to the Guyandotte River and its tributaries. Additionally, the fecal coliform TMDL calls for elimination of untreated sewage discharges in the watershed. Removal of the myriad of pollutants potentially present in untreated sewage will also benefit the aquatic ecosystem. Future monitoring plans to evaluate overall TMDL implementation effectiveness in the Guyandotte River watershed should include provisions for biological assessments to confirm the assumptions made herein.

Many of the waters that are the subject of the pollutant-specific TMDLs have overlapping biological impairment. After developing the pollutant-specific TMDLs, stream by stream evaluations were made to ascertain if accomplishment of the required pollutant reductions would return the water to an unimpaired biological condition. Consideration was given to the magnitude of specified pollutant reductions and the present biological condition of the stream relative to the WVSCI impairment threshold of 60.6

It is reasonable to assume that the biological condition of waters with low pH and/or metals concentrations in excess of aquatic life protection criteria will improve upon the removal of metals and return pH to a circumneutral condition. The fecal coliform bacteria TMDL calls for elimination of untreated sewage discharges and the myriad of pollutants associated with sewage.

The consent decree does not require EPA to establish TMDLs for the 57 stream segments listed for biological impairment only without an identified impairing pollutant that were listed based on failure to support the aquatic life use (“biological), and for which the 2002 Section 303(d) list states the pollutant as “unknown.” EPA had originally intended to establish TMDLs for all waters in the Guyandotte watershed simultaneously. However, the time constraints imposed by the consent decree deadline precluded EPA from performing the monitoring and analysis necessary to identify the impairing pollutant(s) for these waters. Therefore, this report does not establish TMDLs for those 57 waters. It is EPA’s expectation that West Virginia will establish TMDLs for those waters within 8-13 years of their initial listing.

This report presents pH, fecal coliform bacteria, and metals TMDLs for 66 impaired waterbodies in the Guyandotte River watershed. To develop the TMDLs and other watershed and waterbody information, the watershed was divided into 14 regions (Figure 1-3), representing hydrologic units. The 14 watershed regions provide a basis for georeferencing pertinent source information and monitoring data, and for presenting TMDLs. To facilitate hydrologic modeling, the 14 regions were further divided into a total of 369 subwatersheds for the entire Guyandotte River watershed. This information is presented in Appendixes A-1 through A-14 of this report. The numeric designation for each Appendix A section corresponds to the same numerically identified region of the Guyandotte watershed, e.g., A-3 corresponds to Region 3 of the Guyandotte watershed.

Table 1-4. West Virginia 303(d) metals, pH, and fecal coliform listed waterbodies in the Guyandotte River watershed

DNR Name	DNR Code	Miles Affected	Human Health	Aquatic Life	Pollutant	Source	Year Listed[A]
Guyandotte River	O-4-upper and lower	168.00	X	X	Fecal coliform, Iron, Aluminum	Unknown	1998 & 2002
Right Fork/Merritt Creek	OG-10-A	1.50	X	X	Iron	Unknown	2002
Little Cub Creek/Upper Guyandotte River	OG-108	3.60	X	X	Iron	Unknown	2002
Indian Creek	OG-110	18.90	X	X	Metals	Mine drainage	1998 & 2002
Brier Creek/Indian Creek	OG-110-A	4.80	X	X	Metals	Mine drainage	1998 & 2002
Marsh Fork/Brier Creek	OG-110-A-2	2.00	X	X	Metals	Mine drainage	1998 & 2002
Pinnacle Creek	OG-124	26.60	X	X	Metals	Mine drainage	1998 & 2002
Smith Branch/Pinnacle Creek	OG-124-D	2.10	X	X	Metals	Mine drainage	1998 & 2002
Laurel Branch/Pinnacle Creek	OG-124-H	2.10	X	X	Metals	Mine drainage	1998 & 2002
Spider Creek	OG-124-I	3.50	X	X	Metals	Mine drainage	1998 & 2002
Cabin Creek	OG-127	3.60	X	X	Metals	Mine drainage	1998 & 2002
Joe Branch	OG-128	1.60	X	X	Metals	Mine drainage	1998 & 2002
Long Branch	OG-129	2.10	X	X	Metals	Mine drainage	1998 & 2002
Still Run	OG-130	5.30	X	X	Metals	Mine drainage	1998 & 2002
Barkers Creek	OG-131	8.00	X	X	Metals	Mine drainage	1998 & 2002

DNR Name	DNR Code	Miles Affected	Human Health	Aquatic Life	Pollutant	Source	Year Listed[A]
Hickory Branch/Barkers Creek	OG-131-B	2.10	X	X	Metals	Mine drainage	1998 & 2002
Gooney Otter Creek	OG-131-F	6.80	X	X	Metals	Mine drainage	1998 & 2002
Jims Branch/Gooney Otter Creek	OG-131-F-1	1.40	X	X	Metals	Mine drainage	1998 & 2002
Noseman Branch	OG-131-F-2	2.30	X	X	Metals	Mine drainage	1998 & 2002
Slab Fork	OG-134	15.10	X	X	Metals	Mine drainage	1998 & 2002
Measle Fork	OG-134-D	3.30	X	X	pH, metals	Mine drainage	1998 & 2002
Left Fort/Allen Creek	OG-135-A	2.60	X	X	Metals	Mine drainage	1998 & 2002
Devils Fork	OG-137	4.90	X	X	Metals	Mine drainage	1998 & 2002
Winding Gulf	OG-138	15.50	X	X	Metals	Mine drainage	1998 & 2002
Stonecoal Creek	OG-139	10.20	X	X	Metals	Mine drainage	1998 & 2002
Mud River	OGM	79.00	X	X	Selenium	Unknown	2002
Limestone Branch	OG-48	1.80	X	X	pH, metals	Mine drainage	1998 & 2002
Ed Stone Branch/Big Creek	OG-49-A	2.30	X	X	pH, metals	Mine drainage	1998 & 2002
North Branch/ Ed Stone Branch	OG-49-A-1	0.80	X	X	pH, metals	Mine drainage	1998 & 2002
Godby Branch	OG-53	1.50	X	X	pH, metals	Mine drainage	1998 & 2002
Buffalo Creek	OG-61	3.10	X	X	pH, metals	Mine drainage	1998 & 2002
Right Fork/Buffalo Creek	OG-61-A	1.50	X	X	pH	Unknown	2002
Coal Branch/Island Creek	OG-65-A	2.10	X	X	pH, metals	Mine drainage	1998 & 2002
Copperas Mine Fork	OG-65-B	9.30	X	X	pH, metals	Mine drainage	1998 & 2002
Mud Fork	OG-65-B-1	7.50	X	X	pH, metals	Mine drainage	1998 & 2002
Lower Dempsey Branch	OG-65-B-1-A	2.10	X	X	pH, metals	Mine drainage	1998 & 2002
Ellis Branch/Mud Fork	OG-65-B-1-B	1.60	X	X	pH, metals	Mine drainage	1998 & 2002
Upper Dempsey Branch	OG-65-B-1-E	1.30	X	X	pH, metals	Mine drainage	1998 & 2002
Trace Fork/Copperas Mine Fork	OG-65-B-4	3.80	X	X	pH, metals	Mine drainage	1998 & 2002
Hall Fork/Left Fork/Cow Creek	OG-65-J-3-A	1.00	X	X	Selenium	Unknown	2002
Proctor Hollow/Buffalo Creek	OG-75-C.5	1.60	X	X	pH, metals	Mine drainage	1998 & 2002
Huff Creek	OG-76	21.20	X	X	Metals	Mine drainage	1998 & 2002
Toney Fork/Huff Creek	OG-76-L	4.20	X	X	Metals	Mine drainage	1998 & 2002
Oldhouse Branch/Rockhouse Creek	OG-77-A.5	1.10	X	X	pH, metals	Mine drainage	1998 & 2002
Muzzle Creek	OG-92-I	3.30	X	X	Metals	Mine drainage	1998 & 2002
Buffalo Creek/Little Huff Creek	OG-92-K	3.10	X	X	pH, metals	Mine drainage	1998 & 2002
Kezee Fork	OG-92-K-1	0.80	X	X	Metals	Mine drainage	1998 & 2002
Mudlick Fork/Buffalo Creek	OG-92-K-2	0.70	X	X	Metals	Mine drainage	1998 & 2002
Pad Fork	OG-92-Q	4.10	X	X	Metals	Mine drainage	1998 & 2002
Righthand Fork/Pad Fork	OG-92-Q-1	2.10	X	X	Metals	Mine drainage	1998 & 2002
Sturgeon Branch	OG-96-A	1.60	X	X	Metals	Mine drainage	1998 & 2002
Road Branch	OG-96-B	1.60	X	X	Metals	Mine drainage	1998 & 2002

DNR Name	DNR Code	Miles Affected	Human Health	Aquatic Life	Pollutant	Source	Year Listed[A]
Elk Trace Branch/Big Cub Creek	OG-96-C	2.00	X	X	Metals	Mine drainage	1998 & 2002
Toler Hollow	OG-96-F	1.10	X	X	Metals	Mine drainage	1998 & 2002
McDonald Fork	OG-96-H	1.30	X	X	Metals	Mine drainage	1998 & 2002
Reedy Branch	OG-99	2.80	X	X	Metals	Mine drainage	1998 & 2002
Clear Fork	OGC	29.00	X	X	Iron	Unknown	2002
Lower Road Branch	OGC-12	2.50	X	X	Metals	Mine drainage	1998 & 2002
Laurel Fork	OGC-16	23.50	X	X	Metals	Mine drainage	1998 & 2002
Milam Branch	OGC-16-M	4.90	X	X	Metals	Mine drainage	1998 & 2002
Trough Fork	OGC-16-P	3.60	X	X	Metals	Mine drainage	1998 & 2002
Toney Fork/Clear Fork	OGC-19	6.60	X	X	Metals	Mine drainage	1998 & 2002
Crane Fork	OGC-26	4.30	X	X	Metals	Mine drainage	1998 & 2002
Sugartree Branch	OGM-47	1.60	X	X	Selenium	Unknown	2002
Stanley Fork	OGM-48	2.00	X	X	Selenium	Unknown	2002

Note: Impaired streams in this table reflect information provided in West Virginia's 2002 section 303(d) list.
Metals - denotes Aluminum, Iron, and Manganese
A - As designated in Appendix A of 2003 West Virginia Water Quality Standards
B - Trout Waters as designated in 2003 West Virginia Water Quality Standards

Table 1-5. West Virginia 303(d) biological listed waterbodies in the Guyandotte River watershed corresponding to waters listed in Table 1-4

DNR Name	DNR Code	Miles Affected	Human Health	Aquatic Life	Pollutant	Source	Year Listed[a]
Guyandotte River	O-4-upper	50.00		X	Biological	Unknown	2002
Clear Fork	OGC	25.00		X	Biological	Unknown	2002
Smith Branch/Pinnacle Creek	OG-124-D	2.10		X	Biological	Unknown	2002
Joe Branch	OG-128	1.60		X	Biological	Unknown	2002
Long Branch	OG-129	2.10		X	Biological	Unknown	2002
Barkers Creek	OG-131	8.00		X	Biological	Unknown	2002
Slab Fork	OG-134	7.80		X	Biological	Unknown	2002
Left Fort/Allen Creek	OG-135-A	2.60		X	Biological	Unknown	2002
Devils Fork	OG-137	4.90		X	Biological	Unknown	2002
Winding Gulf	OG-138	9.10		X	Biological	Unknown	2002
Stonecoal Creek	OG-139	10.20		X	Biological	Unknown	2002
Mud River	OG-2	79.00		X	Biological	Unknown	2002
Right Fork/Merritt Creek	OG-10-A	2.10		X	Biological	Unknown	2002
Ed Stone Branch/Big Creek	OG-49-A	2.30		X	Biological	Unknown	2002
Godby Branch	OG-53	1.50		X	Biological	Unknown	2002
Coal Branch/Island Creek	OG-65-A	2.10		X	Biological	Unknown	2002
Copperas Mine Fork	OG-65-B	9.30		X	Biological	Unknown	2002
Mud Fork	OG-65-B-1	7.50		X	Biological	Unknown	2002
Lower Dempsey Branch	OG-65-B-1-A	2.10		X	Biological	Unknown	2002
Ellis Branch/Mud Fork	OG-65-B-1-B	1.60		X	Biological	Unknown	2002
Upper Dempsey Branch	OG-65-B-1-E	1.30		X	Biological	Unknown	2002

DNR Name	DNR Code	Miles Affected	Human Health	Aquatic Life	Pollutant	Source	Year Listed[a]
Trace Fork/Copperas Mine Fork	OG-65-B-4	3.80		X	Biological	Unknown	2002
Proctor Hollow/Buffalo Creek	OG-75-C.5	1.60		X	Biological	Unknown	2002
Huff Creek	OG-76	13.90		X	Biological	Unknown	2002
Toney Fork/Huff Creek	OG-76-L	4.20		X	Biological	Unknown	2002
Oldhouse Branch/Rockhouse Creek	OG-77-A.5	1.10		X	Biological	Unknown	2002
Muzzle Creek	OG-92-I	3.30		X	Biological	Unknown	2002
Buffalo Creek/Little Huff Creek	OG-92-K	1.80		X	Biological	Unknown	2002
Toler Hollow	OG-96-F	1.10		X	Biological	Unknown	2002
Laurel Fork	OGC-16	10.90		X	Biological	Unknown	2002
Milam Branch	OGC-16-M	4.90		X	Biological	Unknown	2002
Trough Fork	OGC-16-P	3.60		X	Biological	Unknown	2002
Toney Fork/Clear Fork	OGC-19	6.60		X	Biological	Unknown	2002
Crane Fork	OGC-26	4.30		X	Biological	Unknown	2002
Sugartree Branch	OGM-47	1.60		X	Biological	Unknown	2002
Stanley Fork	OGM-48	2.00		X	Biological	Unknown	2002

Note: Impaired streams in this table reflect information provided in West Virginia’s 2002 section 303(d) list.
[a] - As designated in Appendix A of 2003 West Virginia Water Quality Standards

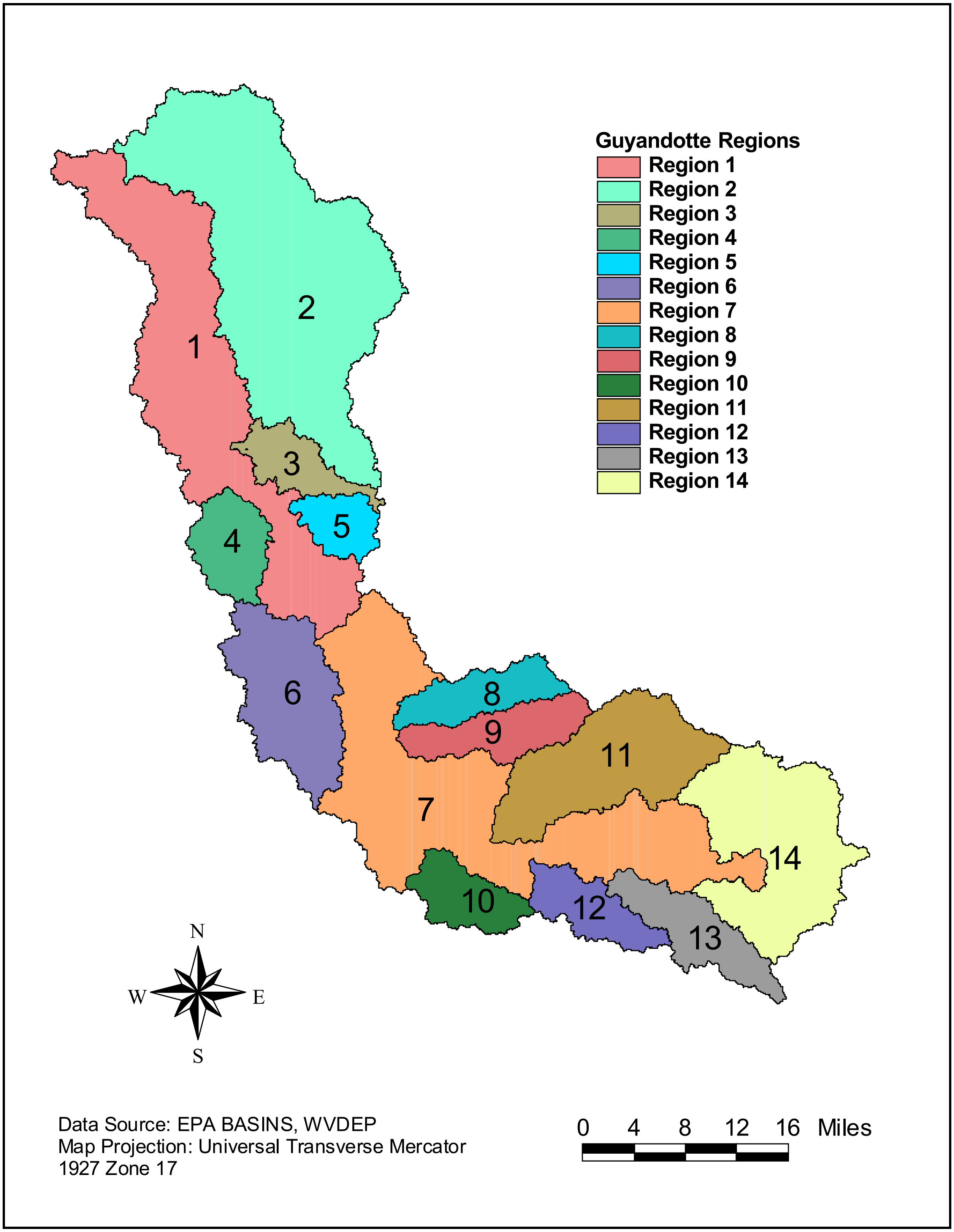


Figure 1-3. Guyandotte River watershed and its 14 regions

1.4 Effects of Aluminum Criteria Change on TMDL Development

On April 17, 2003, EPA approved revisions to certain water quality standards in West Virginia, including an aquatic life protection aluminum criteria change from total recoverable to dissolved. EPA's approval of the change in the aluminum criteria recently was upheld in *West Virginia Rivers Coalition v. Environmental Protection Agency*, Civ. Action No. 03-1022 (E.D. Pa. Jan. 14, 2004). The previous criteria and current criteria are summarized in Table 1-6. This criteria change has made developing aluminum TMDLs problematic because much of the available data in the state is for total aluminum, and there is no accepted translator between total and dissolved aluminum. Available monitoring data shows widely variable ratios between dissolved and total aluminum depending upon sites, soil types and flow conditions.

After careful deliberation, EPA and WVDEP Division of Water and Waste Management (DWWM) determined that the best and most scientifically supported way to evaluate waters under the new aluminum criteria is to obtain additional monitoring data for both total and dissolved aluminum where adequate dissolved aluminum data does not exist. Due to limited funds, all streams in the state will be monitored within the normal Watershed Management Framework monitoring schedule. Additionally, all permittees will be required to monitor both dissolved and total aluminum for three years. This monitoring will determine whether or not the streams are impaired for dissolved aluminum and also provide data necessary to calculate site specific translators, as necessary. Finally, since acid mine drainage is the typical source for aluminum impairments, as well as iron and manganese impairments, TMDL allocations and permit limits set to reduce iron and manganese loads are likely to reduce the aluminum loads as well.

Table 1-6. Water quality criteria for aluminum

Pollutant	Use Designation				
	Aquatic Life				Human Health
	B1, B4		B2		A[c]
	Acute[a]	Chronic[b]	Acute[a]	Chronic[b]	
Previous Water Quality Criteria					
Aluminium, Total (ug/L)	750	-	750	-	-
New Water Quality Criteria					
Aluminium, Dissolved (ug/L)	750	87	750	87	-

Source: WVDEP, 2003; B1=Warm water fishery stream, B2=Trout waters, B4=Wetlands, A=Water supply, public

[a] One hour average concentration not to be exceeded more than once every three years on average

[b] Four-day average concentration not to be exceeded more than once every three years on average

The aluminum criteria change directly impacted TMDL development in the Guyandotte River watershed. Table 1-4 shows waterbodies listed for total aluminum impairment on the 2002 Section 303(d) list. In the Guyandotte River watershed, there was very little dissolved aluminum data available for waters listed for total aluminum. Where adequate dissolved aluminum data does exist, EPA developed TMDLs for dissolved aluminum on waterbodies, including the Guyandotte River mainstem and 10 tributaries listed in Table 1-7. Data supporting the dissolved aluminum TMDLs is located in Table 3 of Appendixes A-1 to A-14. Because of the lack of an accepted translator and variability in the relationship of total aluminum to dissolved aluminum, TMDLs for dissolved aluminum will not be developed for waterbodies previously listed on the 2002 Section 303(d) list for total aluminum where no dissolved aluminum data exists. EPA expects that West Virginia will address these waterbodies by monitoring for dissolved aluminum and total aluminum within the normal Watershed Management Framework Cycle and by requiring permittees to monitor for three years. This monitoring data will determine dissolved aluminum impairment and provide data for future TMDL development or site-specific translator calculations, as necessary. Additionally, Guyandotte River watershed TMDL allocations and permit limits set to reduce iron and manganese loads are likely to reduce most, if not all, of the aluminum load occurring on these streams. Any necessary dissolved aluminum TMDLs will be developed by West Virginia within 8-13 years of the original listing.

Table 1-7. Waterbodies in the Guyandotte River watershed for which dissolved aluminum TMDLs are being developed

Stream Name	Stream Code	Listed on 2002 303(d) List for Total Aluminum	Sufficient Dissolved Aluminum Data Present	Impaired for Dissolved Aluminum and TMDL Developed
Barkers Creek	OG-131	X	X	
Brier Creek/Indian Creek	OG-110-A	X	X	
Buffalo Creek	OG-61	X	X	X
Buffalo Creek/Little Huff Creek	OG-92-K	X	X	
Cabin Creek	OG-127	X	X	
Coal Branch/Island Creek	OG-65-A	X	X	
Copperas Mine Fork	OG-65-B	X	X	X
Crane Fork	OGC-26	X	X	
Devils Fork	OG-137	X	X	
Ed Stone Branch/Big Creek	OG-49-A	X		
Elk Trace Branch/Big Cub Creek	OG-96-C	X	X	
Ellis Branch/Mud Fork	OG-65-B-1-B	X	X	
Godby Branch	OG-53	X		
Gooney Otter Creek	OG-131-F	X	X	
Guyandotte River	O-4	X	X	X
Hickory Branch/Barkers Creek	OG-131-B	X	X	
Huff Creek	OG-76	X	X	
Indian Creek	OG-110	X	X	
Jims Branch/Gooney Otter Creek	OG-131-F-1	X	X	
Joe Branch	OG-128	X	X	
Kezee Fork	OG-92-K-1	X	X	
Laurel Branch/Pinnacle Creek	OG-124-H	X	X	
Laurel Fork	OGC-16	X	X	
Left Fork/Allen Creek	OG-135-A	X	X	
Limestone Branch	OG-48	X		
Long Branch	OG-129	X	X	
Lower Dempsey Branch	OG-65-B-1-A	X	X	
Lower Road Branch	OGC-12	X	X	
Marsh Fork/Brier Creek	OG-110-A-2	X	X	
McDonald Fork	OG-96-H	X	X	
Measle Fork	OG-134-D	X	X	
Milam Branch	OGC-16-M	X	X	
Mud Fork	OG-65-B-1	X	X	
Mudlick Fork/Buffalo Creek	OG-92-K-2	X	X	
Muzzle Creek	OG-92-I	X	X	

Stream Name	Stream Code	Listed on 2002 303(d) List for Total Aluminum	Sufficient Dissolved Aluminum Data Present	Impaired for Dissolved Aluminum and TMDL Developed
Noseman Branch	OG-131-F-2	X	X	
North Branch/ Ed Stone Branch	OG-49-A-1	X		
Oldhouse Branch/Rockhouse Creek	OG-77-A.5	X	X	
Pad Fork	OG-92-Q	X	X	
Pinnacle Creek	OG-124	X	X	
Proctor Hollow/Buffalo Creek	OG-75-C.5	X	X	
Reedy Branch	OG-99	X		
Righthand Fork/Pad Fork	OG-92-Q-1	X	X	
Road Branch	OG-96-B	X	X	
Slab Fork	OG-134	X	X	X
Smith Branch/Pinnacle Creek	OG-124-D	X		
Spider Creek	OG-124-I	X		
Still Run	OG-130	X	X	
Stonecoal Creek	OG-139	X	X	
Sturgeon Branch	OG-96-A	X	X	
Toler Hollow	OG-96-F	X	X	
Toney Fork/Clear Fork	OGC-19	X		
Toney Fork/Huff Creek	OG-76-L	X	X	
Trace Fork/Copperas Mine Fork	OG-65-B-4	X	X	
Trough Fork	OGC-16-P	X	X	
Upper Dempsey Branch	OG-65-B-1-E	X		
Winding Gulf	OG-138	X	X	X
Big Creek	OG-49			X
Clear Fork	OGC			X
Crawley Creek	OG-51			X
Gilbert Creek	OG-89			X
Big Cub	OG-96			X

2. Water Quality Standards

Water quality standards consist of three components: designated and existing uses, narrative and/or numeric water quality criteria necessary to support those uses, and an anti-degradation statement. Water quality standards serve two purposes. The first is to establish the water quality goals for a specific waterbody, and the second is to establish water quality-based treatment controls and strategies beyond the technology-based levels of treatment required by sections 301(b) and 306 of the Clean Water Act (USEPA, 1991). In Title 46*, Legislative Rule, Environmental Quality Board,* Series 1, *Requirements Governing Water Quality Standards,* West Virginia sets forth designated and existing uses as well as numeric and narrative water quality criteria for waters in the state. Appendix E of the *Requirements Governing Water Quality Standards* displays the numeric water quality criteria for a wide range of parameters, while narrative water quality criteria are largely contained in section 46-1-3 of the same document. Dissolved aluminum, total iron, total manganese, selenium, and pH have numeric criteria under the Aquatic Life and the Human Health use designation categories (Table 2-1). The listed waterbodies in the Guyandotte River watershed have been designated as having an Aquatic Life and/or Human Health use (WVDEP, 2003). Additionally, Pinnacle Creek (OG-124) is the only designated trout water in the Guyandotte River watershed (WVDEP, 2003).

Table 2-1. Applicable West Virginia water quality criteria

POLLUTANT	USE DESIGNATION				
	Aquatic Life				Human Health
	B1, B4		B2		A^{C}, C^{C}
	Acute [a]	Chronic [b]	Acute [a]	Chronic [b]	
Aluminum, dissolved (µg/L)	750	87	750	87	-
Iron, total (mg/L)	-	1.5	-	0.5	1.5
Manganese, total (mg/L)	-	-	-	-	1.0
Selenium (ug/L)	20	5	20	5	10
pH	No values below 6.0 or above 9.0	No values below 6.0 or above 9.0	No values below 6.0 or above 9.0	No values below 6.0 or above 9.0	No values below 6.0 or above 9.0
Fecal coliform bacteria	**Human Health Criteria** Maximum allowable level of fecal coliform content for Primary Contact Recreation (either MPN or MF) shall not exceed 200/100 mL as a monthly geometric mean based on not less than 5 samples per month; nor to exceed 400/100 mL in more than 10 percent of all samples taken during the month.				

Note: B1 = warm water fishery streams, B4 = wetlands, B2 = trout waters, A = public water supply, C = water contact recreation.
[a] One-hour average concentration not to be exceeded more than once every 3 years on the average.
[b] Four-day average concentration not to be exceeded more than once every 3 years on the average.
[c] Not to exceed.
Source: WVWQS, 2003

The narrative water quality criterion of 46 CSR 1 - 3.2.i. prohibits the presence of wastes in state waters that cause or contribute to significant adverse impact to the chemical, physical, hydrologic and biological components of aquatic ecosystems. Streams are listed as biologically impaired based on a survey of their benthic macroinvertebrate community. Benthic macroinvertebrate communities are rated using a multimetric index developed for use in wadeable streams of West Virginia. The West Virginia Stream Condition Index (WVSCI) is composed of six metrics that were selected to maximize discrimination between streams with known impairments and reference streams. In general, streams with WVSCI scores less than 60.6 points are considered to be biologically impaired and are included on the 303(d) list.

There are 496 existing water quality stations in the Guyandotte River watershed. Tables 3a, 3b, 3c, 3d, 3e, and 3f in each of the Appendix A appendixes (A-1 through A-14) summarizes applicable water quality data for monitoring stations throughout the watershed. These results support the impairment listings for iron, aluminum, manganese, fecal coliform bacteria, and pH in specified stream segments located in Table 1 of Appendixes A-1 through A-14.

3. Source Assessment

This section identifies and examines the potential sources of aluminum, iron, manganese, selenium, fecal coliform bacteria, and pH in the Guyandotte River watershed. A wide range of data were used to identify potential sources and to characterize the relationship between point and nonpoint source discharges and in-stream response at monitoring stations.

3.1 Data Inventory and Review

Data collection was a cooperative effort involving various governmental groups and agencies in West Virginia, while U.S. EPA Region 3 provided support and guidance for TMDL analysis and development. The categories of data used in developing these TMDLs include physiographic data, which describe the physical conditions of the watershed; environmental monitoring data, which identify potential pollutant sources and their contribution; and in-stream water quality monitoring data. Additional water quality monitoring data gathered by non-governmental groups were obtained through the West Virginia Department of Environmental Protection (WVDEP). Table 3-1 shows the various data types and data sources used in these TMDLs.

Table 3-1. Inventory of data and information used to develop the Guyandotte River watershed TMDLs

Data Category	Description	Data Source(s)
Watershed physiographic data	Landuse	WV Gap Analysis Project (GAP)
	Abandoned mining coverage	WVDEP, Division of Mining and Reclamation (DMR)
	Active and historical mining information	WVDEP, DMR
	Soil data (STATSGO)	U.S. Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS)
	Stream reach coverage	USGS; WVDEP, Division of Water and Waste Management (DWMM)
	Weather information	National Climatic Data Center
	Oil and gas operations coverage	WVDEP, Office of Oil and Gas (OOG)
	Paved and unpaved roads	WV Department of Transportation (DOT), USDOT
	Timber harvest data	USDA, U.S. Forest Service (USFS)
Environmental monitoring data	National Pollutant Discharge Elimination System (NPDES) data	WVDEP, DMR; WVDEP, DWMM
	Discharge Monitoring Report data	WVDEP, DMR, Mining Companies
	Abandoned mine land data	WVDEP, DMR; WVDEP, DWMM
	303(d) listed waters	WVDEP, DWMM
	Water quality monitoring data for 496 sampling stations	EPA STORET; WVDEP, DWMM

3.2 Stream Flow Data

There are 24 U.S. Geological Survey (USGS) flow gauges in the Guyandotte River watershed. Flow data from these USGS gauges were used to support flow analysis for the watershed. Table 3-2 shows the 24 flow gauging stations with available records of flow data and the corresponding period of record for each. These stations were used to characterize the stream flow in the watershed.

Table 3-2. Flow analysis for the Guyandotte River watershed

Station	Stream Name	Start Date	End Date	Minimum (cfs)	Average (cfs)	Maximum (cfs)
03204220	Mud River at Mud, WV	11/1999	12/1999	2.1	16.1	135.0
03203950	Guyandotte River at Midkiff, Wv (aux gauge) Ninemile Creek near Brownsville	3/1979	5/1979	1,260.0	1,847.4	3,350.0
03203700	Island Creek at Logan, Wv	10/1976	10/1977	0.0	214.7	1,520.0
03204205	Unnamed tributary to Ballard Fork near Mud, WV	11/1999	8/2000	0.7	0.2	1.8
03204215	Ballard Fork near Mud, WV	11/1999	8/2000	0.1	2.0	29.0
03204210	Spring Branch near Mud, WV	11/1999	8/2000	0.0	0.4	14.0
03202310	Bearhole Fork at Pineville, WV	11/1997	12/1979	0.1	11.0	278.0
03202695	Milam Fork at Mcgraws, WV	11/1997	12/1979	0.0	14.5	375.0
03202240	Allen Creek at Allen Junction, WV	11/1997	12/1979	0.4	11.8	318.0
03202255	Still Run at Itmann, WV	11/1997	12/1979	0.1	12.2	376.0
03202260	Black Fork above Black Fork Falls near Mullens, WV	12/1980	1/1983	0.0	3.2	81.0
03202262	Black Fork at mouth near Mullens, WV	12/1980	1/1983	0.1	3.7	84.0
03202245	Marsh Fork at Maben, WV	11/1977	11/1980	0.1	9.4	317.0
03202900	Guyandotte River near Justice, WV	10/1962	8/1968	24.0	736.4	25,700.0
03203000	Guyandotte River at Man, WV	10/1989	8/1998	2.8	467.7	9,050.0
03202490	Indian Creek at Fanrock, WV	6/1974	10/1981	1.2	58.1	2,670.0
03202480	Brier Creek at Fanrock, WV	7/1969	8/1977	0.1	10.2	505.0
03203670	Whitman Creek at Whitman, WV	4/1969	8/1977	0.0	13.3	380.0
03202915	Guyandotte River below R.D. Bailey Dam	11/1978	8/1993	2.9	795.3	9,820.0
03202750	Clear Fork at Clear Fork, WV	6/1978	8/2000	2.2	189.7	6,380.0
03202400	Guyandotte River near Baileysville, WV	7/1968	8/2000	23.0	412.6	17,900.0
03203600	Guyandotte River at Logan, WV	10/1962	8/2000	34.0	1,150.5	40,800.0
03204500	Mud River near Milton, WV	11/1924	10/1980	0.0	290.6	11,700.0
03204000	Guyandotte River at Branchland, WV	10/1915	8/1995	3.8	41,800.0	41,800.0

Source: USGS Water Resources Division (2003).

3.3 Water Quality

Water quality monitoring data for the Guyandotte River watershed were obtained from various sources, including the EPA's STORET database, WVDEP DWWM and Division of Mining and Reclamation (DMR), and sampling efforts conducted in fall 2003. During the 2003 sampling effort, eleven stations were monitored weekly in the lower Guyandotte watershed (See Figure 3-5 for locations). Samples were analyzed for total aluminum, dissolved aluminum, total iron, dissolved iron, pH, selenium, total suspended solids (TSS), sulfate, acidity and alkalinity. Field parameters that were measured included dissolved oxygen (DO), specific conductance and pH. Stream flow was also measured at five stations (Stations 6,7,8,9, and 11). In addition, as part of the NPDES program, mining companies are required to monitor in-stream water quality upstream and downstream of all discharging outlets. WVDEP requested that mining companies submit these monitoring data in electronic format from areas affected by TMDL development throughout the state. Monitoring data were received from the following ten mining operations in the Guyandotte River watershed:

- Bluestone Coal Corporation
- Consolidation Coal Company
- Eastern Associated Coal Corporation
- Island Creek Coal Company
- Laurel Run Mining Company
- Kepler Processing Company, Inc.
- Riverton Corporation
- Pioneer Fuel Corporation
- Peachtree Ridge Mining Company, Inc.
- Ferrell Excavating Company, Inc.

The data were used to characterize the in-stream water quality conditions. As stated in Section 2, there are 496 water quality monitoring stations in the watershed. Although a large number of stations provided extensive spatial coverage, few stations provided good temporal distribution of water quality data. The water quality monitoring data, along with pertinent source information, are summarized for each of the 14 regions in Appendixes A-1 through A-14 of this report.

3.4 Sources with NPDES Permits

A point source, according to 40 CFR 122.3, is any discernible, confined, and discrete conveyance, including but not limited to, any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, landfill leachate collection system, and vessel or other floating craft from which pollutants are or may be discharged. The NPDES Program, established under Clean Water Act sections 318, 402, and 405, requires permits for the discharge of pollutants from point sources. Metals and pH point sources can be classified into two major categories: permitted non-mining point sources and permitted mining point sources. Fecal point sources are classified by several different types of sewage permits.

3.4.1 Permitted Non-mining Sources

Data regarding non-mining point sources were retrieved from EPA’s Permit Compliance System (PCS) and WVDEP. Three non-mining point sources in the Guyandotte River watershed are permitted to discharge metals (iron, aluminum, manganese, and/or selenium). These sources are shown in Table 3-3. All discharges are required to discharge within a pH criterion range of 6 to 9 (inclusive). Based on the types of activities and the minimal flow of their discharges, these permitted non-mining sources are believed to be negligible. Under this TMDL, these minor discharges are assumed to operate under their current permit limits. These facilities will be assigned WLAs that allow them to discharge at their current permit limits.

Construction Stormwater permits were not included in the TMDL development process, as limited information was available on these permits in the Guyandotte River watershed. Based on the information that was available, they were considered to be an insignificant source of metals and any effects are accounted for in the in-stream monitoring and margin of safety.

Table 3-3. Non-mining sources in the Guyandotte River watershed

NPDES ID	Facility Name	Facility Type	Status	Issue Date	Expire Date
WV0076899 (now covered under WVG640084)	Town of West Hamlin	Individual Industrial	Active	10/10/2002	8/27/2005
WV0115347 (now covered under WVG 640092)	Mill Creek Wastewater Treatment Plant	Individual Industrial	Active	10/9/2002	8/27/2005
WV0076058	North Springs Branch Landfill	Industrial Solid Waste Landfill	Active	3/10/1998	10/12/2008

Sources: U.S. EPA PCS, WVDEP.

3.4.2 Permitted Mining Sources

Untreated mining-related point source discharges from deep, surface, and other mines typically have low pH values and contain high concentrations of metals (iron, aluminum, and manganese). Mining-related activities are commonly issued NPDES discharge permits that contain effluent limits for total iron, manganese, nonfilterable residue, and pH. Most permits also include effluent monitoring requirements for total aluminum. Since the criteria change from total to dissolved aluminum, all permittees are additionally required to monitor for three years for both total and dissolved aluminum (see Section 1.4). This monitoring will determine whether or not the streams are impaired for dissolved aluminum and also provide data necessary to calculate site-specific translators, as necessary. Division of Mining and Reclamation (DMR) provided a spatial coverage of the mining-related NPDES permit outlets and the related permit limit and discharge data (acquired from West Virginia's ERIS database). The spatial coverage was used to determine the location of the permit outlets, however, additional information was needed to determine the areas of the mining activities. WVDEP DMR also provided a spatial coverage and related SMCRA Article 3 permit information. This information includes both active and inactive mining facilities, which are classified by type of mine and facility status. The mines are classified into eight different categories: coal surface mine, coal underground mine, haul road, coal preparation plant, coal reprocessing, prospective mine, quarry, and other. The haul road and prospective mine categories represent mining access roads and potential coal mining areas, respectively. The permits were also classified into seven categories describing the mining status of each permitted discharge. WVDEP DMR provided a brief description regarding classification and associated potential impact on water quality. Table 3-4 lists the mining types and provides status descriptions.

Table 3-4. Classification of West Virginia mining permit type and status

Type of Mining	Status Code	Description
- Coal surface mine - Coal underground mine - Haul road - Coal preparation plant - Coal reprocessing - Prospective mine - Quarry - Other	Completely Released	Completely reclaimed, revegetated; should not be any associated water quality problems
	Phase II Released	Sediment and ponding are gone, partially revegetated, very little water quality impact
	Phase I Released	Regraded and reseeded: initial phase of the reclamation process; could affect water quality
	Renewed	Active mining facility, assumed to be discharging according to the permit limits
	New	Newly issued permit; could be active or inactive; assumed to be discharging according to permit limits
	Inactive	Currently inactive; could become active anytime; assumed to be discharging according to discharge limits
	Revoked	Bond forfeited; forfeiture might be caused by poor water quality; highest potential for impact on water quality

Source: WVDEP DMR

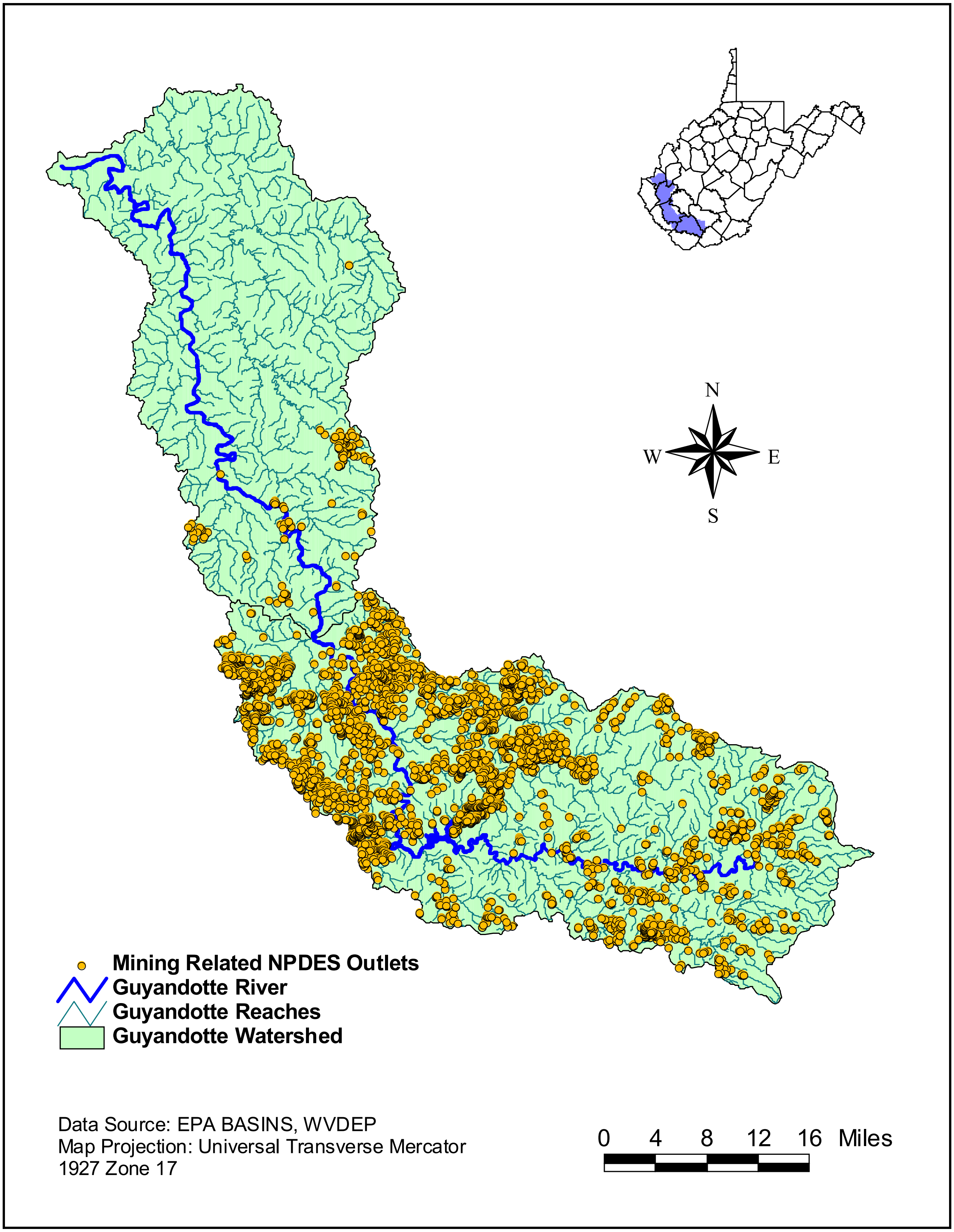
In order to characterize the mining point sources properly, the type, status, and area of each SMCRA Article 3 permit had be reconciled with the locations each of the mining-related NPDES outlets. WVDEP DMR assisted with the process of associating the SMCRA Article 3 permits with NPDES outlets. The mining point sources were then represented in the TMDL development process and were assigned individual wasteload allocations for metals.

Coal mining operations in West Virginia typically have discharge permits for concentrations of total iron, total manganese, total nonfilterable residue, and pH. Permittees are also required to monitor for total aluminum discharges. Mining permits will be subject to dissolved aluminum monitoring requirements upon permit reissuance, as described in Section 1.4.

Sandstone quarries have permit discharge concentrations for total iron, total manganese, total nonfilterable residue, and pH; limestone quarries, however, do not.

There are a total of 301 mining-related NPDES permits in the Guyandotte River watershed. A complete listing of these permits is provided in Appendix B, and Figure 3-1 illustrates the extent of the mining operations in the Guyandotte River watershed.

The Surface Mining Control and Reclamation Act of 1977 (SMCRA, Public Law 95-87) and its subsequent revisions were enacted to establish a nationwide program to protect the beneficial uses of land or water resources, protect public health and safety from the adverse effects of current surface coal mining operations, and promote the reclamation of mined areas left without adequate reclamation prior to August 3, 1977. SMCRA requires a permit for the development of new, previously mined, or abandoned sites for the purpose of surface mining. Permittees are required to post a performance bond that will be sufficient to ensure the completion of reclamation requirements by regulatory authority in the event that the applicant forfeits. Mines that ceased operating by the effective date of SMCRA, (often called “pre-law” mines) are not subject to the requirements of SMCRA.



Data Source: EPA BASINS, WVDEP
Map Projection: Universal Transverse Mercator
1927 Zone 17

Figure 3-1. Mining permits in the Guyandotte River watershed

Title IV of SMCRA is designed to provide assistance for reclamation and restoration of abandoned mines, while Title V states that any surface coal mining operations must be required to meet all applicable performance standards. Some general performance standards include:

- Restoring the land affected to a condition capable of supporting the uses that it was capable of supporting prior to any mining.
- Backfilling and compacting (to ensure stability or to prevent leaching of toxic materials) to restore the approximate original contour of the land with all highwalls.
- Minimizing the disturbances to the hydrologic balance and to the quality and quantity of water in surface and ground water systems both during and after surface coal mining operations and during reclamation by avoiding acid or other toxic mine drainage.

Before August 3, 1977, mining companies were not responsible for reclaiming and restoring mined areas. Drainage from these unreclaimed areas, or abandoned mine lands, was often left untreated.

For purposes of these TMDLs only, WLAs are given to NPDES-permitted discharge points, and LAs are given to discharges from activities that do not have an associated NPDES permit, such as abandoned mine lands, including but not limited to, tunnel discharges, seeps, and surface runoff. The decision to assign load allocations to abandoned and reclaimed mine lands does not reflect any determination by EPA as to whether there are, in fact, unpermitted point source discharges within these landuses. In addition, by establishing these TMDLs with mine drainage discharges treated as load allocations, EPA is not determining that these discharges are exempt from NPDES permitting requirements.

3.4.3 Permitted Fecal Sources

Point sources that experience effluent overflows or that do not comply with permit limits can cause high loadings of fecal coliform bacteria to receiving streams. The most prevalent fecal coliform point sources are the permitted discharges from sewage treatment plants. Fecal coliform bacteria limits of 200 counts/100 ml (monthly average) and 400 counts/100 ml (daily maximum) are imposed in NPDES permits of all types, and are more stringent than applicable water quality criteria. Appendix C lists the 382 point sources in the Guyandotte River watershed that are potential sources of fecal coliform bacteria. More detailed information on these permits is provided in Appendix C.

The following sections discuss specific types of permitted facilities that are considered fecal point sources in the Guyandotte watershed.

Individual NPDES Permits for Sewage Treatment Facilities

There are 22 sewage treatment facilities covered by Individual NPDES permits in the Guyandotte River watershed including 17 publicly owned treatment works (POTW), three NPDES permits designated as “Individual Other,” and two Individual permits with fecal coliform limits (Appendix C). “Individual Other” are those facilities that are not general facilities greater than 50,000 GPD; WV still has some facilities with multiple outlets classified as Individual Other and they will be covered under separate general permit registrations if they are less than 50,000 GPD.

General Sewage Permits

General sewage permits are designed to cover similar discharges from various individual owners and facilities throughout the state under one umbrella permit. General Permit number WVG550000 covers small, privately-owned sewage treatment plants that have a design flow of less than 50,000 gpd. The general permit contains effluent limits and self monitoring requirements for fecal coliform. There are 138 facilities covered under this permit in the watershed, and they are permitted to direct discharge of treated sewage into waters of the State. See Appendix C.

Combined Sewer Overflows (CSOs)

There are also 10 combined sewer overflows (CSOs) that have been identified in the Guyandotte watershed. The CSOs outfalls are part of the sewer system associated with the City of Logan's sewage treatment plant (STP) (WV0033821). All ten outfalls discharge to the Guyandotte River mainstem. These outfalls do not have permit limits for fecal coliform bacteria, however, they are another potential source of fecal coliform bacteria. Based on limited discharge/overflow information, the fecal coliform contributions from periodic discharges of the CSOs outfalls were captured as a part of the urban land use contributions from the City of Logan.

Home Aeration Units

Approximately 222 homes in the Guyandotte River watershed are not connected to a centralized sewage collection and treatment system and do not have septic systems to treat their waste. Instead, these homes use home aeration units (HAUs). HAUs are most often used where there is limited land area for a leach field, a shallow water table, or slowly permeable soils (WVU, 1995 – 1997). HAUs are permitted under General Permit number WV0107000, which has limits for fecal coliform bacteria of 200 counts/100 ml (average monthly) and 400 counts/100 ml (maximum daily).

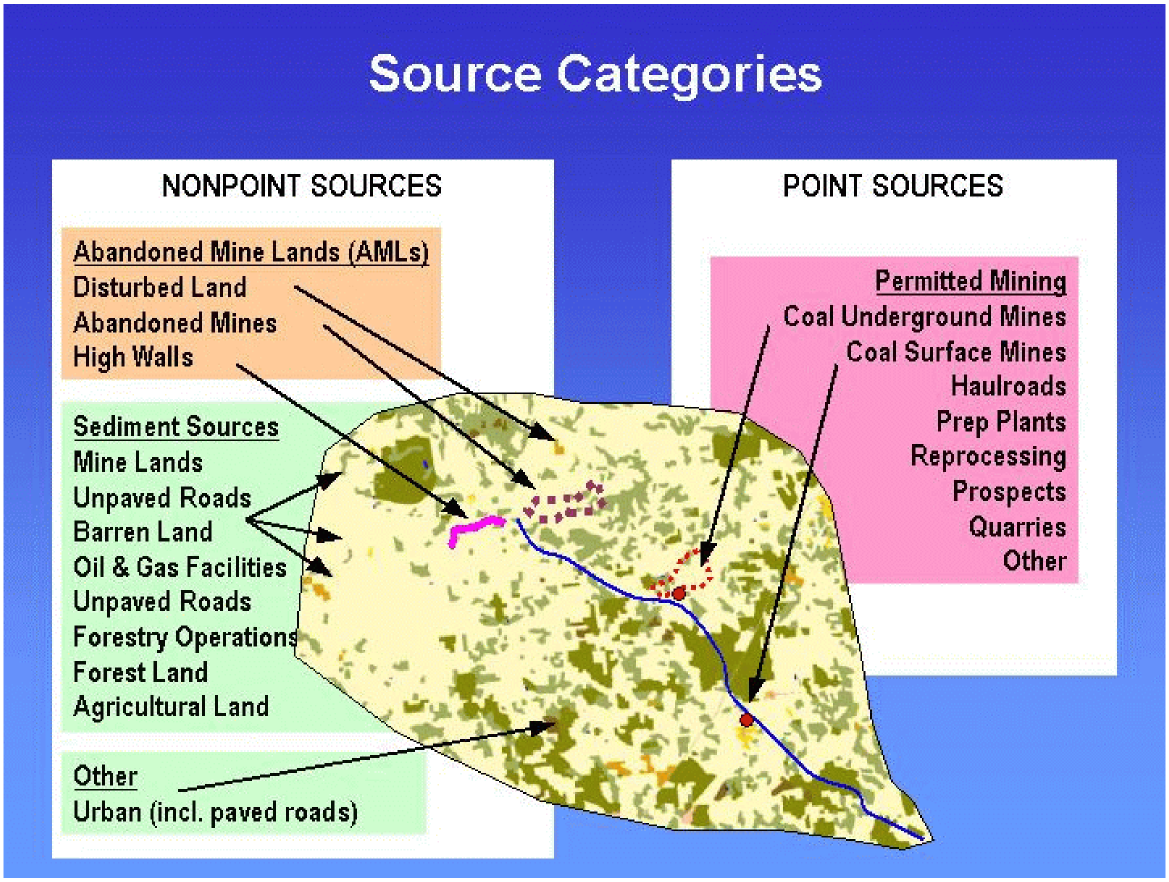
A two-year maintenance contract from the HAU distributor is required immediately after installation, however, the homeowner is subsequently responsible for maintaining the system within permit limits. A survey of HAUs was conducted through a cooperative effort between the Division of Plant and Soil Sciences and the Environmental Services and Training Division of the National Research Center for Coal and Energy, six county health departments, and the West Virginia Bureau of Public Health (WVU, 1995-1997). The purpose of the study was to determine whether HAUs were discharging water that met health and environmental standards. The HAUs included in the study were selected for intensive examination by analyzing water samples for five-day biological oxygen demand (BOD_5), total suspended solids (TSS), and fecal coliform bacteria. In addition, approximately 150 units were tested for levels of residual chlorine and turbidity. The results of the study indicated that many HAUs are not functioning as originally intended. Based on permit criteria for BOD_5, TSS, and fecal coliforms, more than 90 percent of the inspected HAUs failed to meet state effluent criteria for at least one of the pollutants (WVU, 1995-1997). The estimated failure rate for the HAUs in the Fourpole Creek watershed in nearby Cabell County was 50 percent (Stan Mills, county sanitarian, 2002, personal communication). Because HAUs are permitted units, any failure is a permit compliance issue; therefore HAUs were modeled without failure, at their permit limits.

3.5 Sources That Do Not Have NPDES Permits

In addition to permitted point sources, there are unpermitted sources and diffuse sources which also contribute to water quality impairments in the Guyandotte River watershed. Nonpoint metals source contributions and contributions from sources without NPDES permits were grouped for assessment into three separate categories: AML, sediment sources, and other nonpoint sources. Other significant unpermitted sources are facilities that were subject to SMCRA but forfeited their bonds or abandoned operations. Nonpoint and nonpermitted fecal coliform sources include urban runoff, agriculture, wastewater disposal via leaking septic systems and illicit discharges of untreated sewage, and natural sources, such as wildlife.

Based on the identification of a number of abandoned mining activities in the Guyandotte River watershed, abandoned mine lands (AML) represent a significant metals and pH source. Abandoned mines contribute acid mine drainage (AMD), which produces low pH and high metals concentrations in surface and subsurface water. AMD occurs when surface and subsurface water percolates through coal-bearing minerals containing high concentrations of pyrite and marcasite, which are crystalline forms of iron sulfide (FeS_2). The chemical reactions of the pyrite generate acidity in water. A synopsis of these reactions is as follows: Exposure of pyrite to air and water causes the pyrite to oxidize. The sulfur component of pyrite is oxidized, releasing dissolved ferrous (Fe^{2+}) ions and also hydrogen (H^+) ions. It is these H^+ ions that cause the acidity. The intermediate reaction with the dissolved Fe^{2+} ions generates a precipitate, ferric hydroxide [$Fe(OH)_3$], and also releases more H^+ ions, thereby causing more acidity. A third reaction occurs between the pyrite and the generated ferric (Fe^{3+}) ions, in which more acidity (H^+) is released as well as Fe^{2+} ions, which can then enter the reaction cycle (Stumm and Morgan, 1996).

Nonpoint source contributions and contributions from sources without NPDES permits were grouped for assessment into three separate categories: AML, sediment sources, and other nonpoint sources. Figure 3-2 is a schematic of potential sources in the Guyandotte River watershed. The landuse distribution for the Guyandotte River watershed is shown in Figure 3-3.



Source Categories

NONPOINT SOURCES

Abandoned Mine Lands (AMLs)
Disturbed Land
Abandoned Mines
High Walls

Sediment Sources
Mine Lands
Unpaved Roads
Barren Land
Oil & Gas Facilities
Unpaved Roads
Forestry Operations
Forest Land
Agricultural Land

Other
Urban (incl. paved roads)

POINT SOURCES

Permitted Mining
Coal Underground Mines
Coal Surface Mines
Haulroads
Prep Plants
Reprocessing
Prospects
Quarries
Other

Figure 3-2. Potential sources contributing to impairments in the Guyandotte River watershed

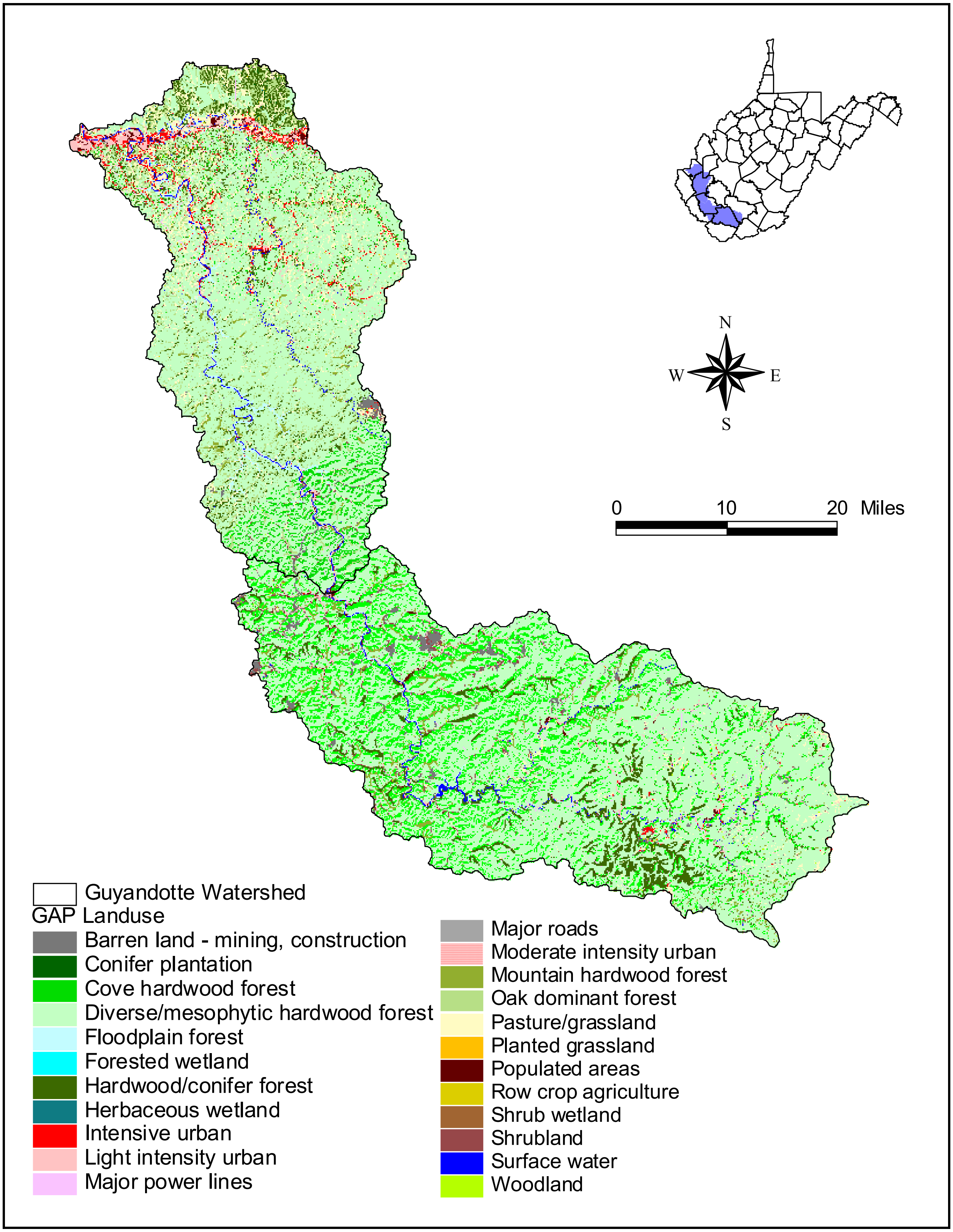


Figure 3-3. Landuse coverage in the Guyandotte River watershed

3.5.1 Abandoned Mine Lands (AML) and Revoked Mines

Generally, the numerous abandoned surface and deep mines are responsible for the AMD flows (WVDEP, 1985). Data regarding AML sites in the Guyandotte River watershed were compiled from spatial coverages provided by WVDEP DMR. The AML sites were classified into three categories:

- *High walls*: generally vertical face of exposed overburden and coal from surface and underground mining activities.
- *Disturbed land*: disturbed land from both surface and underground mining activities.
- *Abandoned mines*: abandoned surface and underground mines.

Additional qualitative data were retrieved from WVDEP DMR Problem Area Data Sheets (PADSs). Information regarding the locations of the largest sources, abandoned mines, is presented in Table 2 in each of Appendixes A-1 through A-14.

Mines with revoked permits no longer have permittees responsible for treating the discharges from the mines. The WVDEP Special Reclamation Program uses forfeited bonds and special coal taxes to achieve the reclamation required by the original permit. In the absence of an NPDES permit, the discharges associated with these landuses were assigned load allocations, as opposed to wasteload allocations. The decision to assign load allocations to abandoned mine lands does not reflect any determination by EPA as to whether there are, in fact, unpermitted point source discharges within these landuses. In addition, by establishing these TMDLs with mine drainage discharges treated as load allocations, EPA is not determining that these discharges are exempt from NPDES permitting requirements.

3.5.2 Sediment Sources

In the Guyandotte River watershed, land-based nonpoint and/or unpermitted sources of sediment include abandoned and active mine areas, forestry operations, oil and gas operations, unpaved roads, agricultural landuses, barren land, and mature forestland. High-sediment-yield areas include disturbed lands such as unpaved roads, forest harvest areas and access roads, oil and gas operations, agricultural land, barren land, and active mine areas, and represent approximately 3 percent of the watershed area. Mature forestland and other undisturbed areas have the lowest sediment yield and therefore the lowest impact on receiving waters. A conceptual representation of sediment loading from nonpoint sources relative to the natural or undisturbed forest condition is presented in Table 3-5. To represent land-based nonpoint sources in the Guyandotte River watershed spatially, the GAP 2000 landuse coverage for each subwatershed was updated to include paved and unpaved road areas, forest harvest areas, oil and gas operations, and mining areas.

Table 3-5. Sediment source characterization

	Sediment Contribution			Time Scale of Impact on Receiving Waterbody	
Sources	**High**	**Medium**	**Low**	**Long**	**Short**
Forest (undisturbed)[a]			X	NA[b]	NA[b]
Forest operations	X				X
Access roads in forest	X			X	
Agriculture		X		X	
Oil and gas drilling		X			X
Oil and gas access road	X			X	
Mining (abandoned)		X		X	
Mining (active)			X	X	
Construction	X				X
Roadway construction	X				X
Paved roads and highways			X	X	
Unpaved roads	X			X	
Point sources (permitted)			X	X	

[a] - Undisturbed forest condition is the reference-level condition.
[b] - NA = Not applicable.

Based on the data analysis and source characterization, AML was identified as a critical and controllable source, especially in the Upper Guyandotte River watershed. Other potential sediment sources were assessed and major contributing landuses either were not present or were not of significant size. High-sediment-yield areas include disturbed lands such as unpaved roads, forest harvest areas and access roads, oil and gas operations, crop land, barren land, and active mine areas. These landuses represent a small portion of the total watershed area. As discussed in Section 3.4.1, Construction Stormwater permits were considered as an insignificant source of metals and/or sediment and any effects were accounted for in the in-stream monitoring and margin of safety.

Additional data analysis was conducted to support source characterization. Appendix D shows the data used to evaluate the relationship between loading sources and in-stream water quality targets for aluminum, iron, and manganese. The analysis was conducted for the Guyandotte River (USGS gauging station 550639) at Huntington, West Virginia, during the period from 1990 to 1995. Other analyses were conducted by comparing aluminum and iron concentrations with total suspended solids (TSS). Data collected at sampling stations along the main stems of the Guyandotte River, Mud River, and Pinnacle Creek from 2000 to 2003 were also used.

The relationships between flow and total aluminum, iron, and manganese concentrations were examined using data collected at Guyandotte River sampling station 550639. The data analyzed at station 550639 consisted of 53 observations for each of the three metals. Figures 1, 2 and 3 in Appendix D demonstrate the relationships between flow and iron, aluminum, and manganese. The data shows that elevated metals concentrations are more likely to occur during flow events at or above the 50th percentile. Figures 4, 5 and 6 in Appendix D indicate a weak relationship between flow and total metal concentrations (iron, 0.2643; aluminum, 0.2791; manganese, 0.1417).

Additional data analysis was conducted on data compiled from the main stem of the Guyandotte River (80 observations), Mud River (55 observations), and Pinnacle Creek (14 observations). The correlation coefficients indicate a positive relationship between increasing TSS and increasing iron concentrations (Appendix D, Figures 7, 8, and 9).

Aluminum concentrations were analyzed from the same data set that was used above. The data from the main stem of the Guyandotte River exhibited a correlation coefficient of 0.8636 (Appendix D, Figure 10), however only very weak relationships between TSS and total aluminum concentrations were seen in the main stem of the Mud River and Pinnacle Creek (Appendix D, Figures 11 and 12).

3.5.3 Other Metals Sources That Do Not Have NPDES Permits

The predominant landuses in the Guyandotte River watershed were identified based on the USGS's GAP 2000 landuse data (representative of the mid-1990s). According to the GAP 2000 data, the major landuses in the watershed are diverse, mesophytic hardwood forest, which constitutes approximately 62 percent of the watershed area, and cove hardwood forest, which makes up 13 percent of the watershed area. In addition to forestland and pasture/grass landuses, other landuses that might contribute nonpoint source metals loads to the receiving streams include barren and urban land. The landuse distribution for the Guyandotte River watershed is presented in Figure 3-3 and Table 3-6.

Table 3-6. GAP 2000 landuse distribution in the Guyandotte River watershed

GAP 2000 Landuse Category	Area (Acres)	Area (Percent)
Diverse/Mesophytic Hardwood	673,573	62.6
Cove Hardwood Forest	140,029	13
Oak Dominant Forest	58,620	5.4
Pasture/Grassland	56,970	5.3
Mountain Hardwood Forest	33,266	3.1
Hardwood/Conifer Forest	29,530	2.7
Light Intensity Urban	15,595	1.4
Barren Land	15,318	1.4
Floodplain Forest	10,957	1
Surface Water	9,876	0.9
Shrubland	8,144	0.8
Moderate Intensity Urban	7,765	0.7
Major Power Lines	4,697	0.4
Populated Areas	4,441	0.4
Intensive Urban	2,382	0.2
Woodland	2,025	0.2
Row Crop Agriculture	1,211	0.1
Conifer Plantation	418	< 0.1
Herbaceous Wetland	355	< 0.1
Major Roads	326	< 0.1
Forested Wetland	85	< 0.1
Shrub Wetland	75	< 0.1
Planted Grassland	33	< 0.1

3.5.4 Selenium Source Characterization

As shown previously in Table 1-5, there are four waterbodies listed on West Virginia's 2002 Section 303(d) list for not meeting water quality criteria for selenium: Mud River, Sugartree Branch, Stanley Fork, and Hall Fork/Left Fork of Cow Creek. These impaired waterbodies are shown in Figure 3-4.

These streams were listed based on data collected by EPA (from August 2000 through February 2001) during investigations for the Mountaintop Removal Environmental Impact Study (USEPA, 2002). As shown in Table 3-7a, all 24 observations on these four streams violated the chronic aquatic life criterion for total selenium (5.0 ug/L), 7 observations violated the acute aquatic life criterion (20.0 ug/L), and 14 observations violated the Human Health not-to-exceed criterion of 10 ug/L.

Table 3-7a. Water quality observations for selenium in the Guyandotte River watershed collected for the Mountaintop Removal Environmental Impact Study

Stream Name	DNR Code	Total Observations	Total Selenium (ug/L)			Water Quality Criteria Violations		
			Ave	Min	Max	5 ug/L	20 ug/L	10 ug/L
Sugar Tree Branch	WVOGM-48	6	36.8	28.3	49.3	6	6	6
Stanley Fork	WVOGM-47	6	10.7	7.2	14.9	6	0	3
Mud River	WVOG-2	6	12.3	5.1	24.8	6	1	4
Hall Fork/Left Fork Cow Creek	WVOG-65-J-3-A	6	8.7	5.6	10.4	6	0	1

Source: WVDEP, EPA

In order to further characterize potential selenium sources in these streams, it was necessary to conduct additional monitoring. EPA collected weekly samples at 11 strategic locations in the Guyandotte watershed from September 2, 2003 through October 21, 2003. The monitoring locations shown in Figure 3-5 were selected to evaluate the spatial distribution of total selenium concentrations in the Guyandotte watershed. The sampling effort also attempted to capture temporal changes from both summer baseflow and episodic runoff events to further examine how in-stream concentrations of total selenium vary with flow. Results of the recent monitoring data summarized in Table 3-7b shows that detectible amounts of selenium are only present in isolated upstream reaches of the Mud River (Stations 6 through 9) in the Guyandotte watershed. Ten samples collected on Hall Fork/Left Fork/Cow Creek all had results below both detection limits and water quality criteria. Therefore, Hall Fork/Left Fork/Cow Creek does not need a TMDL for selenium. West Virginia has delisted Hall Fork/Left Fork/Cow Creek from its Draft 2004 Section 303(d) list based on the recent data and West Virginia's listing methodology.

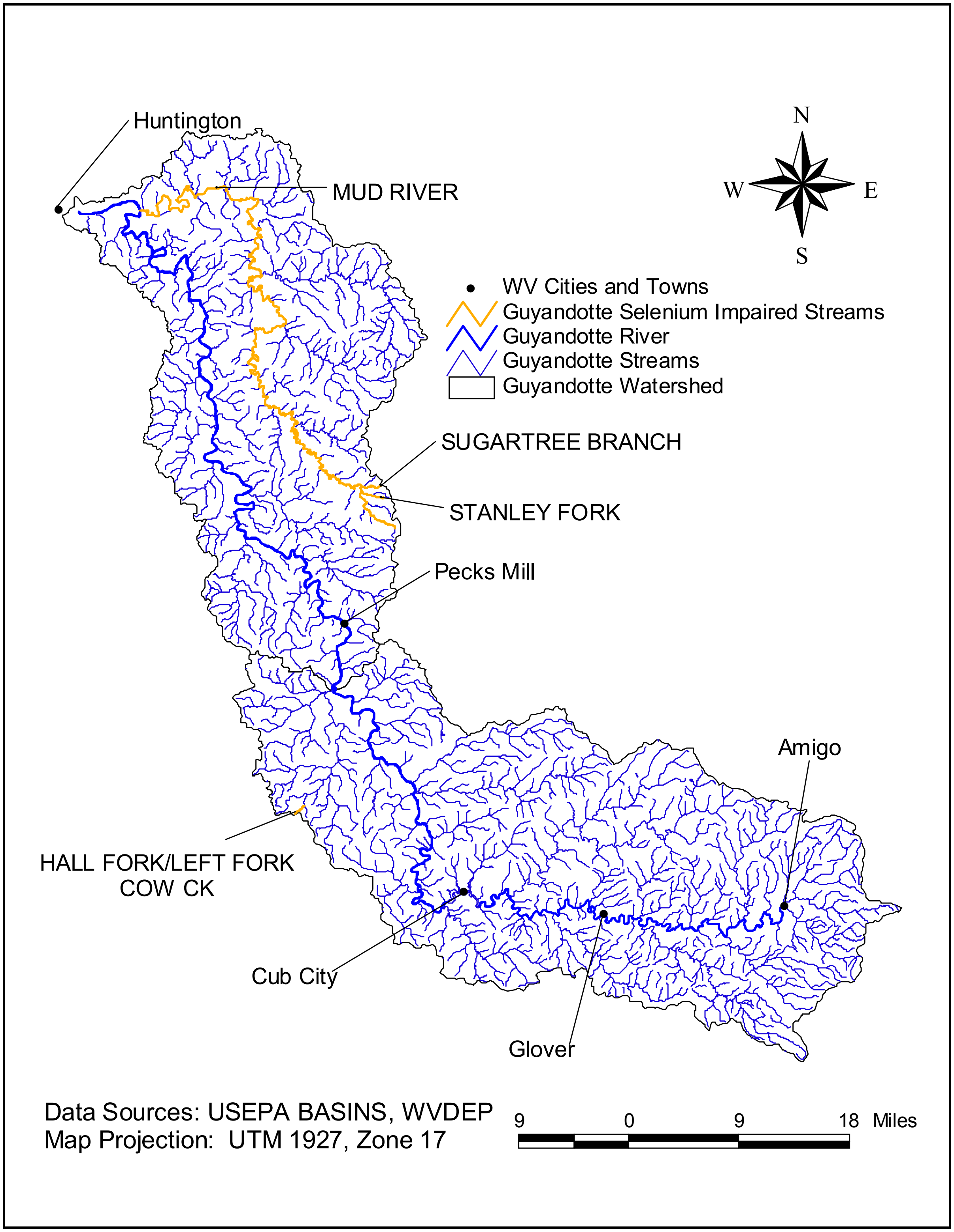


Figure 3-4. Selenium impaired waterbodies in the Guyandotte watershed

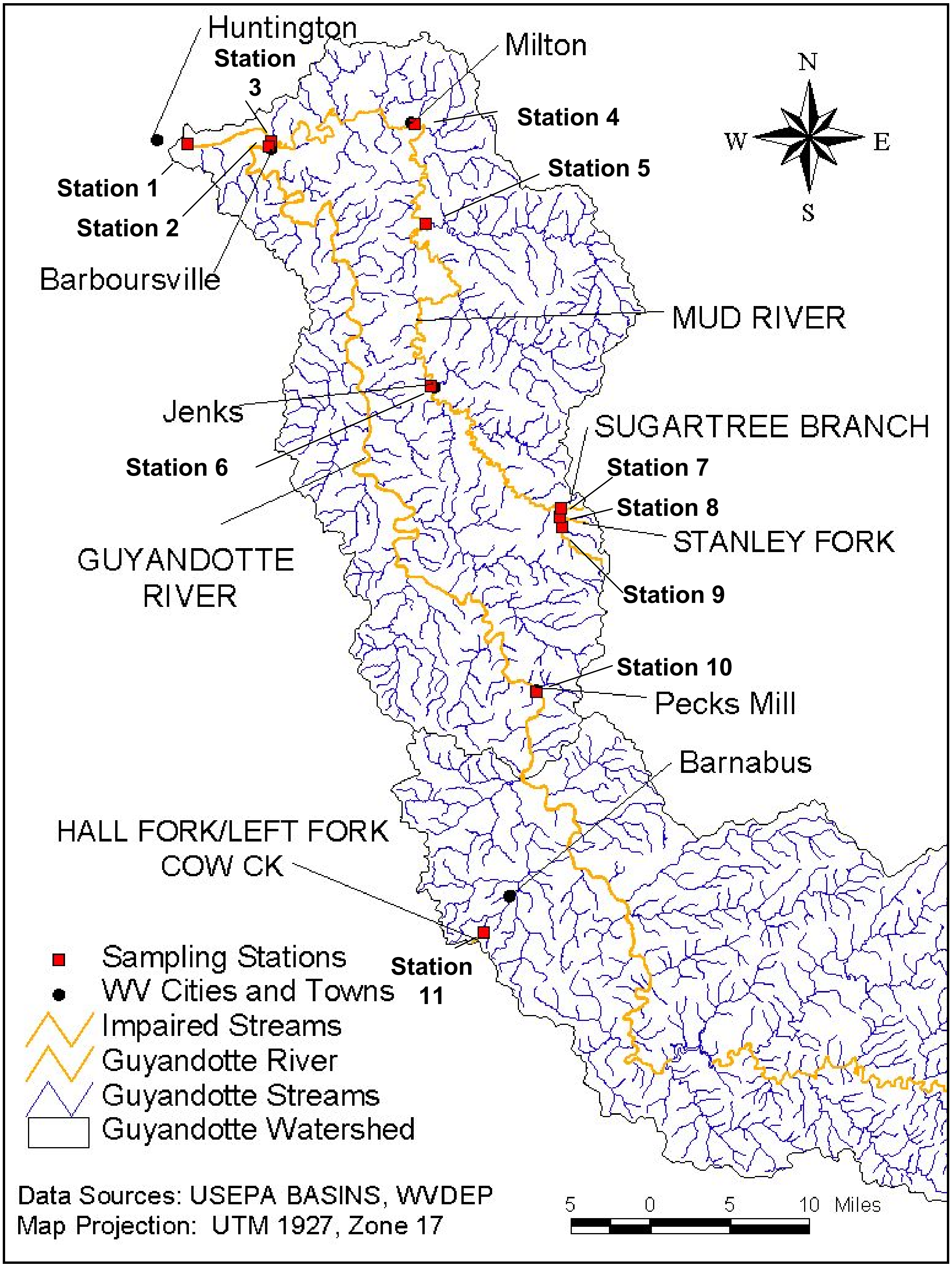


Figure 3-5. Selenium sampling locations in the Guyandotte River watershed

Table 3-7b. Summary of recently collected selenium water quality data from Fall 2003

Station ID	Stream Name	DNR Code	Total Samples	Total Selenium (ug/L)			Total Below Detection Limit (3 ug/L)	Water Quality Criteria Violations		
				Ave	Min	Max		5 ug/L	20 ug/L	10 ug/L
1	Guyandotte River	WVO-4	10	-	-	-	10	0	0	0
2	Guyandotte River	WVO-4	10	-	-	-	10	0	0	0
3	Mud River	WVOG-2	10	-	-	-	10	0	0	0
4	Mud River	WVOG-2	10	-	-	-	10	0	0	0
5	Mud River	WVOG-2	10	-	-	-	10	0	0	0
6	Mud River	WVOG-2	10	3.25	2.85	4.00	4	0	0	0
7	Sugar Tree Branch	WVOGM-47	10	15.71	10.3	19.60	0	10	0	10
8	Stanley Fork	WVOGM-48	10	6.66	5.4	8.00	0	10	0	0
9	Mud River	WVOG-2	10	4.58	2.94	9.40	4	3	0	0
10	Guyandotte River	WVO-4	10	-	-	-	10	0	0	0
11	Hall Fork/Left Fork/Cow Creek	WVOG-65-J-3-A	10	-	-	-	10	0	0	0

Selenium Sources

Selenium is a naturally occurring element that is found in Cretaceous marine sedimentary rocks, coal and other fossil fuel deposits (Dreher, 1992; CCREM 1987; US-EPA 1987; Haygarth 1994). When such deposits are mined, mobilization of selenium is typically enhanced from crushing of ore and waste materials along with the resulting increase in surface area of material exposed to weathering processes. Studies have shown that selenium mobilization appears to be associated with various surface disturbance activities associated with surface coal mining in Wyoming and western Canada (Dreher and Finkelman 1992; McDonald and Strosher 1998). In West Virginia, coals that contain the highest selenium concentrations are found in a region of south central West Virginia where the Allegheny and upper Kanawha Formations of the Middle Pennsylvanian are mined (WVGES 2002). In fact, some of the highest selenium concentrations (16 to 20 ppm) were found in the vicinity of the upper portion of the Mud River watershed near the Lincoln/Logan county line (Figure 3-6).

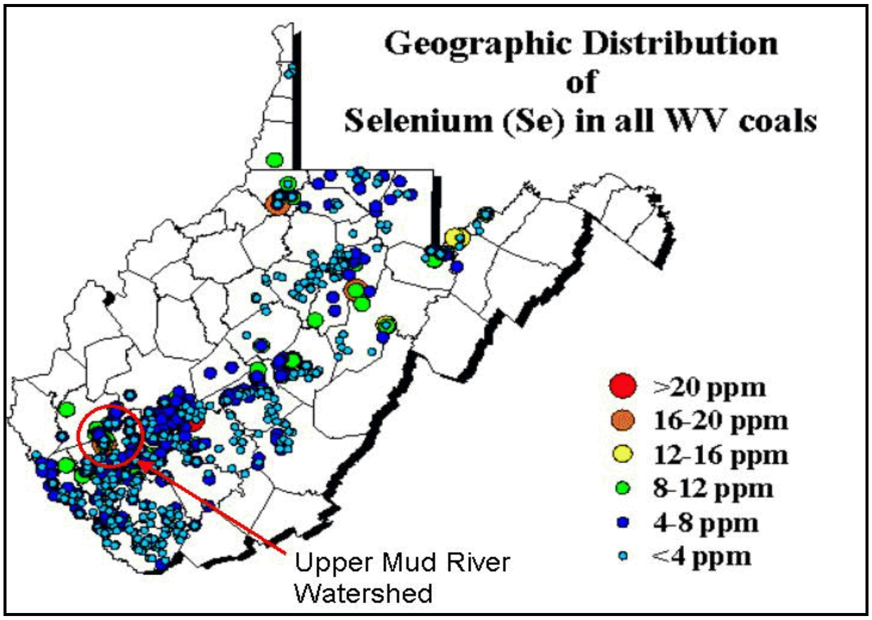


Figure 3-6. Geographic distribution of selenium in WV coals (WVGES)

Mining in the Upper Mud River watershed

WVDEPs mining related GIS coverages were used to identify the location and extent of mining operations in the upper portion of the Mud River watershed. Figure 3-7 illustrates that extensive surface mining operations are present in the upper portion of the Mud River watershed and the presence of valley fills indicate that these mines are mountaintop removal operations. Furthermore, examining the Digital Orthophoto Quadrangles (DOQs) shows nearly all of the Sugartree Branch and Stanley Fork watersheds under various phases of mining and reclamation activities (Figure 3-8)

The four mining related NPDES permits that discharge into the upper portion of the Mud River watershed are issued to a single permittee, Hobet Mining, Inc. Table 3-8 summarizes the NPDES permit information.

Table 3-8. Mining related NPDES permits discharging in the upper portion of the Mud River watershed

PERMIT ID	Responsible Party	Number of. Outlets	NPDES Permit Status Flag	SMCRA Article 3 Permit ID	Mining Type	Article 3 Permit Status	Article 3 Permit Status Code
WV0099392	Hobet Mining, Inc	17	Open	S501692	Surface	Open	Renewed
WV1016695	Hobet Mining, Inc	3	Open	S502295	Surface	Open	New
WV1016776	Hobet Mining, Inc	7	Open	S500396	Surface	Open	Renewed
WV1017225	Hobet Mining, Inc	4	Open	U500798	Underground	Open	New

Summary

Recent water quality monitoring in the Lower Guyandotte watershed indicated that elevated in-stream selenium concentrations were isolated in the upper portion of the Mud River watershed. Given the high selenium content of coals in the upper Kanawha Formation, surface disturbances associated with the extensive surface mining operations is the likely cause of the selenium impairments in Sugartree Branch, Stanley Fork, and the upper portion of the Mud River.

3.5.5 Sources of Fecal Coliform Bacteria That Do Not Have NPDES Permits

Stormwater runoff represents a major nonpoint source of bacteria in both urban and rural areas. Runoff from urban watersheds can be a significant source, delivering bacteria present in litter and in the waste of domestic pets and wildlife to the waterbody. Rural stormwater runoff can transport significant loads of bacteria from livestock pastures, livestock and poultry feeding facilities, and manure storage and application. Natural background sources such as wildlife can also contribute bacteria loadings and may be particularly important in forested or less-developed areas of the watershed. Additional sources of bacteria include on-site wastewater systems (septic tanks, cesspools) that are poorly installed, faulty, or improperly located, and illicit discharges of residential and industrial wastes.

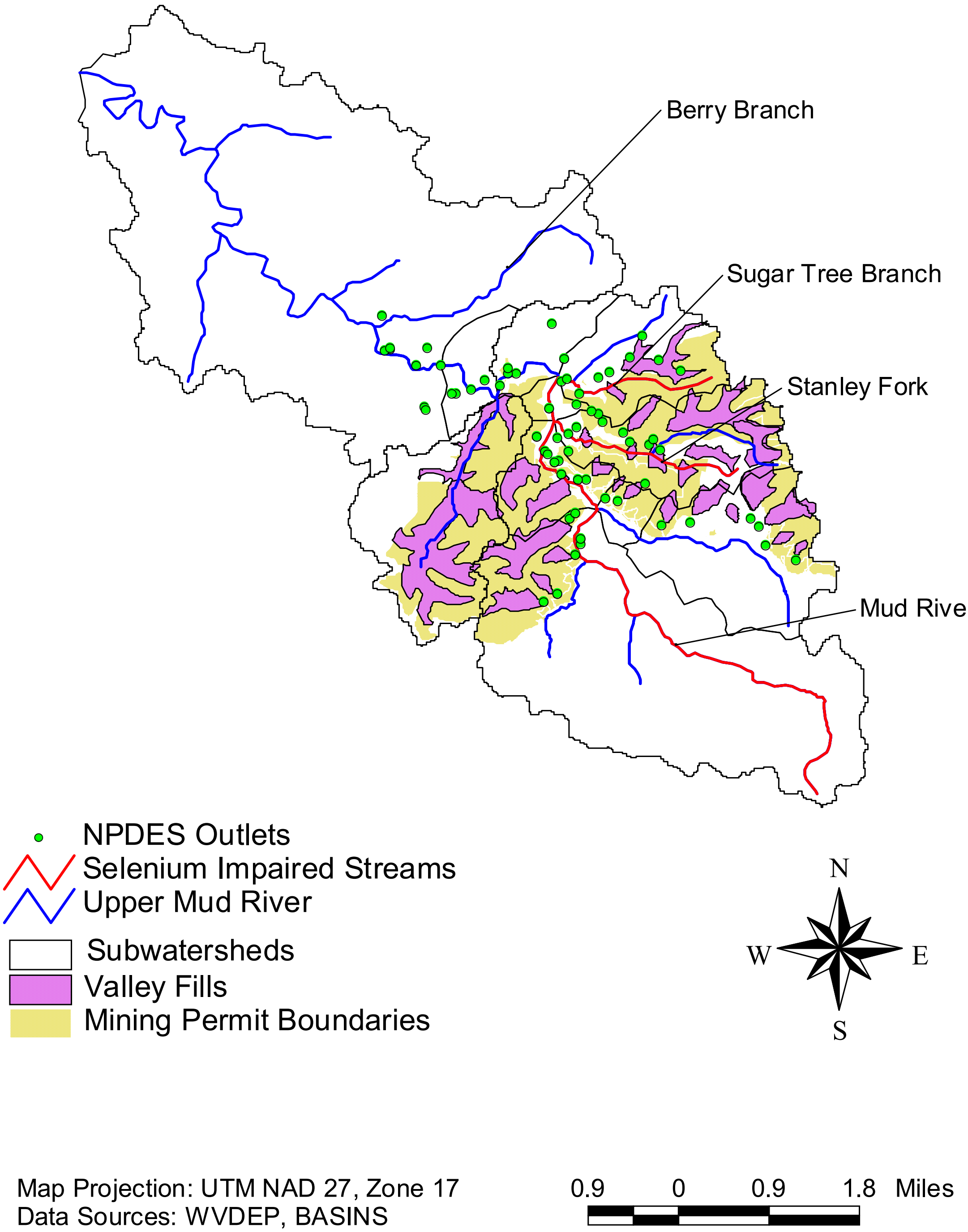


Figure 3-7. Surface mining in the upper portion of the Mud River watershed

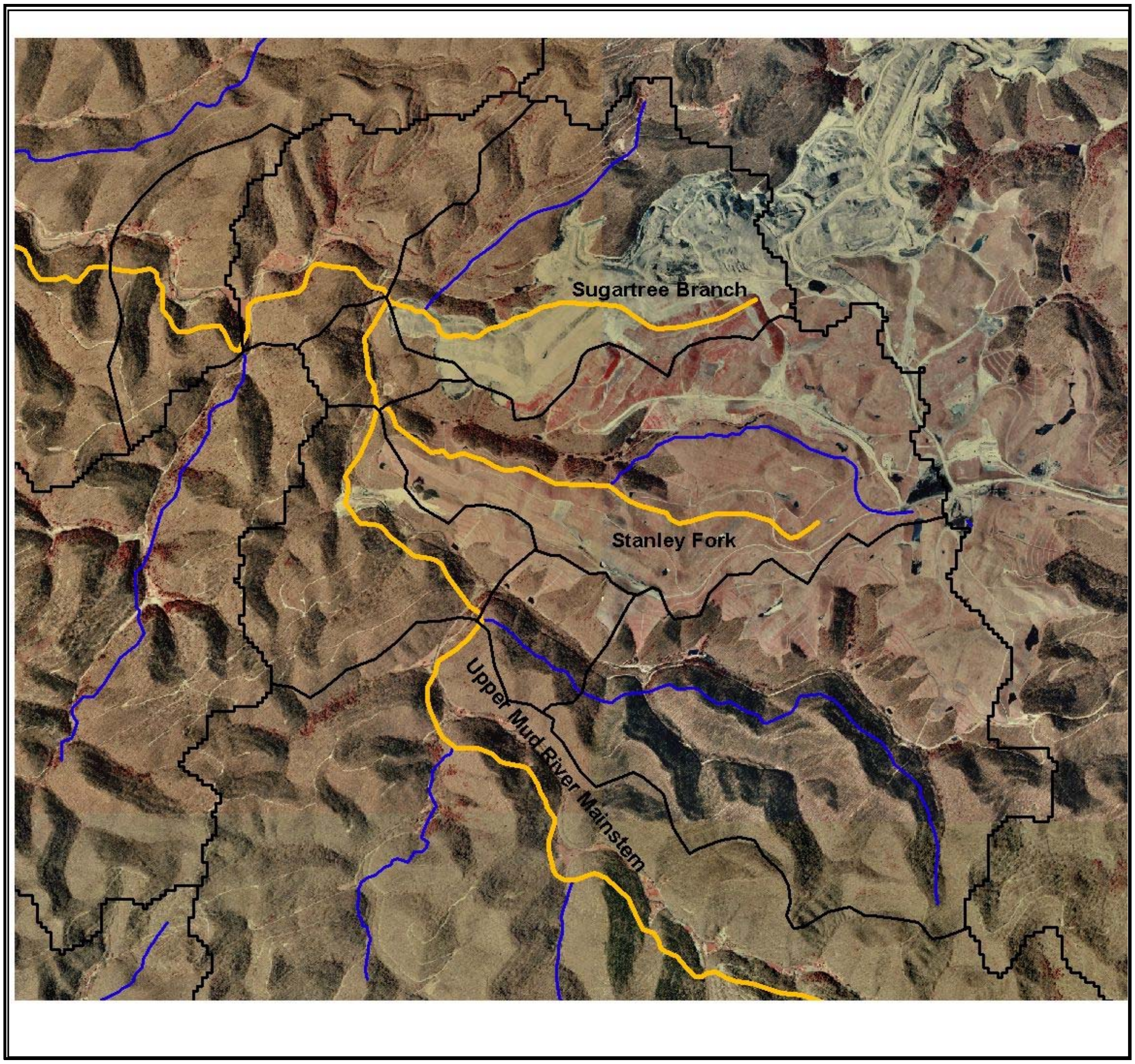


Figure 3-8. Digital Orthophoto Quadrangle of the upper portion of the Mud River watershed

The landuse distribution of the Guyandotte River watershed provides insight into determining nonpoint sources of fecal coliform bacteria. The dominant landuse in the Guyandotte watershed, based on GAP data analysis, is forest (94 percent). Urban areas constitute approximately three percent of the watershed (Table 3-6). Figure 3-3 displays the landuse distribution for the watershed. Other key sources of fecal coliform bacteria identified in the watershed include urban areas, failing septic systems and straight pipes, and natural sources.

Wastewater Disposal

Failing septic systems and straight pipes can contribute fecal coliform bacteria to receiving waterbodies through surface or subsurface malfunctions, and may be the most significant source of fecal coliform bacteria in the Guyandotte River watershed. According to Dave Thorton of the WV Department of Health, the failure rate for septic systems in the nearby Upper Kanawha watershed is estimated to be 70 percent during the first ten years after installation. Census data was used to estimate the number of unsewered homes in the impaired segments of the

Guyandotte River watershed. The TMDL assigns LAs (as opposed to WLAs) to failing septic systems and straight pipes because there are no NPDES Permits associated with them, and because of the type of data available. While we are able to estimate the collective loading contribution of failing septic systems and straight pipes, there is no information as to their individual surface flow contributions and subsurface flow contributions. The fact that these sources receive a load allocation rather than a wasteload allocation does not reflect any determination by EPA as to whether there are, in fact, unpermitted point source discharges. In addition, by assigning a load allocation to these sources, EPA is not determining that these discharges are exempt from NPDES permitting requirements. Generally, EPA considers any straight pipe discharging raw sewage or other pollutants to surface waters as a "point source" for purposes of the CWA (requiring an NPDES permit for authorization to discharge pollutants).

Urban Runoff

Sources of fecal coliform bacteria in urban areas include wildlife and pets, particularly dogs. Much of the loading from urban areas is due simply to the resulting runoff from impervious surfaces during precipitation events. In estimating the potential loading of fecal coliform bacteria from urban areas, accumulation rates are often used to represent the aggregate of available sources. Urban areas, as defined by the GAP landuse, of the Guyandotte River watershed are concentrated around Huntington.

Agriculture

Several agricultural activities or sources related to livestock can contribute fecal coliform bacteria to receiving streams through surface runoff or direct deposition. Grazing livestock and land application of manure result in the deposition and accumulation of bacteria on land surfaces where it is available for washoff and transport during rain events. Additionally, livestock with access to streams can represent a significant source of bacteria, depositing fecal coliform directly to the stream.

Based on GAP 2000 landuse data, it was determined that the impaired portions of the Guyandotte River watershed do not lie in agricultural areas. Although it is assumed that agriculture is not a widespread source of fecal coliform bacteria in the watershed, there may be isolated instances of pastures and feed lots located near impaired segments which may have significant localized impacts on instream bacteria levels.

Natural Sources

Fecal coliform bacteria also originate from natural background sources, primarily in forested areas. Generally, sources include wild animals such as deer, racoons, wild turkeys and waterfowl. Waterfowl may be a significant source in areas of open waters (e.g., flood control basins). The WV Department of Natural Resources estimated a density of 20 deer per acre for the nearby Upper Kanawha watershed, which was also used for the Guyandotte River watershed. Population estimates for other wildlife species were not available. Wildlife is considered a contributing source of fecal coliform bacteria, but not a major source.

4.0 Technical Approach

Establishing the relationship between the in-stream water quality targets and source loadings is a critical component of TMDL development. It allows for evaluation of management options that will achieve the desired source load reductions. The link can be established through a range of techniques, from qualitative assumptions based on sound scientific principles to sophisticated modeling techniques. Ideally, the linkage will be supported by monitoring data that allow the TMDL developer to associate certain waterbody responses to flow and loading conditions. The objective of this section is to present the approach taken to develop the linkage between sources and in-stream response for TMDL development in the Guyandotte watershed.

4.1 Model Framework Selection

Selection of the appropriate approach or modeling technique requires consideration of the following:

- Expression of water quality criteria
- Dominant processes
- Scale of analysis

Numeric aquatic life water quality criteria for aluminum, iron, and selenium, such as those applicable here, require evaluation of magnitude, frequency, and duration. Magnitude refers to the value of the criterion maximum concentration (CMC) to protect against short-term (acute) effects, or the value of the criterion continuous concentration (CCC) to protect against long-term (chronic) effects. Frequency indicates the number of water quality criteria exccedances allowed over a specified time period. West Virginia Water Quality Standards allow one accedence of aquatic life criteria every three years on average. Duration measures the time period of exposure to instream pollutant concentrations. For CMC criteria, exposure is measured over a one-hour period, while exposure for CCC criteria is measured over a four-day period. In addition to these considerations, any technical approach must consider the form of expression of numeric aquatic life criteria that are expressed. West Virginia aquatic life criteria for iron and selenium are expressed in the total recoverable metal form and the criteria for aluminum are expressed as concentrations in the dissolved metal form.

Total fecal coliform bacteria and total manganese criteria are prescribed for the protection of the human health uses of water contact recreation and public water supply. They are presented as a geometric mean concentration, using a minimum of five consecutive samples over a 30-day period, and a maximum daily concentration that is not to be exceeded in more than 10 percent of all samples taken in a month. No accedence of human health protection criteria is allowed.

West Virginia water quality criteria are applicable at all stream flows greater than the 7Q10 flow. The approach or modeling technique must permit representation of in-stream concentrations under a variety of flow conditions in order to evaluate critical flow periods for comparison to chronic and acute criteria.

According to 40 CFR Section 130, TMDLs must be designed to implement applicable water quality standards. The applicable water quality standards for metals, pH and fecal coliforms in West Virginia are presented in Section 2, Table 2-1.

The TMDL development approach must also consider the dominant processes regarding pollutant loadings and in-stream fate. For the Guyandotte watershed, primary sources contributing to metals, pH, and fecal coliform impairments include an array of point and nonpoint sources. Loading processes for nonpoint sources or land-based activities are typically rainfall-driven and thus relate to surface runoff and subsurface discharge to a stream. Permitted discharges may or may not be induced by rainfall.

Key in-stream factors that could be considered include routing of flow, dilution, transport of total metals, sediment adsorption/desorption, and precipitation of metals. In the stream systems of the Guyandotte watershed, the primary physical driving process is the transport of total metals by diffusion and advection in the flow. A significant in-stream process affecting the transport of fecal coliform bacteria is fecal coliform die-off.

Scale of analysis and waterbody type must also be considered in the selection of the overall approach. The approach should have the capability to evaluate watersheds at various scales. The listed waters in the Guyandotte watershed range from small headwater streams to larger tributaries and the Guyandotte River mainstem. Selection of scale should be sensitive to locations of key features, such as abandoned mines and point source discharges. At the larger watershed scale, land areas are lumped into subwatersheds for practical representation of the system, commensurate with the available data. Occasionally, there are site specific and localized acute problems which may require more detailed segmentation or definition of detailed modeling grids.

Based on the considerations described above, analysis of the monitoring data, review of the literature, and past pH, metals, and fecal coliform bacteria modeling experience, the Mining Data Analysis System (MDAS) was used to represent the source-response linkage in the Guyandotte watershed for aluminum, iron, manganese, and fecal coliform bacteria. The MDAS is a comprehensive data management and modeling system that is capable of representing loading from the nonpoint and point sources found in the Guyandotte watershed and simulating in-stream processes. Metals are modeled within MDAS in total recoverable form. Therefore, it is necessary to link MDAS with the Dynamic Equilibrium In-stream Chemical Reactions model (DESC) to appropriately address dissolved aluminum TMDLs in the Guyandotte watershed. The MINTEQ modeling system is used to represent the source-response linkage in the Guyandotte watershed for pH. The methodologies and technical approaches for dissolved aluminum and pH are discussed in sections 4.4 and 4.5, respectively.

4.2 Mining Data Analysis System (MDAS) Overview

The MDAS is a system designed to support TMDL development for areas impacted by AMD. The system integrates the following:

- Graphical interface
- Data storage and management system

- Dynamic watershed model
- Data analysis/post-processing system

The graphical interface supports basic geographic information system (GIS) functions, including electronic geographic data importation and manipulation. Key data sets include stream networks, landuse, flow and water quality monitoring station locations, weather station locations, and permitted facility locations. The data storage and management system functions as a database and supports storage of all data pertinent to TMDL development, including water quality observations, flow observations, permitted facility Discharge Monitoring Reports (DMR), as well as stream and watershed characteristics used for modeling. The system also includes functions for inventorying the data sets. The Dynamic Watershed Model, also referred to as the Hydrological Simulation Program - C++ (HSPC), simulates nonpoint source flow and pollutant loading as well as in-stream flow and pollutant transport, and is capable of representing time-variable point source contributions. The data analysis/post-processing system conducts correlation and statistical analyses and enables the user to plot model results and observation data.

The most critical component of the MDAS to TMDL development is the HSPC model, because it provides the linkage between source contributions and in-stream response. The HSPC is a comprehensive watershed model used to simulate watershed hydrology and pollutant transport as well as stream hydraulics and in-stream water quality. It is capable of simulating flow, sediment, metals, nutrients, pesticides, and other conventional pollutants, as well as temperature and pH for pervious and impervious lands and waterbodies. The HSPC is essentially a re-coded C++ version of selected Hydrologic Simulation Program-FORTRAN (HSPF) modules. HSPC's algorithms are identical to those in HSPF. Table 4-1 presents the modules from HSPF used in HSPC. Refer to the *Hydrologic Simulation Program FORTRAN User's Manual for Release 11* for a more detailed discussion of simulated processes and model parameters (Bicknell et al., 1996).

Table 4-1. Modules from HSPF[a] converted to HSPC

RCHRES Modules	HYDR	Simulates hydraulic behavior
	CONS	Simulates conservative constituents
	HTRCH	Simulates heat exchange and water
	SEDTRN	Simulates behavior of inorganic sediment
	GQUAL	Simulates behavior of a generalized quality constituent
	PHCARB	Simulates pH, carbon dioxide, total inorganic carbon, and alkalinity
PQUAL and IQUAL Modules	PWATER	Simulates water budget for a pervious land segment
	SEDMNT	Simulates production and removal of sediment
	PWTGAS	Estimates water temperature and dissolved gas concentrations
	IQUAL	Uses simple relationships with solids and water yield
	PQUAL	Simple relationships with sediment and water yield

[a] Source: Bicknell et al., 1996

4.3 MDAS Model Configuration

The MDAS was configured for the Guyandotte watershed, and the HSPC model was used to simulate the watershed as a series of hydrologically connected subwatersheds. Configuration of the model involved subdivision of the Guyandotte watershed into modeling units and continuous simulation of flow and water quality for these units using meteorological, landuse, point source loading, and stream data. Specific pollutants that were simulated include total aluminum, total iron, total manganese, and fecal coliforms. This section describes the configuration process and key components of the model in greater detail.

4.3.1 Watershed Subdivision

To represent watershed loadings and resulting concentrations of metals in the Guyandotte River watershed, the watershed was divided into 369 subwatersheds. These subwatersheds are presented in Figure 1 in each of Appendices A-1 through A-14, and they represent hydrologic boundaries. The division was based on elevation data (7.5 minute Digital Elevation Model [DEM] from USGS), stream connectivity (from USGS's National Hydrography Dataset [NHD] stream coverage), impairment status of tributaries, and locations of monitoring stations.

4.3.2 Meteorological Data

Meteorological data are a critical component of the watershed model. Appropriate representation of precipitation, wind speed, potential evapotranspiration, cloud cover, temperature, and dewpoint are required to develop a valid model. Meteorological data were accessed from a number of sources in an effort to develop the most representative dataset for the Guyandotte watershed.

In general, hourly precipitation data are recommended for nonpoint source modeling. Therefore, only weather stations with hourly-recorded data were considered in development of a representative dataset. Long-term hourly precipitation data available from five National Climatic Data Center (NCDC) weather stations located near the watershed were used (Figure 4-1):

- Huntington/Tri-State Airport
- Griffithsville
- Flat Top
- Dry Creek
- Logan

Meteorological data for the remaining required parameters were available from the Beckley-Raleigh County Airport and Charleston WSO Airport stations. These data were applied based on subwatershed location relative to the weather stations.

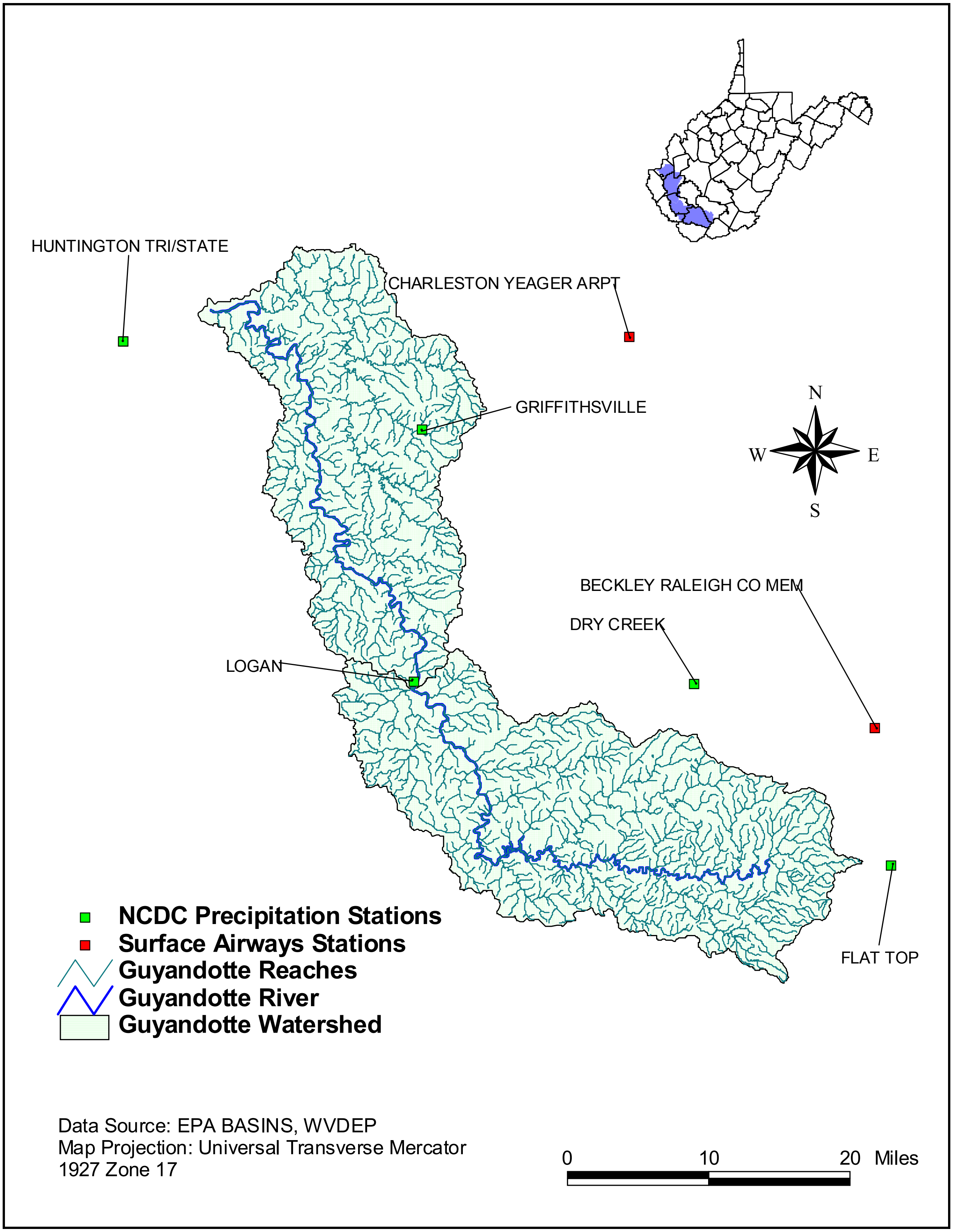


Figure 4-1. Weather stations used in modeling of the Guyandotte Watershed

The use of meteorological data over a period from 1980 to 2002 further ensures that the TMDL methodology is consistent with the technical and regulatory requirements of 40 CFR Section 130. These regulations require TMDLs to consider critical environmental conditions and seasonal environmental variations. The requirements are designed to simultaneously ensure that water quality is protected during times when it is most vulnerable and take into account changes in streamflow and loading characteristics as a result of hydrological or climatological variations. These conditions are important because they describe the factors that combine to cause violations of water quality standards and can help identify necessary remedial actions. The selected period of meteorological data includes extreme wet and dry periods that allow consideration of critical conditions.

4.3.3 Representation of Metals Sources Without NPDES Permits

To explicitly model nonpoint and/or unpermitted sources in the Guyandotte River watershed, the existing GAP 2000 landuse categories were consolidated to create model landuse groupings, shown in Table 4-2. Several additional landuse categories were created and added to the model landuse groupings. The additional landuse categories are explained in the following sections. The updated landuse coverage provided the basis for estimating and distributing total aluminum, iron, and manganese loadings associated with conventional landuses.

Contributions of relevant parameters from groundwater sources are also considered. In the case of naturally-occurring parameters, such as aluminum, iron, and manganese, it is important to consider and incorporate groundwater contributions for a more accurate representation of actual conditions.

Table 4-2. Metals model landuse grouping

Model Category	GAP2000 Category
Barren	Barren land - mining / construction
Cropland	Row Crop Agriculture
Mature Forest	Shrubland
	Conifer Plantation
	Floodplain Forest
	Cove Hardwood Forest
	Diverse / Mesophytic hardwood Forest
	Hardwood / Conifer Forest
	Oak dominant forest
	Mountain Hardwood Forest
	Mountain Hardwood / Conifer Forest
	Mountain Conifer Forest
	Woodland
Pasture	Major Powerline
	Pasture/Grassland
	Planted Grassland
Urban Impervious (See Table 4-3)	Major Highways (90% impervious)
	Populated Area - mixed land Cove (15% impervious)r
	Light intensity urban (15% impervious)
	Moderate intensity urban (50% impervious)
	Intensive Urban (80% impervious)

Model Category	GAP2000 Category
Urban Pervious (See Table 4-3)	Major Highways (10% pervious)
	Populated Area - mixed land Cover (85% pervious)
	Light intensity urban (85% pervious)
	Moderate intensity urban (50% pervious)
	Intensive Urban (20% pervious)
Water	Surface Water 1
	Surface Water 2
Wetlands	Forested Wetland
	Shrub Wetland
	Herbaceous Wetland

Abandoned Mine Lands (AML)

The AML categories were broken down into three landuse categories: high walls, disturbed land, and abandoned mines. The abandoned mines represent either discharge from abandoned deep mines or seeps and leachate from other abandoned mine sites. Specific data regarding the three AML landuses was not available from the GAP 2000 landuse coverage. WVDEP provided AML landuse coverage data which were incorporated into the GAP 2000 landuse coverage. In order to incorporate these landuses to appropriately account for runoff and loading characteristics, the existing GAP 2000 landuse coverage was modified on a subwatershed basis. For instance, assume that data from WVDEP indicated no active mining, 60 acres of abandoned mines, 40 acres of disturbed land, and 20 acres of high walls in a particular subwatershed, while available GAP 2000 data indicated 900 acres of forested land and 100 acres of “active mining land” in the same watershed. The GAP 2000 data would be modified such that the 100 acres of “active mining land” would become 120 acres of AML landuse distributed according to the WVDEP data (i.e. 60 acres of abandoned mines, 40 acres of disturbed land, and 20 acres of high walls). Because the size of the new AML landuse coverage exceeds the original “active mining land” coverage by 20 acres, the forested landuse coverage is reduced by 20 acres such that the total size of the watershed remains constant. In no case was the total size of any subwatershed modified as a result of including more accurate data regarding AML landuses.

Sediment Sources

Additional landuse categories were required to represent differences in the sediment loading and transport characteristics from various landuse activities. Separate landuse categories were designated for forest harvest areas (recent timber removal), burned forest (areas disturbed by forest fires) oil and gas operations, paved roads, and unpaved roads.

The West Virginia Bureau of Commerce, Division of Forestry provided information on the registered logging in the Guyandotte watershed. This information included the area of land that is logged and a sub-set of land that has been disturbed by roads and landings over the past five years. The Division of Forestry also provided information on the forested areas that have been disturbed by forest fires over the past five years. Both the harvested and burned areas can be found in Appendix E. Harvested areas and burned areas then were subtracted from the Mature Forest landuse category. The harvested forest and burned forest landuse categories represent the total timber harvested and burned in each subwatershed.

WVDEP Office of Oil and Gas (WVDEP OOG) provided information regarding oil and gas operations in the Guyandotte River watershed. Active oil and gas operations were assumed to have a well site and access road area of approximately 6,400 square feet. This assumption was supported by results from a random well survey conducted by WVDEP OOG in the Elk River watershed during the summer of 2001 that showed similar average well site and access road areas. The cumulative area for oil and gas operations in each subwatershed was subtracted from the mature forest categories as stated above.

Information on paved and unpaved roads in the watershed was obtained from the Census 2000 TIGER/Line Files. These GIS files provide the location and length of roads for the entire country. Each road is also assigned a code based on its attributes. The codes start with an A, and are followed by a number. The codes are described below in Table 4-3. The lengths of roads by subwatershed were calculated by intersecting the Tiger Road shapefile with the subwatershed delineation. Following this, an estimated width was assigned to each category of roads, to obtain an area. Based on the description for the appropriate category, the roads were designated as paved, unpaved, or in the case of A4, 60% paved, and 40% unpaved. Unpaved road areas were subtracted from mature forest lands. Paved road areas were subtracted from the urban impervious landuse category and then from forest lands if necessary.

Table 4-3. Assigned perviousness and estimated width for each type of road

Code	Description	Percent Pervious	Estimated Width (ft)
A1	Primary Highway With Limited Access	0%	35
A2	Primary Road Without Limited Access	0%	35
A3	Secondary and Connecting Road	0%	26
A4	Local, Neighborhood, and Rural Road	40%	16
A5	Vehicular Trail	100%	12
A6	Road with Special Characteristics	0%	12
A7	Road as Other Thoroughfare	0%	12

From: Census 2000 TIGER/Line® Technical Documentation

Feature Class A, Roads Description:

A1 - Primary Highway With Limited Access

Interstate highways and some toll highways are in this category (A1) and are distinguished by the presence of interchanges. These highways are accessed by way of ramps and have multiple lanes of traffic. The opposing traffic lanes are divided by a median strip.

A2 - Primary Road Without Limited Access

This category (A2) includes nationally and regionally important highways that do not have limited access as required by category A1. It consists mainly of US highways, but may include some state highways and county highways that connect cities and larger towns. A road in this category must be hard-surface (concrete or asphalt). It has intersections with other roads, may be divided or undivided, and have multi-lane or single-lane characteristics.

A3 - Secondary and Connecting Road

This category (A3) includes mostly state highways, but may include some county highways that connect smaller towns, subdivisions, and neighborhoods. The roads in this category generally are smaller than roads in Category A2, must be hard-surface (concrete or asphalt), and are usually undivided with single-lane characteristics. These roads usually have a local name along with a route number and intersect with many other roads and driveways.

A4 - Local, Neighborhood, and Rural Road

A road in this category (A4) is used for local traffic and usually has a single lane of traffic in each direction. In an urban area, this is a neighborhood road and street that is not a thorough-fare belonging in categories A2 or A3. In a rural area, this is a short-distance road connecting the smallest towns; the road may or may not have a state or county route number. Scenic park roads, unimproved or unpaved roads, and industrial roads are included in this category. Most roads in the Nation are classified as A4 roads.

A5 - Vehicular Trail

A road in this category (A5) is usable only by four-wheel drive vehicles, is usually a one-lane dirt trail, and is found almost exclusively in very rural areas. Sometimes the road is called a fire road or logging road and may include an abandoned railroad grade where the tracks have been removed. Minor, unpaved roads usable by ordinary cars and trucks belong in category A4, not A5.

A6 - Road with Special Characteristics

This category (A6) includes roads, portions of a road, intersections of a road, or the ends of a road that are parts of the vehicular highway system and have separately identifiable characteristics.

A7 - Road as Other Thoroughfare

A road in this category (A7) is not part of the vehicular highway system. It is used by bicyclists or pedestrians, and is typically inaccessible to mainstream motor traffic except for private-owner and service vehicles. This category includes foot and hiking trails located on park and forest land, as well as stairs or walkways that follow a road right-of-way and have names similar to road names.

Other Sources

Impervious urban lands contribute nonpoint source metals loads to the receiving streams through the washoff of metals that build up in industrial areas, on paved roads, and in other urban areas because of human activities. Percent impervious estimates for urban landuse categories were used to calculate the total area of impervious urban land in each subwatershed. Pervious and impervious urban land areas were estimated using typical percent pervious/impervious assumptions for urban land categories, as shown in Table 4-4.

Table 4-4. Average percent perviousness and imperviousness for different landuse types

Landuse	Pervious (%)	Impervious (%)
Pasture	100	0
Cropland	100	0
Forest	100	0
Barren	100	0
Wetlands	100	0
Populated Areas	85	15
Light Intensity Urban	85	15
Moderate Intensity Urban	50	50
Intensive Urban	20	80
Major Highway	10	90

4.3.4 Fecal Coliform Bacteria Nonpoint and/or Unpermitted Source Representation

To explicitly model nonpoint and/or unpermitted sources of fecal coliform bacteria in the Guyandotte River watershed, the existing GAP 2000 landuse categories were consolidated to create model landuse groupings, shown in Table 4-5. The updated landuse coverage provided the basis for estimating and distributing fecal coliform bacteria loadings associated with conventional landuses.

In addition, contributions of fecal coliform bacteria from groundwater sources are also considered. In the case of naturally-occurring parameters, such as fecal coliform bacteria, it is important to consider and incorporate groundwater contributions for a more accurate representation of actual conditions.

Table 4-5. Fecal coliform bacteria model landuse grouping

Model Category	GAP2000 Category
Barren	Barren Land - Mining / Construction
Cropland	Row Crop Agriculture
Forest	Mountain Hardwood Forest
	Conifer Plantation
	Floodplain Forest
	Cove Hardwood Forest
	Diverse / Mesophytic Hardwood Forest
	Shrubland
	Oak Dominant Forest
	Woodland
	Mountain Hardwood / Conifer Forest
	Mountain Conifer Forest
	Major Powerline
	Hardwood / Conifer Forest
Pasture	Pasture / Grassland
	Planted Grassland
Urban Impervious (See Table 4-4)	Intensive Urban (80% impervious)
	Major Highway (90% impervious)
	Populated Area - Mixed Land Cover (15% impervious)

Model Category	GAP2000 Category
	Light Intensity Urban (15% impervious)
	Moderate Intensity Urban (50% impervious)
Urban Pervious (See Table 4-4)	Major Highway (10% pervious)
	Intensive Urban (20% pervious)
	Light Intensity Urban (85% pervious)
	Moderate Intensity Urban (50% pervious)
	Populated Area - Mixed Land Cover (85% pervious)
Water	Surface Water 1
	Surface Water 2
Wetlands	Forested Wetland
	Shrub Wetland
	Herbaceous Wetland

The nonpoint and/or unpermitted fecal coliform sources within the Guyandotte River watershed are represented differently in the model depending on their type and behavior. The following nonpoint and/or unpermitted fecal coliform sources have been identified within the listed watersheds:

- Urban and residential runoff
- Leaking sanitary sewers
- Failing septic systems and straight pipe discharges
- Grazing livestock
- Runoff from cropland
- Wildlife

Frequently, nonpoint sources are characterized by build-up and wash-off processes. Bacteria accumulates on land surfaces where it is subject to die-off and wash-off with surface water runoff. These nonpoint sources are represented in the model as land-based runoff from the landuse categories. Fecal coliform accumulation rates (number per acre per day) can be calculated for each landuse based on all sources contributing fecal coliforms to the land surface. For example, grazing livestock and wildlife are specific sources contributing to landuses within the watershed. The landuses that experience bacteria accumulation due to livestock and wildlife include:

- Cropland (wildlife)
- Forest (wildlife)
- Pasture (livestock and wildlife)
- Wetlands (wildlife)

Accumulation rates can be derived using the distribution of animals by landuse and using typical fecal coliform production rates for different animal types (Table 4-6). For example, the fecal coliform bacteria's accumulation rate for pasture lands is the sum of the individual fecal coliform accumulation rates due to contributions from grazing livestock (cattle) and wildlife.

Table 4-6. Fecal coliform production rates for beef cattle and deer

Animal	Fecal Coliform Production Rate	Reference
Beef cow	1.0 x 10^{11} counts/day	ASAE, 1998
Deer	5 x 10^{8} counts/day	Linear interpolation; Metcalf & Eddy, 1991

Direct contributions to the waterbodies from in-stream cattle were not included in this TMDL modeling effort because of the relatively small number of cattle estimated to be in the watershed (see Section 3.5.6).

Urban lands contribute nonpoint source fecal coliform bacteria loads to the receiving streams through the washoff of fecal coliform bacteria that build up on both pervious and impervious surfaces in industrial areas, on paved roads, and in residential areas because of human activities and wildlife. Percent pervious and impervious estimates for urban landuse categories were used to calculate the total area of urban pervious and urban impervious land in each subwatershed. Pervious and impervious urban land areas were estimated using typical percent pervious/impervious assumptions for various types of urban landuses, as shown in Table 4-4.

Literature values for typical fecal coliform bacteria accumulation rates were used to calculate the fecal coliform bacteria accumulation rates for urban areas. Urban areas were consolidated into two landuse categories: urban pervious and urban impervious, based on typical percent pervious/imperviousness for the various urban landuse types (Table 4-5). The calculated fecal accumulation rate used for urban impervious is 9.33 E+06 fecal coliform counts/ac/day, and the value used for urban pervious is 7.53 E+09 fecal coliform counts/ac/day. The fecal coliform contribution from family pets (dogs) was included in the urban pervious accumulation rate by assuming one pet per household, using the number of households in each county as listed in the 1990 census data. The literature value used for the fecal coliform production rate for domestic animals is 4.09E+09 #/animal/day (LIRPB, 1978). The contribution from domestic pets was included in the total fecal accumulation rate for pervious urban areas, assuming dogs remained mostly on the pervious surfaces associated with low-density residential areas.

Failing septic systems and straight pipes represent sources that can contribute fecal coliforms to receiving waterbodies through surface or subsurface flow. The number of septic systems and straight pipes per subwatershed were determined using U.S. Census data. The 1990 Census provided the number of unsewered homes for census tracts in Boone, Cabell, Lincoln, Logan, Mingo, Putnam, Raleigh, and Wyoming counties. The number was then divided by the total census tract area to obtain a density of unsewered homes. The density was then applied to the corresponding subwatershed on an area-weighted basis. Figures 4-2 and 4-3 show the estimated number of unsewered homes in the Guyandotte River watershed.

The number of homes served by septic systems and straight pipes was estimated from the number of unsewered homes in the Guyandotte River watershed. Areas within the Guyandotte

River watershed where discharges of untreated sewage are known to occur were identified by WVDEP Construction Assistance staff. For the subwatersheds lying in these areas, it was assumed that 25% of the unsewered homes in the subwatershed were discharging untreated sewage directly to the waterbody (straight pipes) and 75% of the unsewered homes were served by septic systems. For other unsewered areas, it was assumed that 10% of the unsewered homes were discharging untreated sewage directly to the waterbody and 90% of the unsewered homes were served by septic systems. For the areas within the Guyandotte watershed that are known to be served by sewer systems, it was assumed that 100% of the unsewered homes were served by septic systems. A failure rate of 70% was applied to the number of homes served by septic systems in each subwatershed to determine the number of failing septic systems to be represented in the model. To provide for a margin of safety accounting for the uncertainty of the number, location, and behavior (e.g., surface vs. subsurface breakouts; proximity to stream) of the straight pipes and failing systems, they are represented in the model as direct sources of fecal coliforms to the stream reaches. Fecal coliform contributions from failing septic system and straight pipe discharges are included in the model with a representative flow and concentration, which were quantified based on the following information:

- Number of straight pipes in each subwatershed.
- Number of failing septic systems in each subwatershed (failure rate of 70% discussed in Section 3.5.6).
- Estimated population served by the septic systems and straight pipes (calculated from census tract averages of people per household, obtained from 1990 Bureau of the Census data).
- An average daily discharge of 70 gallons/person/day (Horsley & Witten, 1996).
- Straight pipe effluent concentration of 1.0 E+06 fecal coliform counts/100 mL (septic effluent concentration from Horsley & Witten, 1996).
- Septic effluent concentration reaching the stream of 1.0 E+04 fecal coliform counts/100 mL (estimated using the septic effluent concentration from Horsley & Witten, 1996, accounting for die-off between septic tank and stream).

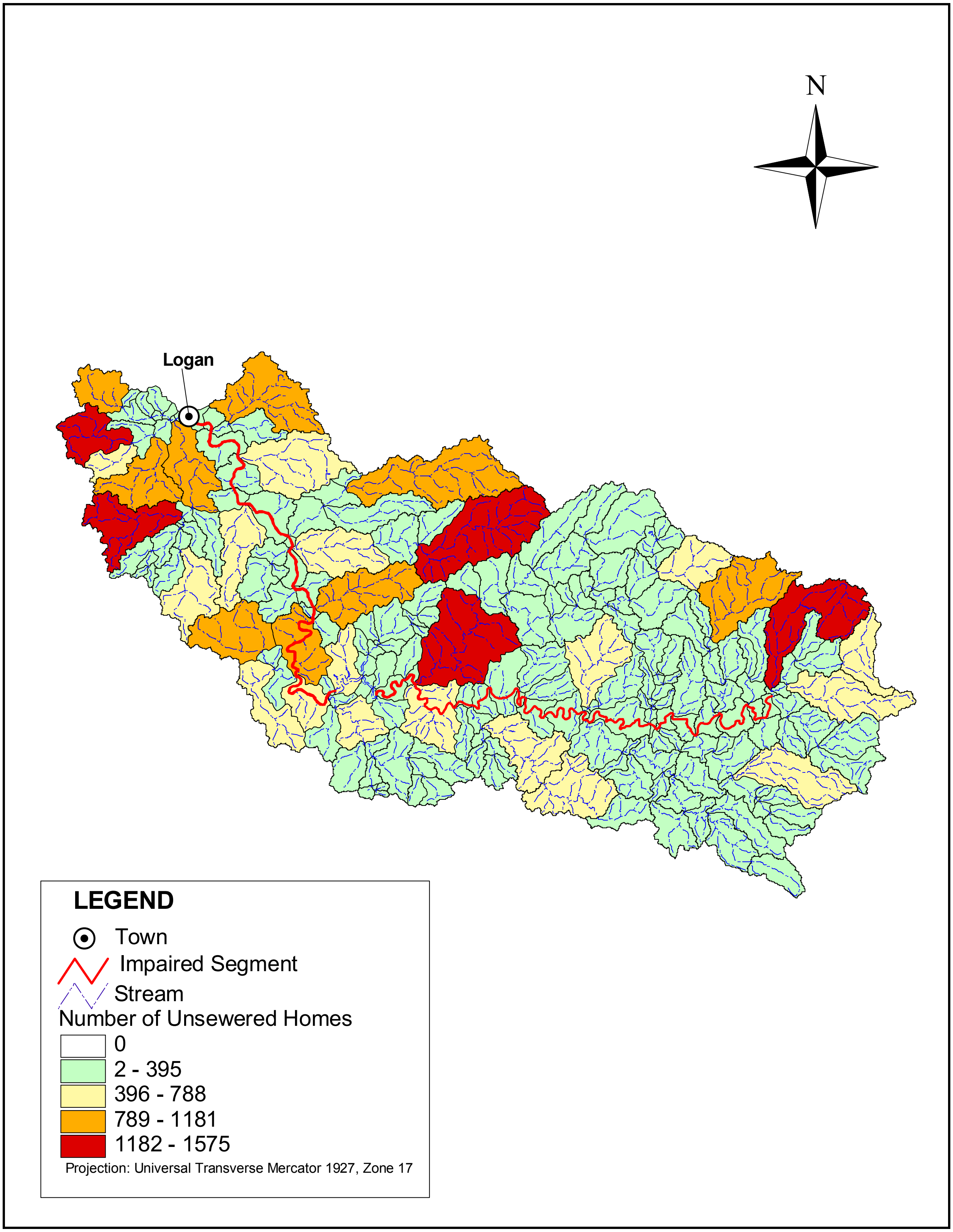


Figure 4-2. Number of unsewered homes in the Upper Guyandotte River watershed

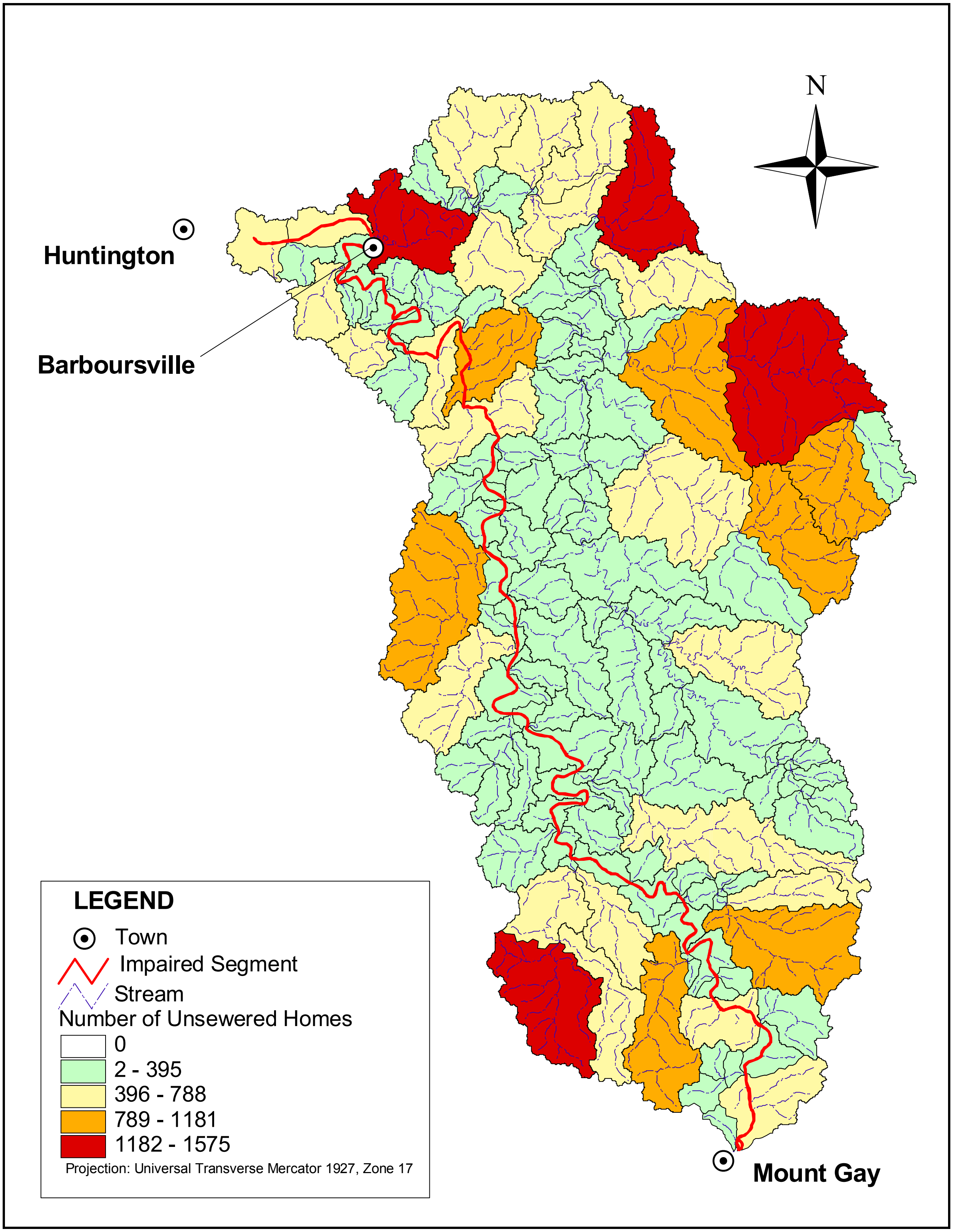


Figure 4-3. Number of unsewered homes in the Lower Guyandotte River watershed

4.3.5 Permitted Metals Source Representation

Permitted Non-mining Point Sources

As stated in Section 3, there are three non-mining point sources in the Guyandotte watershed that are permitted to discharge metals. These point sources were represented in MDAS as continuous flow point sources using the design flow of each facility and the permit limits listed in Table 3-3. Under this TMDL, these minor discharges are assumed to operate under their current permit limits. These facilities will be assigned WLAs that allow them to discharge at their current permit limits.

Permitted Mining Point Sources

The permitted mining point sources were introduced as nine landuse categories based on the type of mine and the current status of the mine. Phase II and Completely Released permitted facilities were not modeled since reclamation of these mines is either completed or nearly complete, and they are assumed to have little potential water quality impact (WVDEP, 2000a). Table 4-7 shows the landuses representing current active mines that were modeled.

Table 4-7. Model nonpoint source representation of different permitted mines

Type and status of active mine	Landuse representation
Active deep mines	ADM
Active surface mines, renewed surface mines	ASM
Inactive deep mines, new deep mines	IADM
Inactive surface mines, new surface mines	IASM
Other mines (other, haulroad, prospect, quarry)	Other
Phase 1 released deep mines	PIDM
Phase 1 released surface mines	PISM
Revoked deep mines	RDM
Revoked surface mines	RSM
Revoked other mines	ROM

To account for the additional deep mine landuse categories that were not categorized in the GAP 2000 landuse coverage (ADM, IADM, RDM and PIDM), the area of each permitted deep mine was subtracted from the existing GAP 2000 landuse area as described in Section 4.3.3. The remaining additional landuse categories (ASM, PISM, RSM, ROM and Other) were subtracted from the barren landuse areas. Due to the lack of information available, the size of each mine was assumed to be equivalent to the surface disturbed area, which was provided by WVDEP DMR mining permit database. To account for this assumption, the hydrologic parameters within the model were adjusted to make the permitted mine landuses simulate continuous flow discharges. These areas are shown in Appendix B. A summary of the landuse distribution is shown in Table 4-8a and Table 4-8b.

Table 4-8a. Modeled landuse distribution in acres for Regions 1 through 7

Modeled Landuse	1	2	3	4	5	6	7
ADM	0	0	0	0	0	84	879
Agriculture	421	771	2	2	0	0	4
AML	622	72	0	3	116	5,009	1,486
ASM	14	3,909	0	0	4	3,733	8,598
Barren	656	961	0	39	100	113	64
Burned Forest	2,074	2,051	884	1,521	228	2,211	7,302
Forest	136,274	176,154	22,212	25,991	17,594	48,991	158,180
Harvested Forest	515	1,472	184	23	0	679	1,865
Highwall	171	21	0	2	26	496	976
IADM	4	17	0	2	0	146	305
IASM	0	36	0	0	51	1,299	1,269
Oil and Gas	108	164	31	23	9	15	88
OM	47	0	0	0	6	803	2,010
P1DM	0	0	0	0	0	72	150
P1SM	0	0	0	0	0	666	1,079
Pasture	16,180	30,213	397	1,327	473	682	3,619
Paved Roads	1,243	1,322	75	128	106	305	1,000
RDM	90	0	0	0	0	50	102
ROM	0	0	0	0	0	92	120
RSM	0	0	0	0	0	487	1,353
Skid Roads	39	111	14	2	0	51	140
Unpaved Roads	619	710	59	79	51	155	487
Urban Impervious	2,220	2,555	0	0	0	65	184
Urban Pervious	7,251	7,151	0	2	9	1,117	1,983
Water	3,556	2,030	4	9	3	56	3,365
Wetland	81	334	0	0	1	2	24
Total	**172,185**	**230,054**	**23,862**	**29,153**	**18,777**	**67,379**	**196,632**

Table 4-8b. Modeled landuse distribution in acres for Regions 8 through 14

Modeled Landuse	8	9	10	11	12	13	14
Barren	54	76	0	35	89	149	391
Mature Forest	3	0	0	47	0	0	0
Cropland	175	21	17	1,917	19	583	968
InterForest	2,345	823	10	1,838	670	523	0
Pasture	0	0	7	6	0	58	51
Strip Mining	248	2,907	437	798	359	176	785
Urban Imper	22,128	27,608	25,160	69,638	23,816	30,968	84,783
Urban Per	334	110	65	1,318	275	801	5,805
Wetlands	133	120	96	536	9	55	474
Water	10	11	5	116	0	84	108
Annual Forest Harvest	279	726	0	147	1,093	1,542	446
Paved Roads	14	21	14	50	25	11	38
Unpaved Roads	722	0	0	1,178	75	206	421
Oil & Gas Ops	0	11	26	33	13	13	44
ADM	1,545	408	0	264	0	0	0
IADM	151	165	137	2,409	670	820	4,619
RDM	162	151	105	346	82	116	513
PIDM	0	7	9	0	0	0	127
ASM	0	0	0	0	0	0	9
RSM	196	0	0	10	0	0	8

Modeled Landuse	8	9	10	11	12	13	14
PIRS	25	8	5	99	21	60	437
OTHER	115	64	47	177	52	85	291
ROM	4	0	1	46	7	201	187
AML	443	158	94	780	45	154	1,236
Disturbed	7	2	1	599	9	39	132
Highwall	0	1	2	58	1	12	45
Total	**29,093**	**33,398**	**26,238**	**82,445**	**27,330**	**36,656**	**101,918**

Point sources were represented differently, depending on the modeling scenario for TMDL development. The two major scenarios, which are described in more detail later in this section and in Section 5, are the model calibration scenario and the allocation scenarios.

Calibration Condition

To match model results to historical data, which is described in more detail in the Model Calibration section (4.6), it was necessary to represent the existing point sources using available historical data. The period selected for water quality calibration, 1994-2001, was the time period for which monitoring data were available. Discharges that were issued permits after the calibration period were not considered during the calibration process. If time-series Discharge Monitoring Report data (DMRs) were available, continuous flow permitted mines were represented in the model using average flows and pollutant loads. The DMR data includes monthly average and maximum daily values for flow, pH, total aluminum, total iron, and manganese. The monthly average metals concentrations were multiplied by the discharge flows to estimate average loadings for these point sources.

In most cases, time-series DMRs were insufficient to support representation in the model, indicating that the permitted mine discharges were precipitation driven. For these situations, discharges from permitted mines were represented in the model by adjusting parameters affecting pollutant concentrations in the PQUAL (simulation of quality constituents for pervious land segments) and IQUAL (simulation of quality constituents for impervious land segments) modules of HSPC. These parameters were assigned using 75th percentile DMR concentrations of similar mining activities within the entire Guyandotte watershed. Concentrations from these mines were adjusted to be consistent with typical discharge characteristics from similar mining activities or to match site-specific in-stream monitoring data.

Allocation Conditions

Modeling for allocation conditions required running multiple scenarios, including a baseline scenario and multiple allocation scenarios. This process is further explained in Section 5. For the allocation conditions, all permitted mining facilities were represented using precipitation-driven nonpoint source processes in the model. The period of 1987 to 1992, which represents a range of precipitation conditions, was applied to the sources that are present today for the allocation scenario. Under this nonpoint source representation, flow was estimated in a manner similar to other nonpoint sources in the watershed (i.e., based on precipitation and hydrologic properties). This is consistent with WV DMR's estimation that discharges from most surface mines are precipitation-driven (WVDEP, 2000b). Discharges from deep mines are typically continuous flow and were estimated by the method described earlier in this section. Under baseline conditions, the concentration of metals from point source discharges, including NPDES mining permits, was consistent with permit limits; i.e., the waste load allocation (WLA) based on permit limits. During the allocation scenario, reductions were applied to abandoned mine lands, sediment producing lands, and active mines in order to achieve in-stream TMDL endpoints.

Mining discharge permits have either technology-based or water quality-based limits. Monthly average permit concentrations for technology-based limits are 3.0 mg/L and 2.0 mg/L for total iron and manganese, respectively, with a "report only" limit for total aluminum. Monitoring requirements for dissolved aluminum are currently being addressed by permit reissuance (see section 1.4). Permitted discharges with water quality-based limits must meet in-stream water quality criteria at end-of-pipe. Point sources were assigned concentrations based on the appropriate limits. For technology-based permits, the waste load concentration for aluminum was assumed to be the 98th percentile value of the available DMR data for mining discharges in the Guyandotte River watershed (3.72 mg/L).

Allocations were made to provide consistency with the technical and regulatory requirements of 40 CFR Section 130. For instance, following the data analysis and model calibration, it was determined that violations of applicable water quality criteria occur at both low-flow and high-flow conditions. Accordingly, the TMDL, model calibration, and allocation process were designed to consider both low-flow and high-flow conditions.

4.3.6 Fecal Coliform Permitted Source Representation

A total of 382 point sources have NPDES permits regulating fecal coliform bacteria discharge to the Guyandotte River and its tributaries (see Section 3.4). 138 of the permits for fecal coliforms are general sewage permits. These general sewage point sources are represented in MDAS with a constant flow and fecal coliform count. The representative constant flow is the design flow provided in the NPDES permit for each facility. The fecal coliform discharges from each of the facilities are represented in the MDAS model by the monthly average discharge limitation of 200 fecal coliform counts/100 mL provided in the NPDES permits.

222 of the point sources with NPDES permits regulating the discharge of fecal coliform bacteria are the HAUs discussed in Section 3.4.3. HAUs were represented in the model by their design flow and the average monthly permitted fecal coliform discharge of 200 counts /100mL.

The 22 remaining point sources are regulated by individual NPDES permits that contain fecal coliform effluent limits. 17 of these are designated as Publicly Owned Treatment Works (POTW). Sewage treatment facilities operating under individual permits were represented in the model by their design flow and the average monthly permitted fecal coliform limit of 200 counts/100 ml.

4.3.7 Stream Representation

Modeling subwatersheds and calibrating hydrologic and water quality model components requires routing flow and pollutants through streams and comparing the modeled concentrations to water quality criteria. Each subwatershed was represented with a single stream. Stream segments were identified using the USGS NHD stream coverage.

To route flow and pollutants, rating curves must be developed. Rating curves were developed for each stream using Manning's equation and representative stream data. Required stream data include slope, Manning's roughness coefficient, and stream dimensions, including mean depths and channel widths. Manning's roughness coefficient was assumed to be 0.05 for all streams (representative of natural streams). Slopes were calculated based on digital elevation model (DEM) data and stream lengths measured from the NHD stream coverage. Stream dimensions were estimated using regression curves that relate upstream drainage area to stream dimensions (Rosgen, 1996).

4.3.8 Hydrologic Representation

Hydrologic processes were represented in the HSPC using algorithms from the PWATER (water budget simulation for pervious land segments) and IWATER (water budget simulation for impervious land segments) modules of HSPF (Bicknell et al., 1996). Parameters associated with infiltration, groundwater flow, and overland flow were designated during model calibration.

4.3.9 Pollutant Representation

In addition to flow, four pollutants were modeled with the HSPC:

- Total aluminum
- Total iron
- Total manganese
- Fecal coliform bacteria

The loading contributions of these pollutants from different nonpoint sources were represented in the HSPC using the PQUAL (simulation of quality constituents for pervious land segments) and IQUAL (simulation of quality constituents for impervious land segments) modules in HSPF (Bicknell et al., 1996). Pollutant transport was represented in the streams using the GQUAL (simulation of behavior of a generalized quality constituent) module. Values for the pollutant representation were refined through the water quality calibration process.

4.4 Dissolved Aluminum TMDL Methodology using Dynamic Equilibrium in-Stream Chemical reactions (DESC)

As stated previously, it was necessary to link the watershed model (MDAS) with the Dynamic Equilibrium in-Stream Chemical reactions model (DESC) to appropriately address dissolved aluminum TMDLs in the Guyandotte River watershed. To establish this linkage, the MDAS model was first set up and calibrated to simulate in-stream concentrations of total metals (iron, aluminum, and manganese). The MDAS calibration process is discussed in detail in Section 4.6. Once calibration was complete, the time series flow and water quality output from MDAS was entered in the DESC to simulate dissolved metals behavior. DESC was then calibrated to further refine the simulation of dissolved metals. The current version of the model supports daily MDAS output files as time series input (the model will interpolate input values based on smaller time steps for the model to be stable).

4.4.1 DESC Overview

The (DESC) model dynamically simulates fate and transport of chemical pollutants in surface water. DESC is capable of simulating water quality in a multiple watershed setting by routing flow from upstream to downstream while simulating the transformation of in-stream water quality constituents.

The DESC model is composed of two major components:

- simulation of pollutant transport and
- simulation of selected chemical reactions using MINTEQ computational codes (EPA, 1991).

The model includes advective and diffusive transport equations that are solved using a numerical solution of the explicit finite difference method. The chemical equilibrium solutions are solved using the Newton-Raphson approximation method to solve mass balance (linear) and mass action equations (nonlinear) as in MINTEQ. The model can simulate various chemical reactions as long as thermodynamic data is available to the model. The MINTEQ database contains information for more than 5,000 chemical reactions. If a targeted chemical reaction is not available in the database, it can be added by the user. For the pollutant transport routine, the DESC utilizes time series or constant total chemical concentrations and flow and the physical characteristics of the stream as inputs. The transport routine assumes one-dimensional trapezoidal stream cross-sections with in-stream concentrations equally distributed throughout each segment. Time series average depth data from the watershed model is used to estimate time series flow. The model fully connects all chemical reactions with the transport routine and pollutants are routed from upstream to downstream allowing for loading inputs from landuses. The model supports all major chemical reactions and some kinetic reactions that need to be considered in the mining-affected stream. Examples of these reactions include:

- Adsorption of metals onto iron oxide included on the surface of clay or other soil particles
- Adsorption of metals onto aluminum oxide
- Saturation calculations with dissolved and precipitated conditions within the water column and sediment
- Kinetic photo iron reduction
- Microbial iron oxidation
- Homogeneous oxidation processes

4.4.2 DESC Calibration

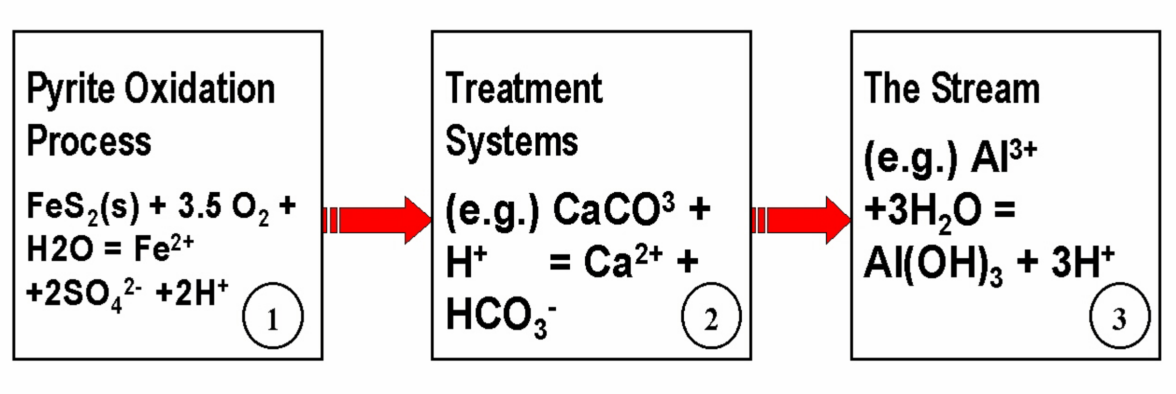
The DESC is equipped with an option for either manual or automatic calibration. The main parameters used to calibrate total and dissolved concentrations are alkalinity values in streams, the settling velocity of freshly precipitated materials, and the time required for precipitated material to be inactive. Theses values were derived based on observed data or literature values. Examples of some of the calibration parameters are listed below:

- Settling velocity
- Incoming ratio of ferric and ferrous iron into the first stream segment
- Selection of solubility constants depending on the maturity of precipitated materials
- Light energy
- Carbonate concentration
- Particle surface area percentage
- Time required for precipitated material to be inactive

4.5 pH TMDL Methodology Overview

4.5.1 Overview

Streams affected by acid mine drainage often exhibit high metals concentrations (specifically for iron [Fe], aluminum [Al], and manganese [Mn]) along with low pH. The relationship between these metals and pH provides justification for using metals TMDLs as a surrogate for a separate pH TMDL calculation. The following figure shows three representative physical components that are critical to establishing this relationship.



Note: Several major ions compose the water chemistry of a stream. The cations are usually Ca^{2+}, Mg^{2+}, Na^+, K^+, and H^+, and the anions consist of HCO_3^-, CO_3^{2-}, NO_3^-, Cl^-, SO_4^{2-}, and OH^- (Stumm and Morgan, 1996).

Component 1 describes the beginning oxidation process of pyrite (FeS_2) resulting from its exposure to H_2O and O_2. This process is common in mining areas. The kinetics of pyrite oxidation processes are also affected by bacteria (Thiobacillus ferrooxidans), pH, pyrite surface area, crystallinity, and temperature (PADEP, 2000). The overall stoichiometric reaction of the pyrite oxidation process is as follows:

$$FeS_2(s) + 3.75\ O_2 + 3.5\ H_2O \longrightarrow Fe(OH)_3\ (s) + 2SO_4^{2-} + 4H^+$$

Component 2 presents an example chemical reaction occurring within a mining treatment system. Examples of treatment systems include wetlands, successive alkalinity-producing systems, and open limestone channels. Carbonate and other bases (e.g., hydroxide) created in treatment systems consume hydrogen ions produced by pyrite oxidation and hydrolysis of metals, thereby increasing pH. The increased pH of the solution will precipitate metals as metal hydroxides. Treatment systems may not necessarily work properly, however, because the removal rate of metals, and therefore the attenuation of pH, depends on chemical constituents of the inflow; the age of the systems; and physical characteristics of the systems such as flow rate and detention rate (West Virginia University Extension Service, 2000).

It is assumed that implementing TMDLs in the Guyandotte watershed for dissolved aluminum, total iron, and total manganese will result in in-stream metals concentrations that meet the water quality criteria. This assumes that treatment systems are implemented properly and effectively increase pH in order to precipitate metals and thus lower their in-stream concentrations.

After treatment, the focus shifts to Component 3 and the relationship between metals concentrations and pH in the stream. The chemical process that needs to be considered is the hydrolysis reaction of metals in the stream. Component 3 presents an example of this reaction. To estimate the pH resulting from chemical reactions occurring in the stream, MINTEQA2, a geochemical equilibrium speciation model for dilute aqueous systems, was used.

4.5.2 MINTEQA2 Application

MINTEQA2 is an EPA geochemical equilibrium speciation model capable of computing equilibrium aqueous speciation, adsorption, gas phase partitioning, solid phase saturation states, and precipitation-dissolution of metals in an environmental or lab setting. The model includes an extensive database of reliable thermodynamic data. The MINTEQA2 model was run for each of the pH impaired streams in the Guyandotte watershed using the inputs shown in Table 4-9.

Table 4-9. Input values for MINTEQA2

Species	Input Values (mg/L)
Ca	18
Mg	12
Na [(a)]	6.3
K [(a)]	2.3
Cl [(a)]	7.8
SO_4	77.0
Fe [(b)]	1.5
Al	Maximum observed value for specific pH impaired stream
Mn [(b)]	1.0
Alkalinity	56.0 (as $CaCO_3$)

[a] source: Livingstone (1963)
[b] allowable maximum concentrations (TMDL endpoints)

Input values for Fe and Mn were based on TMDL endpoints (maximum allowable limits). Since dissolved aluminum TMDLs were only developed for selected streams in the Guyandotte watershed, aluminum TMDL endpoints could not be used. Therefore, the maximum observed concentrations for the specific pH impaired stream were used as the total aluminum inputs. The alkalinity value was based on the geometric mean of observed in-stream concentrations in the Guyandotte watershed. Similarly, the geometric mean of observation values were used for the remaining ions requiring input for MINTEQA2. Where observation data were not available, literature values were used for the chemical species. Additionally, the model was set to equilibrium with atmospheric CO_2. The resultant equilibrium pH for each of the pH impaired streams are presented in Table 4-10.

Table 4-10. MINTEQA2 results for the pH impaired streams in the Guyandotte River watershed

DNR Name	DNR Code	Pollutant	Maximum Observed Total Aluminum (ug/L)	pH (MINTEQ)
Buffalo Creek	OG-61	pH	9.96	7.40
Buffalo Creek/Little Huff Creek	OG-92-K	pH	0.20	8.28
Coal Branch/Island Creek	OG-65-A	pH	3.00	8.14
Copperas Mine Fork	OG-65-B	pH	3.90	8.09
Ed Stone Branch/Big Creek	OG-49-A	pH	0.87	8.25
Ellis Branch/Mud Fork	OG-65-B-1-B	pH	0.29	8.27
Godby Branch	OG-53	pH	4.65	8.03
Limestone Branch	OG-48	pH	0.90	8.25
Lower Dempsey Branch	OG-65-B-1-A	pH	3.70	8.10
Measle Fork	OG-134-D	pH	5.79	7.94
Mud Fork	OG-65-B-1	pH	1.80	8.21
North Branch/Big Creek Ed Stone Branch	OG-49-A-1	pH	1.52	8.22
Oldhouse Branch/Rockhouse Creek	OG-77-A.5	pH	8.00	7.65
Proctor Hollow/Buffalo Creek	OG-75-C.5	pH	3.00	8.14
Right Fork/Buffalo Creek	OG-61-A	pH	no value	-
Trace Fork/Copperas Mine Fork	OG-65-B-4	pH	3.00	8.14
Upper Dempsey Branch	OG-65-B-1-E	pH	6.70	7.84

Results from MINTEQA2 imply that pH will be within the West Virginia criterion of above six and below nine (inclusive), provided that in-stream metals concentrations simultaneously meet applicable water quality criteria. Once in-stream metal concentrations are within water quality criteria, natural alkalinity present within the Guyandotte River watershed will also help to resolve pH impairments.

4.5.3 Assumptions

The chemical processes generating AMD and the processes to treat AMD are subject to many variables which may or may not be addressed in the chemical equations. Some of these variables are discussed below.

Iron (Fe)

Ferric iron was selected as total iron based on the assumption that the stream will be in equilibrium with the atmospheric oxygen. Because iron exhibits oxidized and reduced states, the redox portion of the iron reactions may need to be considered. The reduced state of iron, ferrous iron, can be oxidized to ferric iron through abiotic and biotic oxidation processes in the stream. The first process refers to oxidation by increasing the dissolved oxygen through the mixing of flow. The other process is oxidation by microbial activity in acidic conditions on bedrock (Mcknight and Bencala, 1990). Photoreduction of hydrous oxides can also increase the dissolved ferrous form. This reaction could increase the pH of the stream followed by oxidation and hydrolysis reactions of ferrous iron (Mcknight, Kimball and Bencala, 1988). Since water quality data are limited, the concentration of total Fe was assumed to be constant at 1.5 mg/L, and it was assumed that the total Fe increase by photoreduction would be negligent. This assumption could ignore pH changes during daytime.

Sodium (Na), Potassium (K), and Chloride (Cl)

The concentration of Na, K, and Cl can be higher in streams affected by acid mine drainage. These ions are conservative and are not reactive in natural water, however, so it is likely that the pH of the stream would not be affected.

Calcium (Ca), Magnesium (Mg*)*

Ca and Mg ions may have higher concentrations than the values used for the modeling in this study due to the dissolution of minerals under acidic conditions and the reactions within treatment systems. Increasing the concentrations of these ions in the stream, however, could result in more complex forms with sulfate in the treatment system and in the river. This should not affect pH.

Manganese (Mn)

Manganese oxide (MnO_2) can have a redox reaction with ferrous iron and produce ferric iron (Evangelou, 1998). This ferric iron can then undergo a hydrolysis reaction and produce hydrogen ions, thereby decreasing pH.

Biological Activities

Biological activities such as photosynthesis, respiration, and aerobic decay can influence the pH of localized areas in the stream. Biological reactions such as the following:

$$CO_2 + H_2O \longleftrightarrow 1/6\ C_6H_{12}O_6 + O_2$$

will assimilate CO_2 during photosynthesis and produce CO_2 during respiration or aerobic decay. Reducing CO_2 levels will increase the pH and increasing CO_2 levels will lower the pH of the water (Langmuir, 1997). It is possible that as a result of these biological activities, the pH standards might be violated even though metals concentrations are below in-stream water quality standards.

Kinetic Considerations

The kinetic aspect of metal reactions in the stream is an important factor that also needs to be considered. For example, Fe and Mn can be oxidized very rapidly if the pH of the solution is 7.5 to 8.5; otherwise, the oxidization process is much slower (Evangelou, 1995). Violation of metals concentrations without pH violation might be a result of reaction kinetics.

4.6 MDAS Model Calibration

After the model was configured, calibration was performed at multiple locations throughout the Guyandotte River watershed. Calibration refers to the adjustment or fine-tuning of modeling parameters to reproduce observations. Model calibration focused on two main areas: hydrology and water quality. Upon completion of the calibration at selected locations, the calibrated dataset containing parameter values for modeled sources and pollutants was complete. This dataset was applied to areas where calibration data were not available.

A significant amount of time-varying monitoring data were necessary to calibrate the model. Available monitoring data in the watershed were identified and assessed for application to calibration (Tables 3a, 3b, 3c. 3d, 3e, 3f, 3g, 3h and 3i in each of Appendices A-1 through A-14). Only monitoring stations with data that represented a range of hydrologic conditions, source types, and pollutants were selected.

4.6.1 Hydrology Calibration

Hydrology was the first model component calibrated. The hydrology calibration involved a comparison of model results to in-stream flow observations at selected locations and the subsequent adjustment of hydrologic parameters. Key considerations included the overall water balance, the high-flow low-flow distribution, storm flows, and seasonal variation.

In order to best represent hydrologic variability throughout the watershed, three locations with daily flow monitoring data were selected for calibration. The stations were USGS 03204000 Guyandotte at Branchland, USGS 03203600 Guyandotte at Logan, and USGS 03202750 Clear Fork at Clear Fork. The model was calibrated at these three locations for water years 1994 and 1995 by running the model over a calibration time period of 10/1/1993 - 9/30/1995. Flow-frequency curves, temporal comparisons (daily and monthly), and comparisons of high flows and low flows were developed to support calibration. The calibration involved adjustment of infiltration, subsurface storage, evapotranspiration, surface runoff, and interception storage parameters.

After adjusting the appropriate parameters within acceptable ranges, good correlations were found between model results and observed data for the comparisons made. Flow-frequency curves and temporal analyses are presented in Appendix F. Hydrology calibration statistics are shown in Table 4-11.

Parameter values were validated for an independent, extended time period (10/1/1983 through 9/30/1993) after calibrating parameters at the stations. The station chosen for validation was USGS 0320400 Guyandotte at Branchland. Validation involved comparison of model results and flow observations without further adjustment of parameters. The validation comparisons also showed a good correlation between modeled and observed data. Figure 4-4 presents a monthly summary of validation results. Refer to Appendix F for more detailed validation results.

Table 4-11. Comparison of simulated and observed flow for water years 1994 and 1995 (USGS 03203600)

Simulated versus Observed Flow	Percent Error	Recommended Criterion[1]
Error in total volume	**12.49**	+/- 10%
Error in 50% lowest flows	**32.94**	+/- 10%
Error in 10% highest flows	**-3.43**	+/- 15%
Seasonal volume error - Summer	**26.14**	+/- 30%
Seasonal volume error - Fall	**28.77**	+/- 30%
Seasonal volume error - Winter	**1.20**	+/- 30%
Seasonal volume error - Spring	**18.62**	+/- 30%
Error in storm volumes	**-17.58**	+/- 20%
Error in summer storm volumes	**-14.48**	+/- 50%

[1] Recommended Criterion: HSPExp

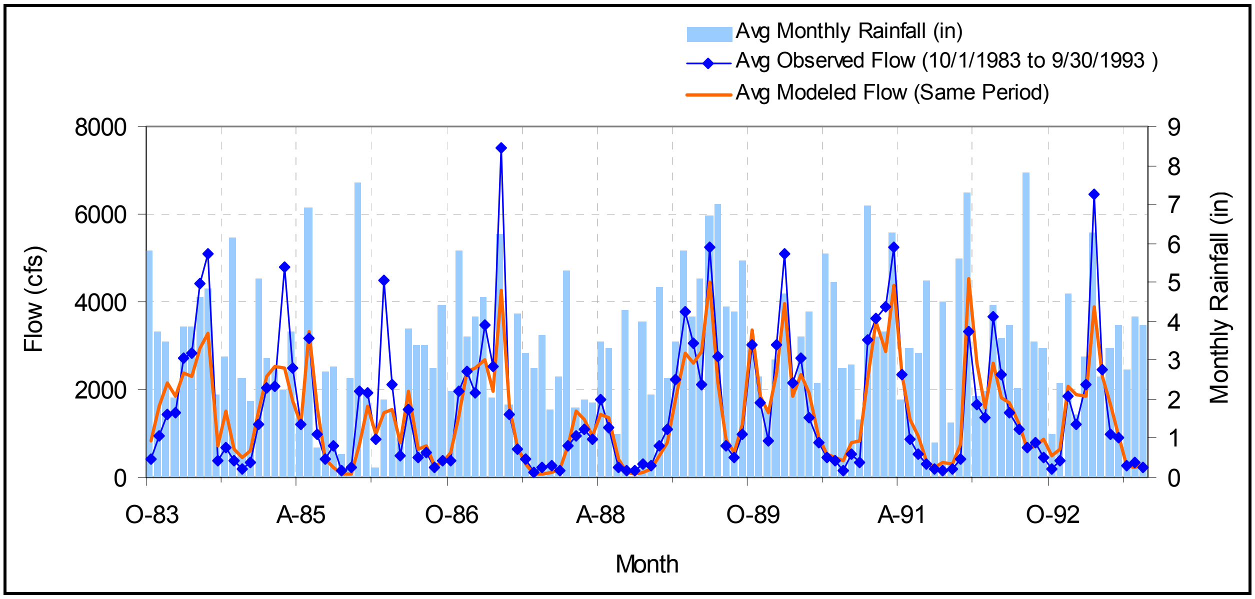


Figure 4-4. Comparison of Simulated and Observed Flow for the validation period (USGS 0320400 Guyandotte at Branchland)

4.6.2 Water Quality Calibration

After calibration for hydrology is complete, water quality calibration is performed. In the broadest sense, calibration consists of executing the watershed model, comparing time series water quality output to available water quality observation data, and adjusting water quality parameters within a reasonable range. In order to establish reasonable ranges for use in water quality calibration, DMR and high flow data were analyzed to develop appropriate water quality parameters for active mines (surface, deep, and other mines, but not AML or revoked mines) and barren lands. Reasonable water quality parameters for AML were based on previous watershed modeling experience in areas with AML (*pH and Metals TMDLs for the Tug Fork River Watershed, 2002* and *pH and Metals TMDL for the West Fork River Watershed, 2002*). Parameters for background conditions were based on observed water quality data.

The approach taken to calibrate water quality focused on matching trends identified during the water quality analysis. The water quality calibration period was 1994-2001. Daily average in-stream concentrations from the model were compared directly to observed data. Observed data were obtained from EPA's STORET database as well as from WVDEP Division of Water and Waste Management, and data submitted by various mining companies throughout the watershed. All data were obtained through WVDEP. The objective was to best simulate low flow, mean flow, and storm peaks at representative water quality monitoring stations. Representative stations were selected based on both location (distributed throughout the Guyandotte watershed) and loading source type. Results of the water quality calibration are presented in Appendix F.

4.7. Selenium TMDL Methodology Overview

As discussed in Section 4-1, the TMDL approach must consider the dominant processes regarding pollutant loadings and in-stream fate. For the impaired tributaries of the upper Mud River, the primary sources contributing to selenium impairments are the point sources associated with the surface mines. A pollutant flow analysis was performed in order to evaluate critical flow periods for comparison to water quality criteria for selenium. Measured flow data and the observed in-stream concentrations from Stations 6 through 9 were used in the analyses. In general, in-stream selenium concentrations increased during low flow conditions as shown in Figure 4-5.

The critical low flow condition was determined by calculating the 7Q10 flow for the streams in the upper Mud River watershed. Since there are no USGS flow gaging stations in the upper Mud River watershed that have data for extended periods, the calibrated model flow from MDAS was used to determine the low flow 7Q10 conditions. Based on the 7Q10 analyses, all areas upstream of Upton Branch have a low flow 7Q10 of 0cfs as shown in Figure 4-6.

Since the primary sources contributing to selenium impairments are the point sources at a low flow 7Q10 condition of 0 cfs, the nonpoint source contributions of selenium were considered to be negligible. Therefore, the TMDLs were based on wasteload allocations assigned at water quality criteria for selenium at the end of pipe for the surface mining discharging upstream of the 7Q10 condition of 0cfs (Upton Branch).

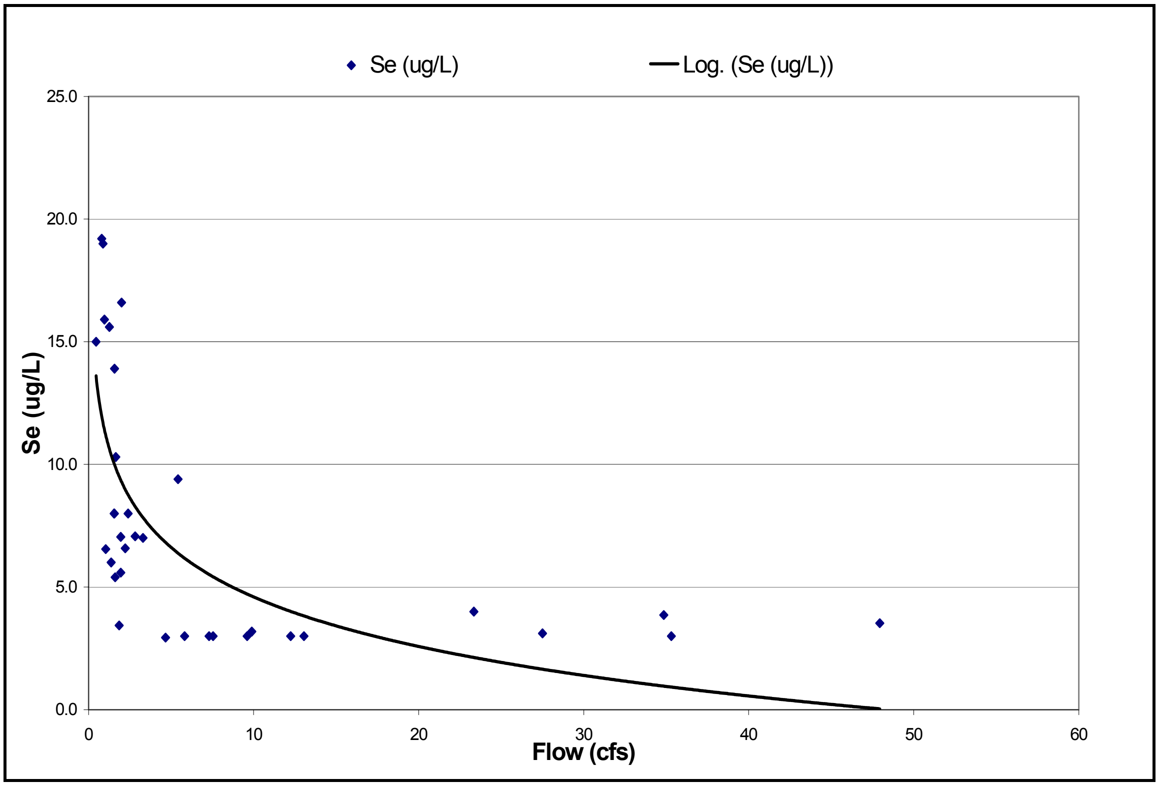


Figure 4-5. Selenium-Flow correlation analysis for Stations 6 through 9

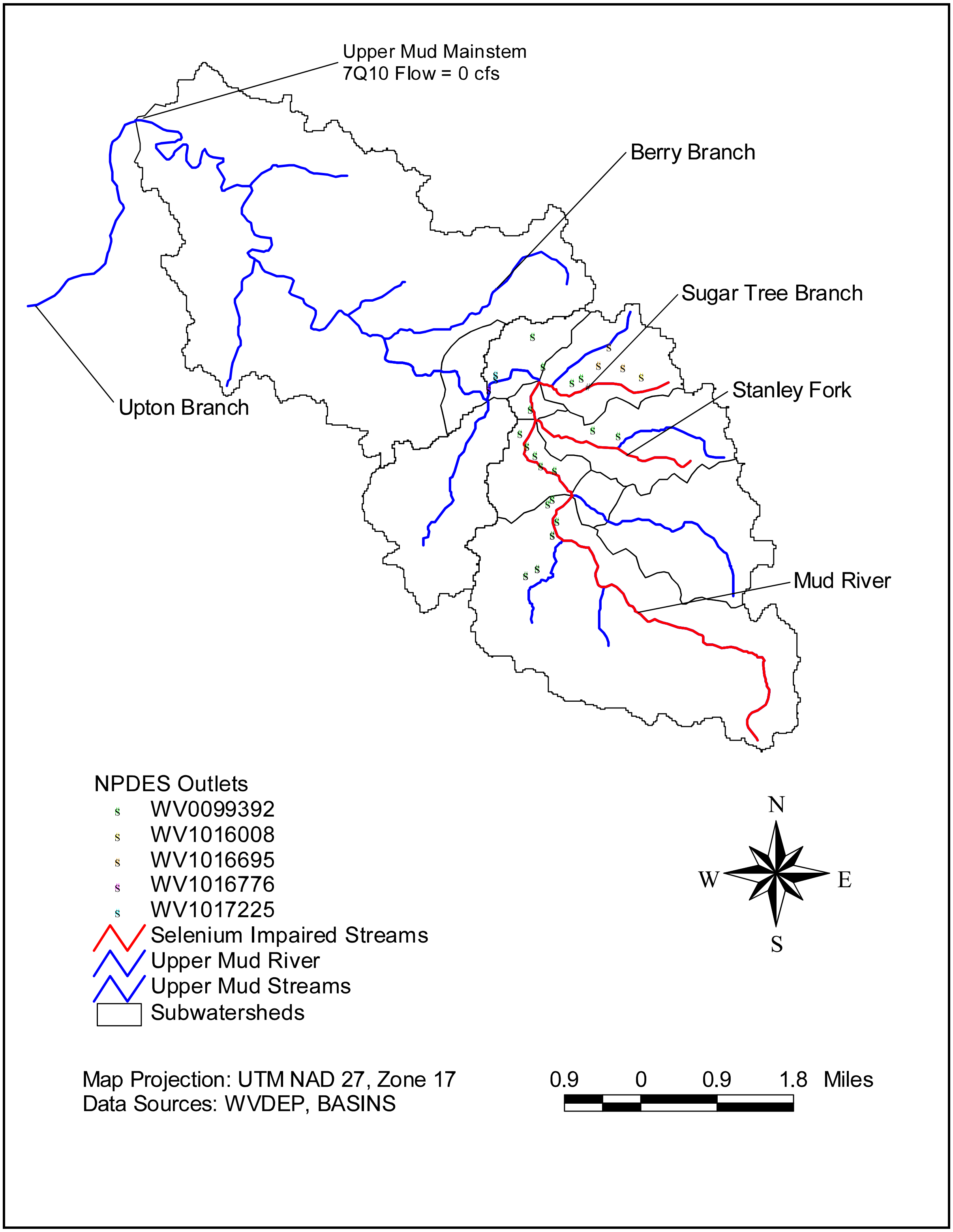


Figure 4-6. Upper Mud Watershed where the low 7Q10 flow was calculated to be 0 cfs

5.0 Allocation Analysis

TMDLs are comprised of the sum of individual wasteload allocations (WLAs) for point sources, load allocations (LAs) for nonpoint sources, and natural background levels. In addition, the TMDL must include a margin of safety (MOS), either implicitly or explicitly, that accounts for the uncertainty in the relationship between pollutant loads and the quality of the receiving water body. TMDLs can be expressed in terms of mass per time or by other appropriate measures. Conceptually, this definition is denoted by the equation:

TMDL= Summation of WLAs + Summation of LAs + MOS

In order to develop aluminum, iron, manganese, selenium, pH, and fecal coliform bacteria TMDLs for each of the waterbodies in the Guyandotte watershed listed on the West Virginia Section 303(d) list, the following approach was taken:

- Define TMDL endpoints
- Simulate baseline conditions
- Assess source loading alternatives
- Determine the TMDL and source allocations

5.1 TMDL Endpoints

TMDL endpoints represent the in-stream water quality targets used in quantifying TMDLs and their individual components. Different TMDL endpoints are necessary for dissolved aluminum, total iron, manganese, pH, selenium, and fecal coliform bacteria. West Virginia's numeric water quality criteria for the subject pollutants (identified in Section 2) and an explicit margin of safety (MOS) were used to identify endpoints for TMDL development.

5.1.1 Dissolved Aluminum, Total Iron, and Manganese

The TMDL endpoints for dissolved aluminum were selected as selected as 712.5 ug/L (based on the 750 ug/L acute criteria for aquatic life minus a 5 percent MOS) and 82.7 ug/L (based on the 87 ug/L chronic criteria for aquatic life minus a 5 percent MOS). The endpoint for total iron was selected as 1.425 mg/L (based on the 1.5 mg/L criteria for aquatic life minus a 5 percent MOS). The endpoint for manganese was selected as 0.95 mg/L (based on the 1.0 mg/L criteria for human health minus a 5 percent MOS).

Components of the TMDLs for aluminum, iron, and manganese are presented in terms of mass per time for nonpoint sources and mass per time and mass per volume for point sources in this report.

5.1.2 Fecal Coliform Bacteria

The endpoint for fecal coliform bacteria was selected as the instantaneous endpoint of 380 counts/100mL based on the 400 counts/100mL criterion for human health minus a 5 percent MOS and the geometric mean endpoint of 190 counts/100mL based on the 200 counts/100mL geometric mean criterion minus an approximate 5 percent MOS. The instantaneous criterion is more stringent and more difficult to obtain, however, both criteria are satisfied in this TMDL.

5.1.3 Selenium

In meeting the West Virginia water quality criteria for selenium at the end of pipe for the surface mining point sources, there will be no excessive contribution of selenium to the streams in the upper Mud River watershed at the low flow 7Q10 conditions where the assimilative capacity is lowest. This results in the inclusion of an implicit margin of safety. Determination of an explicit margin of safety is not necessary for these particular TMDLs because in presenting the allocations as a concentration at the water quality criteria for selenium the sources will comply with the water quality standards and there will be no uncertainty involved.

5.1.4 pH

The water quality criteria for pH requires it to be above six and below nine (inclusive). In the case of acid mine drainage, pH, is not a good indicator of the acidity in a waterbody and can be a misleading characteristic. Water with near neutral pH (~seven) but containing elevated concentrations of dissolved ferrous (Fe^{2+}) ions can become acidic after oxidation and precipitation of the iron (PADEP, 2000). Therefore, a more practical approach to meeting the water standards of pH is to use the concentration of metal ions as a surrogate for pH. Through reducing in-stream metals, namely iron, to meet water quality criteria (or TMDL endpoints), it is assumed that the pH will result in meeting the WQS. This assumption is based on the application of MINTEQA2, a geochemical equilibrium speciation model, to aqueous systems representative of waterbodies in the Guyandotte watershed. By inputting into the model the total concentrations of metals, a pH value can be predicted. Refer to Section 4.5 for a detailed description of the modeling.

5.1.5 Margin of Safety

An implicit MOS was included in TMDL development through application of a dynamic model for simulating daily loading over a wide range of hydrologic and environmental conditions, and through the use of conservative assumptions in model calibration and scenario development. In addition to this implicit margin of safety, a 5 percent explicit MOS was used to account for the differences between modeled and monitored data. Long-term water quality monitoring data were used for model calibration. While these data represented actual conditions, they were not continuous time series and may not have captured the full range of in-stream conditions that occurred during the simulation period. The explicit 5 percent MOS also accounts for those cases where monitoring data may not have captured the full range of in-stream conditions.

5.2 Baseline Conditions

The calibrated model provided the basis for performing the allocation analysis. The first step in this analysis involved simulation of baseline conditions. Baseline conditions represent existing nonpoint source loading conditions, unpermitted source loading conditions, and permitted point source discharge conditions. The baseline conditions allow for an evaluation of in-stream water quality under the “worst currently allowable” scenario.

The MDAS model was run for baseline conditions using hourly precipitation data for a representative 6-year time period. The precipitation experienced over this period was applied to the landuses and pollutant sources as they existed at the time of this TMDL development. Predicted in-stream concentrations were compared directly to the TMDL endpoints. Using the model linkage described in Section 4.5, total aluminum was simulated using the MDAS model and the DESC model was used to compare predicted dissolved aluminum concentrations to the TMDL endpoint. This comparison allowed evaluation of the expected magnitude and frequency of exceedances under a range of hydrologic and environmental conditions, including dry periods, wet periods, and average periods.

Figure 5-1 presents the annual rainfall totals for the years 1980 through 2001 at the Logan, WV weather station. The years from 1987-1992 are marked to indicate that a range of precipitation conditions was used for TMDL development in the Guyandotte watershed.

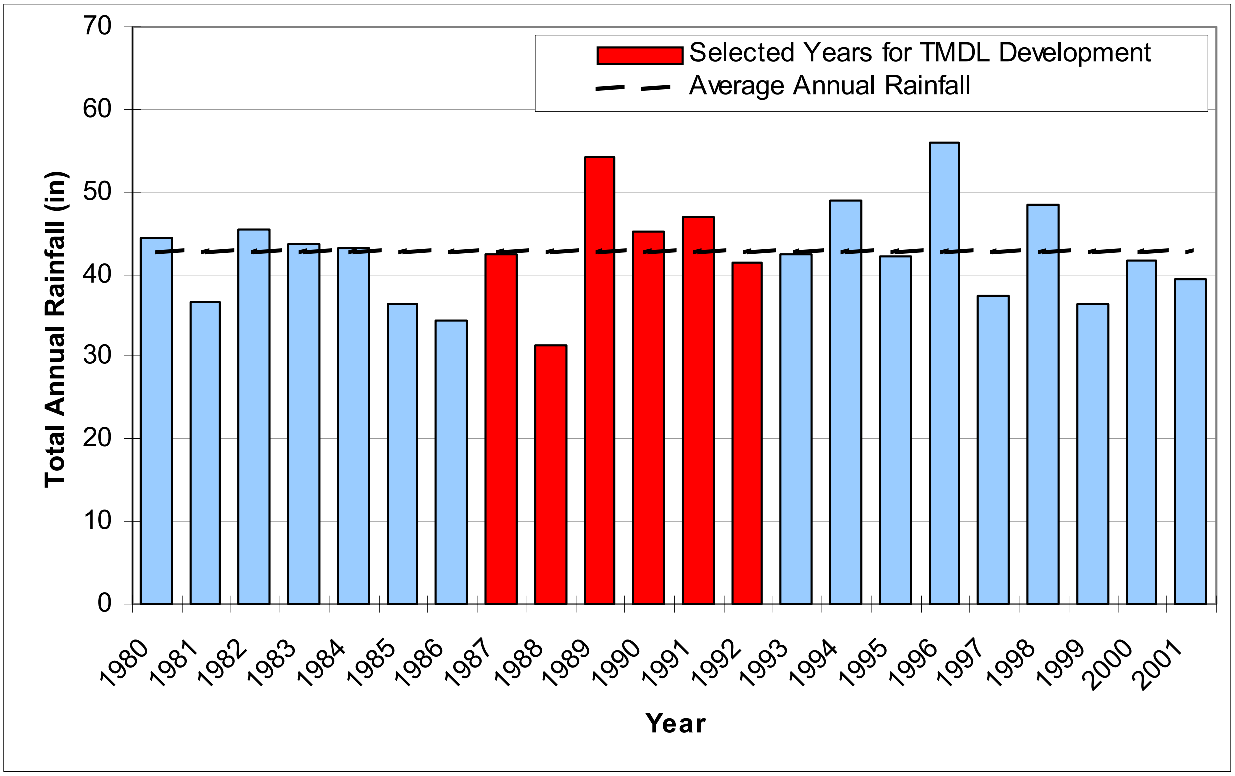


Figure 5-1. Annual Precipitation totals and Percentile Ranks for the Logan weather station

Permitted conditions for the mining facilities were represented using precipitation-driven flow estimations and the metals concentrations presented in Table 5-1.

Table 5-1. Metals concentrations used in representing permitted conditions for mines

Pollutant	Technology-based Permits	Water Quality-based Permits
Aluminum, total	3.27 mg/L (98th percentile DMR values)	monitor only
Iron, total	3.2 mg/L	1.5 mg/L
Manganese, total	2.0 mg/L	1.0 mg/L

Permitted conditions for fecal coliform bacteria point sources were represented during baseline conditions using the design flow for each facility and the monthly average discharge of 200 counts/100mL.

5.3 Source Loading Alternatives

Simulation of baseline conditions provided the basis for evaluating each stream's response to variations in source contributions under virtually all conditions. This sensitivity analysis gave insight into the dominant sources and how potential decreases in loads would affect in-stream metals concentrations. For example, loading contributions from abandoned mines, permitted facilities, and other nonpoint sources were individually adjusted and in-stream concentrations were observed.

Multiple scenarios were run for the impaired waterbodies. Successful scenarios were those that achieved the TMDL endpoints under all conditions for dissolved aluminum, iron, manganese, and fecal coliform bacteria throughout the 6-year modeling period. For dissolved aluminum scenario development, the DESC was compared directly to TMDL endpoint. If predicted dissolved aluminum concentrations exceeded the TMDL endpoint, the total aluminum sources represented in MDAS were reduced. Exceedances for dissolved aluminum and iron were allowed once every three years. The averaging period associated with each water quality criterion was considered in these assessments. In general, loads contributed by sources that had the greatest impact on in-stream concentrations were reduced first. If additional load reductions were required to meet the TMDL endpoints, then subsequent reductions were made in point source (permitted) contributions.

An example of the concentrations for baseline and TMDL conditions for iron are presented in Figure 5-2.

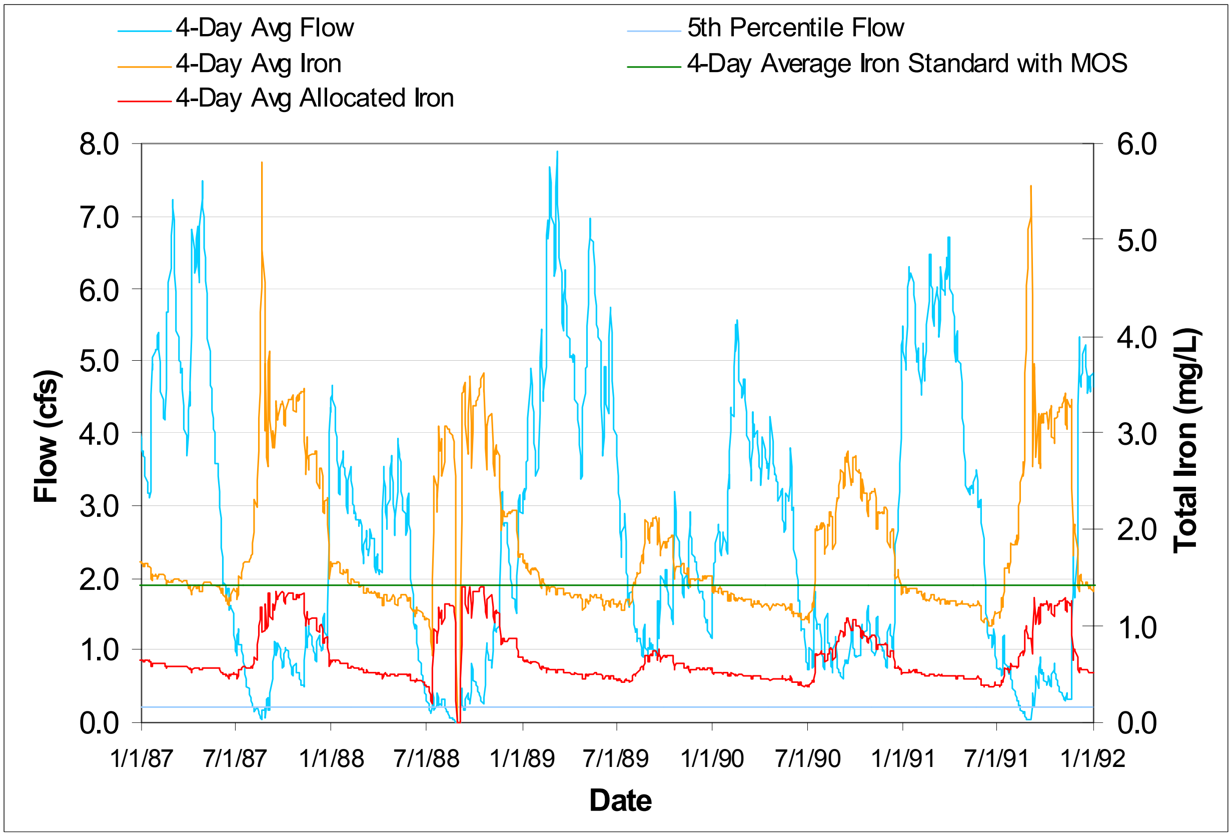


Figure 5-2. Baseline and TMDL conditions for iron

5.4 TMDLs and Source Allocations

5.4.1 Dissolved Aluminum, Total Iron and Total Manganese TMDLs

TMDLs and source allocations were developed for impaired segments of tributaries in the Guyandotte watershed. A top-down methodology was followed to develop these TMDLs and allocate loads to sources. Headwaters were first analyzed, because their impact frequently had a profound effect on down-stream water quality. Loading contributions were reduced from applicable sources for these waterbodies and TMDLs were developed. Source reductions never resulted in loading contributions less than natural conditions represented by the undisturbed forest (Table 5-2). Model results from the selected successful scenarios were then routed through down-stream waterbodies. Therefore, when TMDLs were developed for down-stream impaired waterbodies, up-stream contributions were representing existing or unreduced conditions from unimpaired streams and reduced conditions from impaired streams. Using this method, contributions from all sources were weighted equitably. In some situations, reductions in sources impacting unlisted headwaters were required in order to meet downstream water quality criteria. In other situations, reductions in sources impacting impaired headwaters ultimately led to improvements down-stream. This effectually decreased required loading reductions from potential down-stream sources.

The following general methodology was used when allocating to sources for the Guyandotte watershed TMDLs.

- For watersheds with AMLs but no permitted point sources, AMLs were reduced first, until in-stream water quality criteria were met or to conditions no less than those of undisturbed forest. If further reductions were required, then the sediment sources (Harvested Forest, Burned Forest, Oil and Gas operations, and Roads) were reduced until water quality criteria were met.
- For watersheds with AMLs and point sources, point sources were set at the precipitation induced load defined by the permit limits and AMLs were subsequently reduced. AMLs and revoked mining permits were reduced (point sources were not reduced) until in-stream water quality criteria were met, if possible. If further reduction was required once AMLs and revoked mines were reduced, sediment sources were then reduced. If even further reduction was required, the point source discharge limits were then reduced.
- For watersheds where dissolved aluminum TMDLs were developed, source allocations for total iron and manganese were developed first since their total in-stream concentrations (primarily iron) significantly reduce pH and consequently increase dissolved aluminum concentrations. If the dissolved aluminum TMDL endpoint was not attained after source reductions to iron and manganese, the total aluminum sources were reduced based on the methodology described above.

Table 5-2. Source Reduction (AML) for SWS 209

Parameter	Landuse	Total Area (acres)	Base Load (lb/yr)	Base Unit Area (lb/ac/yr)	Allocated Load (lb/yr)	Allocated Unit Area Loading (lb/ac/yr)
Aluminum	Undisturbed Forest	1000.00	390	0.39	390	0.39
Aluminum	AML	1000.00	224,989	224.99	9,000	9.00
Iron	Undisturbed Forest	1000.00	355	0.36	355	0.36
Iron	AML	1000.00	88,079	88.08	4,404	4.40
Manganese	Undisturbed Forest	1000.00	217	0.22	217	0.22
Manganese	AML	1000.00	391,081	391.08	7,822	7.82

Maximum Reductions: Fe: 95%; Al: 96%; Mn: 98%

The TMDLs for the Guyandotte watershed were determined on a subwatershed basis for each of the 14 defined regions.

Wasteload Allocations (WLAs)

Waste load allocations (WLAs) were made for all permitted mining operations except for limestone quarries and those with a Completely Released or Phase Two Released classification.

Loading from revoked permitted facilities was assumed to be a nonpoint source contribution based on the absence of a permittee.[1].

Based on the types of activities and the nature of their discharges, permitted non-mining sources (shown in Table 3-3) are believed to be negligible. Under this TMDL, these minor discharges are assumed to operate under their current permit limits. These facilities will be assigned WLAs that allow them to discharge at their current permit limits.

The WLAs for iron and manganese are presented in Tables 4a and 4b in Appendices A-1 through A-14, respectively. The WLAs for the dissolved aluminum TMDLs are presented in terms of total aluminum in Table 4c of Appendixes A-7 - A-14. TMDLs were based on a dissolved aluminum TMDL endpoint, however sources were represented in terms of total aluminum, therefore dissolved aluminum TMDLs are presented in total terms. The WLAs are presented as annual loads, in terms of pounds per year and as constant concentrations. They are presented on an annual basis as an average annual load, because they were developed to meet TMDL endpoints under a range of conditions observed throughout the year. Using the WLAs presented, permit limits can be derived using EPA's *Technical Support Document for Water Quality-based Toxics Control* (USEPA, 1991) to find the monthly average discharge concentration. The WLA concentration ranges are as follows: Al: 0.75-3.72 mg/L, Fe:1.5 -3.2 mg/L, Mn: 1.0-2.0 mg/L.

Construction permits are modeled as background and are accounted for in Tables 5a, 5b, and 5c of Appendix A as "Other NPS." Therefore, the construction permits' limits are equivalent to existing limits and no reductions are required to achieve and maintain water quality standards.

Load Allocations (LAs)

Load allocations (LAs) were made for the dominant source categories, as follows:

- Abandoned mine lands - including abandoned mines (surface and deep) and high walls
- Revoked permits - loading from revoked permitted facilities
- Sediment sources - metals loading associated with sediment contributions from harvested forest, oil and gas well operations, and roads
- Other nonpoint sources - urban, agricultural, and forested land contributions (loadings from other nonpoint sources were not reduced)

The LAs for iron and manganese are presented in Tables 5a and 5b for each of Appendixes A-1 through A-14. The LAs for the dissolved aluminum TMDLs are presented in terms of total aluminum in Table 5c of Appendixes A-7 through A-14. TMDLs were based on a dissolved aluminum TMDL endpoint, however sources were represented in terms of total aluminum, therefore dissolved aluminum TMDLs are presented in total terms. The LAs are presented as annual loads, in terms of pounds per year. They are presented on an annual basis (as an average

---

[1] The decision to assign load allocations to abandoned and reclaimed mine lands does not reflect any determination by EPA as to whether there are unpermitted point source discharges within these landuses. In addition, in establishing these TMDLs with mine drainage discharges treated as load allocations, EPA is not determining that these discharges are exempt from NPDES permitting requirements.

annual load), because they were developed to meet TMDL endpoints under a range of conditions observed throughout the year. Tables 5-3, 5-4, and 5-5 present the summation of the LAs and the summation of the WLAs for aluminum, iron, and manganese for each of the 303(d) listed segments.

Table 5-3. Load and waste load allocations for dissolved aluminum

Region	DNR-Code	DNR-Name	Baseline LA	LA	Baseline WLA	WLA	MOS	TMDL	Percent Reduction
1	O-4	Guyandotte River	2,559,382	770,442	715,044	687,657	76,742	1,534,841	55
1	OG-51	Crawley Creek	4,348	4,348	0	0	229	4,577	0
11	OG-100	Clear Fork (OGC)	460,464	121,115	66,410	59,338	9,498	189,951	66
14	OG-134	Slab Fork	18,936	10,598	2,543	2,543	692	13,833	39
14	OG-138	Winding Gulf	160,013	31,576	14,270	14,270	2,413	48,259	74
5	OG-49	Big Creek	27,641	13,793	1,026	1,026	780	15,599	48
6	OG-65-B	Copperas Mine Fork	103,302	17,750	59,827	59,827	4,083	81,660	52
7	OG-89	Gilbert Creek	27,811	7,855	29,029	27,912	1,882	37,649	37
7	OG-96	Big Cub Creek	27,050	6,278	10,780	10,780	898	17,956	55
8	OG-75	Buffalo Creek	50,985	12,409	80,003	60,806	3,853	77,068	44

TMDLs were based on a dissolved aluminum TMDL endpoint, however sources were represented in terms of total aluminum, therefore dissolved aluminum TMDLs are presented in total terms.

Table 5-4. Load and waste load allocations for iron

Region	DNR-Code	DNR-Name	Baseline LA	LA	Baseline WLA	WLA	MOS	TMDL	Percent Reduction
1	O-4	Guyandotte River	760,790	421,132	710,685	515,830	49,314	986,276	36
1	OG-10-A	Right Fork/Merritt Creek	272	272	0	0	14	286	0
1	OG-48	Limestone Branch	294	268	0	0	14	282	9
1	OG-51	Crawley Creek	3,261	2,962	0	0	156	3,118	9
1	OG-53	Godby Branch	56	56	0	0	3	59	0
1	OG-61	Buffalo Creek	3,149	847	0	0	45	892	73
1	OG-61-A	Right Fork/Buffalo Creek	64	64	0	0	3	68	0
10	OG-92-I	Muzzle Creek	1,750	1,343	0	0	71	1,414	23
10	OG-92-K	Buffalo Creek/Little Huff Creek	1,338	534	112	112	34	680	55
10	OG-92-K-1	Kezee Fork	65	65	0	0	3	69	0
10	OG-92-K-2	Mudlick Fork/Buffalo Creek	16	16	0	0	1	16	0
10	OG-92-Q	Pad Fork	4,310	1,497	506	506	105	2,109	58
10	OG-92-Q-1	Righthand Fork/Pad Fork	872	383	380	380	40	804	39
11	OG-100	Clear Fork (OGC)	96,785	44,298	66,783	58,120	5,390	107,808	37
11	OGC-12	Lower Road Branch	1,995	732	3,753	2,064	147	2,944	51
11	OGC-16	Laurel Fork	52,779	25,096	23,899	20,476	2,399	47,971	41
11	OGC-16-M	Milam Branch	2,076	1,706	0	0	90	1,796	18
11	OGC-16-P	Trough Fork	4,624	2,916	3,699	3,560	341	6,817	22
11	OGC-19	Toney Fork/Clear Fork	3,013	2,169	4,062	4,062	328	6,560	12
11	OGC-26	Crane Fork	8,033	1,678	2,779	2,779	235	4,692	59

Region	DNR-Code	DNR-Name	Baseline LA	LA	Baseline WLA	WLA	MOS	TMDL	Percent Reduction
12	OG-110	Indian Creek	7,812	6,703	40,586	28,130	1,833	36,666	28
12	OG-110-A	Brier Creek/Indian Creek	394	394	153	153	29	575	0
12	OG-110-A-2	Marsh Fork/Brier Creek	70	70	109	109	9	189	0
13	OG-124	Pinnacle Creek	25,744	8,827	50,291	43,092	2,733	54,651	32
13	OG-124-D	Smith Branch/Pinnacle Creek	497	497	240	240	39	775	0
13	OG-124-H	Laurel Branch/Pinnacle Creek	55	55	809	606	35	696	23
13	OG-124-I	Spider Creek	285	285	34	34	17	336	0
14	OG-131	Barkers Creek	17,532	11,597	5,840	5,840	918	18,355	25
14	OG-131-B	Hickory Branch/Barkers Creek	351	351	0	0	18	370	0
14	OG-131-F	Gooney Otter Creek	8,785	3,341	4,559	4,559	416	8,316	41
14	OG-131-F-1	Jims Branch/Gooney Otter Creek	389	160	0	0	8	169	59
14	OG-131-F-2	Noesman Branch	1,301	530	573	573	58	1,161	41
14	OG-134	Slab Fork	10,630	8,317	2,489	2,489	569	11,374	18
14	OG-134-D	Measle Fork	124	124	0	0	7	130	0
14	OG-135-A	Left Fort/Allen Creek	2,652	564	0	0	30	594	79
14	OG-137	Devils Fork	4,519	4,519	0	0	238	4,757	0
14	OG-138	Winding Gulf	46,604	16,604	13,966	13,966	1,609	32,179	50
14	OG-139	Stonecoal Creek	14,328	5,279	3,460	3,460	460	9,199	51
5	OG-49	Big Creek	8,588	6,670	1,004	1,004	404	8,078	20
5	OG-49-A	Ed Stone Branch/Big Creek	73	73	0	0	4	77	0
5	OG-49-A-1	North Branch/ Ed Stone Branch	26	26	0	0	1	28	0
6	OG-65-A	Coal Branch/Island Creek	960	366	0	0	19	386	62
6	OG-65-B	Copperas Mine Fork	30,340	13,410	58,552	41,575	2,894	57,879	38
6	OG-65-B-1	Mud Fork	13,107	6,131	0	0	323	6,454	53
6	OG-65-B-1-A	Lower Dempsey Branch	1,434	516	0	0	27	544	64
6	OG-65-B-1-B	Ellis Branch/Mud Fork	2,049	829	0	0	44	872	60
6	OG-65-B-1-E	Upper Dempsey Branch	435	166	0	0	9	175	62
6	OG-65-B-4	Trace Fork/Copperas Mine Fork	6,679	1,030	13,877	8,326	492	9,848	54
7	OG-108	Little Cub Creek/Upper Guyandotte River	2,185	763	0	0	40	804	65
7	OG-127	Cabin Creek	861	861	331	331	63	1,255	0
7	OG-128	Joe Branch	2,787	483	791	791	67	1,341	64

Region	DNR-Code	DNR-Name	Baseline LA	LA	Baseline WLA	WLA	MOS	TMDL	Percent Reduction
7	OG-129	Long Branch	1,539	317	1,606	1,606	101	2,024	39
7	OG-130	Still Run	4,711	1,820	1,136	1,136	156	3,111	49
7	OG-77-A.5	Oldhouse Branch/Rockhouse Creek	396	137	47	47	10	194	58
7	OG-89	Gilbert Creek	16,846	6,273	28,410	25,518	1,673	33,464	30
7	OG-96	Big Cub Creek	12,292	4,338	10,696	9,052	705	14,095	42
7	OG-96-A	Sturgeon Branch	34	34	0	0	2	36	0
7	OG-96-B	Road Branch	1,571	948	2,928	2,196	166	3,310	30
7	OG-96-C	Elk Trace Branch/Big Cub Creek	1,793	402	0	0	21	424	78
7	OG-96-F	Toler Hollow	305	145	443	310	24	480	39
7	OG-96-H	McDonald Fork	836	293	2,595	1,817	111	2,221	39
7	OG-99	Reedy Branch	2,153	2,153	4,211	2,948	268	5,369	20
8	OG-75	Buffalo Creek	27,377	10,812	78,297	48,677	3,131	62,620	44
8	OG-75-C.5	Proctor Hollow/Buffalo Creek	956	341	3,127	1,626	104	2,070	52
9	OG-76	Huff Creek	22,634	14,366	36,286	25,815	2,115	42,296	32
9	OG-76-L	Toney Fork/Huff Creek	3,319	1,068	6,083	3,954	264	5,286	47

Table 5-5. Load and waste load allocations for manganese

Region	DNR-Code	DNR-Name	Baseline LA	LA	Baseline WLA	WLA	MOS	TMDL	Percent_ Reduction
1	O-4	Guyandotte River	760,790	421,132	710,685	515,830	49,314	986,276	36
1	OG-10-A	Right Fork/Merritt Creek	272	272	0	0	14	286	0
1	OG-48	Limestone Branch	294	268	0	0	14	282	9
1	OG-51	Crawley Creek	3,261	2,962	0	0	156	3,118	9
1	OG-53	Godby Branch	56	56	0	0	3	59	0
1	OG-61	Buffalo Creek	3,149	847	0	0	45	892	73
1	OG-61-A	Right Fork/Buffalo Creek	64	64	0	0	3	68	0
10	OG-92-I	Muzzle Creek	1,750	1,343	0	0	71	1,414	23
10	OG-92-K	Buffalo Creek/Little Huff Creek	1,338	534	112	112	34	680	55
10	OG-92-K-1	Kezee Fork	65	65	0	0	3	69	0
10	OG-92-K-2	Mudlick Fork/Buffalo Creek	16	16	0	0	1	16	0
10	OG-92-Q	Pad Fork	4,310	1,497	506	506	105	2,109	58
10	OG-92-Q-1	Righthand Fork/Pad Fork	872	383	380	380	40	804	39
11	OG-100	Clear Fork (OGC)	96,785	44,298	66,783	58,120	5,390	107,808	37
11	OGC-12	Lower Road Branch	1,995	732	3,753	2,064	147	2,944	51
11	OGC-16	Laurel Fork	52,779	25,096	23,899	20,476	2,399	47,971	41
11	OGC-16-M	Milam Branch	2,076	1,706	0	0	90	1,796	18
11	OGC-16-P	Trough Fork	4,624	2,916	3,699	3,560	341	6,817	22

Region	DNR-Code	DNR-Name	Baseline LA	LA	Baseline WLA	WLA	MOS	TMDL	Percent_ Reduction
11	OGC-19	Toney Fork/Clear Fork	3,013	2,169	4,062	4,062	328	6,560	12
11	OGC-26	Crane Fork	8,033	1,678	2,779	2,779	235	4,692	59
12	OG-110	Indian Creek	7,812	6,703	40,586	28,130	1,833	36,666	28
12	OG-110-A	Brier Creek/Indian Creek	394	394	153	153	29	575	0
12	OG-110-A-2	Marsh Fork/Brier Creek	70	70	109	109	9	189	0
13	OG-124	Pinnacle Creek	25,744	8,827	50,291	43,092	2,733	54,651	32
13	OG-124-D	Smith Branch/Pinnacle Creek	497	497	240	240	39	775	0
13	OG-124-H	Laurel Branch/Pinnacle Creek	55	55	809	606	35	696	23
13	OG-124-I	Spider Creek	285	285	34	34	17	336	0
14	OG-131	Barkers Creek	17,532	11,597	5,840	5,840	918	18,355	25
14	OG-131-B	Hickory Branch/Barkers Creek	351	351	0	0	18	370	0
14	OG-131-F	Gooney Otter Creek	8,785	3,341	4,559	4,559	416	8,316	41
14	OG-131-F-1	Jims Branch/Gooney Otter Creek	389	160	0	0	8	169	59
14	OG-131-F-2	Noesman Branch	1,301	530	573	573	58	1,161	41
14	OG-134	Slab Fork	10,630	8,317	2,489	2,489	569	11,374	18
14	OG-134-D	Measle Fork	124	124	0	0	7	130	0
14	OG-135-A	Left Fort/Allen Creek	2,652	564	0	0	30	594	79
14	OG-137	Devils Fork	4,519	4,519	0	0	238	4,757	0
14	OG-138	Winding Gulf	46,604	16,604	13,966	13,966	1,609	32,179	50
14	OG-139	Stonecoal Creek	14,328	5,279	3,460	3,460	460	9,199	51
5	OG-49	Big Creek	8,588	6,670	1,004	1,004	404	8,078	20
5	OG-49-A	Ed Stone Branch/Big Creek	73	73	0	0	4	77	0
5	OG-49-A-1	North Branch/ Ed Stone Branch	26	26	0	0	1	28	0
6	OG-65-A	Coal Branch/Island Creek	960	366	0	0	19	386	62
6	OG-65-B	Copperas Mine Fork	30,340	13,410	58,552	41,575	2,894	57,879	38
6	OG-65-B-1	Mud Fork	13,107	6,131	0	0	323	6,454	53
6	OG-65-B-1-A	Lower Dempsey Branch	1,434	516	0	0	27	544	64
6	OG-65-B-1-B	Ellis Branch/Mud Fork	2,049	829	0	0	44	872	60
6	OG-65-B-1-E	Upper Dempsey Branch	435	166	0	0	9	175	62
6	OG-65-B-4	Trace Fork/Copperas Mine Fork	6,679	1,030	13,877	8,326	492	9,848	54
7	OG-108	Little Cub Creek/Upper Guyandotte River	2,185	763	0	0	40	804	65

Region	DNR-Code	DNR-Name	Baseline LA	LA	Baseline WLA	WLA	MOS	TMDL	Percent_ Reduction
7	OG-127	Cabin Creek	861	861	331	331	63	1,255	0
7	OG-128	Joe Branch	2,787	483	791	791	67	1,341	64
7	OG-129	Long Branch	1,539	317	1,606	1,606	101	2,024	39
7	OG-130	Still Run	4,711	1,820	1,136	1,136	156	3,111	49
7	OG-77-A.5	Oldhouse Branch/Rockhouse Creek	396	137	47	47	10	194	58
7	OG-89	Gilbert Creek	16,846	6,273	28,410	25,518	1,673	33,464	30
7	OG-96	Big Cub Creek	12,292	4,338	10,696	9,052	705	14,095	42
7	OG-96-A	Sturgeon Branch	34	34	0	0	2	36	0
7	OG-96-B	Road Branch	1,571	948	2,928	2,196	166	3,310	30
7	OG-96-C	Elk Trace Branch/Big Cub Creek	1,793	402	0	0	21	424	78
7	OG-96-F	Toler Hollow	305	145	443	310	24	480	39
7	OG-96-H	McDonald Fork	836	293	2,595	1,817	111	2,221	39
7	OG-99	Reedy Branch	2,153	2,153	4,211	2,948	268	5,369	20
8	OG-75	Buffalo Creek	27,377	10,812	78,297	48,677	3,131	62,620	44
8	OG-75-C.5	Proctor Hollow/Buffalo Creek	956	341	3,127	1,626	104	2,070	52
9	OG-76	Huff Creek	22,634	14,366	36,286	25,815	2,115	42,296	32
9	OG-76-L	Toney Fork/Huff Creek	3,319	1,068	6,083	3,954	264	5,286	47

5.4.2 Fecal Coliform Bacteria TMDLs

A top-down methodology was followed to develop the Fecal Coliform TMDL for the Guyandotte River mainstem and allocate loads to sources. Since the modeling effort was developed on a large scale to address the fecal coliform bacteria impairment in the Gyuyandotte mainstem, source contributions from the upstream tributaries in the Guyandotte River watershed were reduced to meet the TMDL endpoint in the Guyandotte River mainstem only. Loading contributions from each tributary were reduced and assigned a gross load allocation. Headwaters tributaries were reduced first because their impact frequently had a profound effect on downstream water quality in the Guyandotte mainstem. Headwater tributary loads were incorporated into gross load allocations for tributaries to the Guyandotte River mainstem.

The following general methodology was used when allocating to sources for the Guyandotte River fecal coliform bacteria TMDL:

- All point sources in the Guyandotte watershed were set at permit limits (200 counts/100mL monthly average) and all illicit, non-disinfected discharges of human waste (i.e., straight pipes and failing septic systems) as well as any Sanitary Sewer Overflows (SSOs) and CSOs were eliminated. If further reduction was necessary, source loadings from residential areas and agricultural lands were subsequently reduced until in-stream water quality criteria were met.
- Tributaries to the Guyandotte River mainstem are not known to be impaired for fecal coliform bacteria. Future monitoring in the Guyandotte River watershed may reveal fecal

coliform impairments which would then be listed on the Section 303(d) list of impaired waters. Subsequent TMDL development would follow West Virginia's Watershed Management Framework process.

Wasteload Allocations (WLAs)

Waste load allocations (WLAs) were made for all facilities permitted to discharge fecal coliform bacteria directly to the Guyadotte mainstem. This TMDL analysis assumed that all permittees exceeding their permit limits will be notified and the exceedances will be stopped before implementation of this TMDL. Therefore, all permitted fecal coliform sources are represented by the monthly average fecal coliform limit of 200 counts/100mL and no reductions were applied.

Municipal Separate Storm Sewer System (MS4s)

EPA's stormwater permitting regulations require municipalities to obtain permit coverage for all storm water discharges from separate storm sewer systems (MS4s). There are two designated MS4 municipalities along the Guyandotte River mainstem: the City of Huntington and Town of Barboursville. Because these municipalities have filed a Notice of Intent for MS4 permit issuance, and for lack of clearly defined Municipal Separate Storm Sewer System (MS4s) drainage areas, the area within the corporate limits watershed is therefore assumed to be subject to MS4 storm water permits. The source loading associated with stormwater runoff from the urban and residential landuses within corporate limits of each municipality were included in the waste load allocations. The Town of Milton is a designated MS4 municipality in the Guyandotte watershed that discharges to the Mud River mainstem. The fecal coliform bacteria TMDL was developed for the Guyandotte mainstem only and headwater tributary loads were incorporated into gross load allocations for tributaries to the Guyandotte River mainstem. Therefore, loading associated with the Milton MS4 was included in the gross load allocation for the Mud River (see Table 6 in Appendix A-2). Stormwater permits and their relationship to TMDLs are discussed further in Appendix G.

The fecal coliform bacteria WLAs are presented as annual loads, in terms of counts per year. They are presented on an annual basis (as an average annual load), because they were developed to meet TMDL endpoints under a range of conditions observed throughout the year. Table 5-6 presents the individual WLAs for the Guyandotte River watershed.

Table 5-6. Individual fecal coliform MS4 WLAs for the Guyandotte River watershed

Town	Parameter	Baseline Load	Reduced Load	% Reduction
Barboursville	Fecal coliform	1.61721E+13	4.29734E+12	73
Huntington	Fecal coliform	7.84365E+13	2.35309E+13	73

Load Allocations (LAs)

The endpoint for fecal coliform bacteria was selected as the instantaneous endpoint of 380 counts/100mL based on the 400 counts/100mL criterion for human health minus an approximate 5 percent MOS and the geometric mean endpoint of 190 counts/100mL based on the 200 counts/100mL geometric mean criterion minus an approximate 5 percent MOS.

Table 5-7 presents the summation of the LAs and WLAs for fecal coliform bacteria for the Guyandotte river mainstem. LAs and WLAs for tributaries to the Guyandotte River are presented in Table 6 of Appendixes A-1 through A-14.

Table 5-7. Load and waste load allocations for fecal coliform bacteria for the Guyandotte River mainstem

Outlet	DNR Code	DNR Name	Baseline LA	LA	Baseline WLA	WLA	MOS	TMDL	Percent Reduction
1000	O-4	Guyandotte River	1.28e+16	1.30e+15	214819668659	214819668659	6.87e+13	1.37e+15	89.81

5.4.3 Selenium TMDLs

The following general methodology was used when allocating to sources for the selenium TMDLs in the upper Mud River Watershed

- Nonpoint sources in the watershed did not appear to be contributing excessive loads of selenium to the watershed and, therefore, are not required to reduce loadings.
- The WLAs were determined by setting the allocation at the water quality criteria for selenium

The selenium TMDLs for the upper Mud River watershed are presented in Table 5-8.

Table 5-8. Selenium TMDLs for the Mud River watershed

DNR Code	Stream Name	TMDL (ug/L)	MOS	WLA (ug/L)	LA(ug/L)
WVOG-2	Mud River upstream of Upton Fork	5.0	Implicit	5.0	NA
WVOGM-47	Sugar Tree Branch	5.0	Implicit	5.0	NA
WVOGM-48	Stanley Fork	5.0	Implicit	5.0	NA

Wasteload Allocation

WLAs were assigned to the surface mining point sources in the upper Mud watershed. The WLAs are presented as concentrations, in terms of micrograms per liter at a 7Q10 flow of 0 cfs. The WLA for each point source is 5 ug/L for selenium based on the assumption that a discharge concentration meeting the water quality criteria will result in meeting the water quality criteria in the impaired streams as well.

Load Allocation

Since a 7Q10 flow of 0 cfs would result in an absence of flow from nonpoint sources because of their dependence on rainfall and runoff processes, the LA is equivalent to 0 ug/L for selenium.

5.4.4 pH Modeling Results

As described in Section 4.5.2, the MINTEQA2 model was run for each of the pH impaired streams in the Guyandotte watershed to simulate various scenarios. Input values for Fe and Mn were based on TMDL endpoints (maximum allowable limits) and the maximum observed concentrations for the specific pH impaired stream were used as the total aluminum inputs (refer to Section 4.5.2 for details). The resultant equilibrium pH for each of the pH impaired streams are presented in Table 4-10.

5.4.5 Seasonal Variation

TMDL must consider seasonal variation in the derivation of the allocation. For the Guyandotte River watershed metals TMDLs, seasonal variation was considered in the formulation of the modeling analysis. By using continuous simulation (modeling over a period of several years), seasonal hydrologic and source loading variability was inherently considered. The metals concentrations simulated on a daily time step by the model were compared to TMDL endpoints. An allocation which meets these endpoints throughout the year was developed.

5.4.6 Critical Conditions

TMDL developers must select the environmental conditions that will be used for defining allowable loads. Many TMDLs are designed around the concept of a “critical condition.” The critical condition is the set of environmental conditions which, if controls are designed to protect, will ensure attainment of objectives for all other conditions.

Nonpoint source loading is typically precipitation-driven. In-stream impacts tend to occur during wet weather and storm events that cause surface runoff to carry pollutants to waterbodies. During dry periods, little or no land-based runoff occurs, and elevated in-stream bacteria levels may be due to point sources (Novotny and Olem, 1994). Water quality data analysis in the Guyandotte watershed shows high aluminum, iron, manganese, and fecal coliform bacteria concentrations during both high and low flow, indicating that there is both a point and nonpoint source issue. Both high-flow and low-flow periods were taken into account during TMDL development by using a long period of weather data that represented wet, dry and average flow periods (see Section 5.2). As stated previously, the critical condition for high selenium concentrations occurs at a low flow 7Q10 condition of 0 cfs and the nonpoint source contributions of selenium were considered to be negligible. Therefore, the TMDLs were based on wasteload allocations assigned at water quality criteria for selenium at the end of pipe.

5.4.7 Future Growth

This Guyandotte TMDL does not include specific future growth allocations to each subwatershed. However, the absence of specific future growth allocations does not prohibit new mining in the subwatersheds for which load allocations and/or wasteload allocations have been established pursuant to this TMDL. Pursuant to 40 CFR 122.44 (d)(1)(vii)(B), effluent limits must be "consistent with the assumptions and requirements of any available wasteload allocation for the discharge...." In addition, federal regulations generally prohibit issuance of a permit to a new discharger "if the discharge from its construction or operation will cause or contribute to the violation of water quality standards." 40 CFR 122.4(i). A discharge permit for a new discharger could be issued in the subwatersheds for which this TMDL establishes load and/or wasteload allocations under the following scenarios:

1. A new facility could be permitted anywhere in the watershed, provided that effluent limitations are based upon the achievement of water quality standards end-of-pipe for the pollutants of concern in the TMDL.

2. Remining could occur without a specific allocation to the new permittee, provided that the requirements of existing State remining regulations are achieved. Remining activities are viewed as a partial nonpoint source load reduction from Abandoned Mine Lands.

3. Reclamation and release of existing permits could provide an opportunity for future growth provided that permit release is conditioned upon achieving discharge quality better than the wasteload allocation prescribed by the TMDL.

West Virginia may revise the TMDL, with approval from EPA, to reallocate the distribution of loads to accommodate future growth. It is also possible that the TMDL might be refined in the future through remodeling. Such refinement might incorporate new information and/or redistribute pollutant loads. Trading might provide an additional opportunity for future growth, contingent on the state’s development of a statewide or watershed-based trading program.

5.4.8 Water Quality Trading

This TMDL neither prohibits nor authorizes trading in the Guyandotte River watershed. Both the WVDEP and EPA generally endorse the concept of trading and recognize that it might become an effective tool for TMDL implementation. However, significant regulatory framework development is necessary before large-scale trading in West Virginia may be realized. EPA will cooperate with WVDEP in its development of a statewide or watershed-based trading program. Further, EPA supports program development assisted by a consensus-based stakeholder process.

Before the development of a formal trading program, it is conceivable that the regulation of specific point source-to-point source trades might be feasible under the framework of the NPDES program. EPA commits to cooperate with the WVDEP to facilitate such trades if opportunities arise and are proven to be environmentally beneficial.

6.0 Reasonable Assurance

Three primary programs that provide reasonable assurance for maintenance and improvement of water quality in the watershed are in effect. The WVDEP's duties and responsibilities for issuing NPDES permits, efforts to reclaim abandoned mine lands and the Watershed Management Framework will be the three focal points in water quality improvement.

Additional opportunities for water quality improvement are both ongoing and anticipated. Historically, a great deal of research into mine drainage has been conducted by scientists at West Virginia University, the West Virginia Division of Natural Resources, the United States Office of Surface Mining, the National Mine Land Reclamation Center, the National Environmental Training Laboratory and many other agencies and individuals. Funding from EPA's 319 Grant program has been used exclusively to remedy mine drainage impacts. These many activities are expected to continue and result in water quality improvement.

A list of funded and pending water and wastewater projects in West Virginia can be found at http://www.wvinfrastructure.com/projects/index.html.

6.1 Permitting Program

Division of Mining and Reclamation

The NPDES program has adjusted it permitting cycle to coincide with the Watershed Management Framework Cycle. The Guyandotte River is divided into two distinct watersheds for purposes of the Framework Cycle. The Upper Guyandotte is part of Hydrologic Group E with permit reissuance scheduled for 2005. The Lower Guyandotte is part of Hydrologic Group C that is scheduled for permit reissuance in 2008. WVDEP will incorporate the TMDL wasteload allocations during permit reissuance.

6.2 Reclamation

Office of Abandoned Mine Lands and Reclamation

Within DEP, the primary entity that deals with abandoned mine drainage issues is the Division of Land Restoration. Within the Division, the Office of Abandoned Mine Lands and Reclamation was created in 1981 to manage the reclamation of lands and waters affected by mining prior to passage of the Surface Mining Control and Reclamation Act (SMCRA) in 1977. A fee placed on coal mined within West Virginia funds the AML&R Office's budget. Allocations from the AML fund are made to state and tribal agencies through the congressional budgetary process.

AML&R has also increased its emphasis on correcting water quality problems at sites that were primarily chosen for protection of public health, safety and property. This new emphasis on improving water quality, in conjunction with it's activities as part of the Framework, will aid in clean up of sites already selected for remediation activities.

AML&R is planning remediation activities at the following sites in the Guyandotte River watershed:

- Gooney Otter Refuse Piles

- Little Huff Creek (Draining Portals)
- Helen Portals
- Stonecoal Creek Complex
- McAlpin Eroding Dump
- Rhodell Refuse
- Rossmore Loadout
- Island Creek #18 Structures
- Stollings (Szucks) Drainage

Office of Special Reclamation

The Office of Special Reclamation is responsible for completing the reclamation plan at sites where the mining permit is revoked and the reclamation bond forfeited. The work includes land reclamation of unreclaimed areas to achieve the planned postmining landuse and water reclamation where problem discharges exist. Money for the reclamation comes from the Special Reclamation Fund. Revenues into the fund include a per-ton tax on each ton of coal mined, forfeited reclamation bonds, and civil penalty collections.

Both AML&R and Special Reclamation are active partners in the Watershed Framework. Both entities stand to play a significant role in water quality improvements made in the Guyandotte watershed due to the significant number of mining sites located in the watershed. The combined efforts of all of the agencies in the Framework will provide a leadership role in correcting the non-point source related problems in the Guyandotte watershed.

6.3 Watershed Management Framework

Management Framework

The Watershed Management Framework consists of a group of state and federal agencies whose goal is to develop and implement management strategies through a cooperative long-range planning effort. The Framework consists of representatives from the following partner agencies:

Bureau for Public Health
Department of Highways
Department of Environmental Protection
State Conservation Agency
Division of Forestry
Division of Natural Resources
WVU Extension Services
ORSANCO
US Geological Survey
US Office of Surface Mining
Monongahela National Forest
US Environmental Protection Agency
Natural Resources Conservation Service
U S Army Corp of Engineers
Department of Agriculture

The principle area of focus for the Framework is to correct problems related to non-point source pollution. Each of the partner agencies has placed a greater emphasis on identification and correction of non-point source pollution. The combined resources of these agencies provides various avenues to address all different types of non-point sources both through public education and on-the-ground projects. The Framework uses the five-year Watershed Cycle to identify the watersheds where restoration efforts will be focused. Each year the Framework agencies meet to prioritize watersheds from within a certain Hydrologic Group to begin the planning process. The selection process includes evaluation of completed TMDLs for the watersheds under consideration.

The Watershed Management Framework is incorporated by reference into West Virginia's Continuing Planning Process. Among other things, the Watershed Management Framework includes the management schedule for how TMDLs will be integrated and implemented. The Watershed Management Framework also incorporates as part of its priority selection criteria, the state's list of impaired waters under Section 303(d). In 2000, the schedule for TMDL development under Section 303(d) was merged with the Watershed Management Framework process. Chapter 3.2.2 of the Watershed Management Framework, entitled "Developing and Implementing Integrated Management Strategies" identifies a six-step process for developing integrated management strategies and action plans for achieving the state's water quality goals. Step 3 of that process includes "identifying point source and/or nonpoint source management strategies - or Total Maximum Daily Loads - predicted to best meet the needed [pollutant] reduction." Following development of the TMDL, Steps 5 and 6 provide for preparation, finalization and implementation of an "action plan" that would implement the TMDL and any other appropriate water quality improvement strategy.

The process used by the Management Framework is based on the efforts of local project teams. The teams are composed of members from Framework agencies and stakeholders having an interest and/or residing within the watershed. Team formation is based on the impairments or protection needs of the watershed. The team's goal is to develop a project plan that allows the most efficient use of resources from all parties involved in the effort. For selected watersheds, the local project teams can use the TMDL recommendations to help plan future activities. Once the project plan has been developed and funded, the agencies can implement projects to address the restoration recommended by the TMDL.

The Framework will be considering watershed selection for Hydrologic Group C watersheds, including the Lower Guyandotte, in 2006 and the Hydrologic Group E watersheds, including the Upper Guyandotte in 2008. At these times the recommendations of the Guyandotte TMDL will be assessed for project planning purposes. The actions of the Framework will bring the combined resources of the numerous state and federal agencies into sharp focus on the water quality problems in West Virginia.

7.0 Monitoring Plan

Follow-up monitoring of the Guyandotte River watershed is recommended. Future monitoring can be used to evaluate water quality conditions, changes or trends in water quality conditions, and contribute to an improved understanding of the source loading behavior. The following monitoring activities are recommended for this TMDL.

WVDEP should continue monitoring the impaired segments of the Guyandotte River watershed via its established Watershed Management monitoring approach in the Lower Guyandotte River watershed from 7/2003 to 6/2004, 7/2008 to 6/2009, and beyond, and in the Upper Guyandotte River watershed from 7/2005 to 6/2006, 7/2010 to 6/2011, and beyond.

WVDEP or other entities conducting restoration activities should monitor in advance of, during, and after installation of reclamation activities affecting water quality at abandoned mine sites.

WVDEP should consider additional stations and more frequent sampling of water quality in the impaired reaches, and continue to encourage participation by active watershed organizations.

WVDEP should emphasize the use of proper Quality Assurance Quality Control (QA/QC) protocols to avoid potential sample contamination during water sample collection and transfer.

8.0 Public Participation

EPA policy is that there must be full and meaningful public participation in the TMDL development process. Each state must, therefore, provide for public participation consistent with its own continuing planning process and public participation requirements. As a result, it is the intent of EPA in partnership with WVDEP to solicit public input by providing opportunities for public comment and review of the draft TMDLs. The public comment period began on January 30, 2004 and ended March 1, 2004. Public notices were published in eleven newspapers listed in Table 8-1.

Table 8-1 Newspapers where public notices were published

County	Newspaper
Logan	*Logan Banner*
Wyoming	*The Independent Herald*
Wyoming	*The Advocate*
Mingo	*The Gilbert Times*
Mingo	*Williamson Daily News*
Raleigh	*The Register Herald*
Cabell	*The Cabell Record*
Cabell	*The Herald Dispatch*
Lincoln	*The Lincoln Journal*
Kanawha	*The Charleston Gazette*
Kanawha	*Charleston Daily Mail*

The public meetings pertaining to the Guyandotte River watershed occurred as follows:

- An informational public meeting to present the Draft TMDL was held on February 24, 2004 at Logan High School in Logan, West Virginia.
- An informational public meeting to present the Draft TMDL was held on February 25, 2004 at Hamlin Middle School in Hamlin, West Virginia.

References

American Society of Agricultural Engineers (ASAE). 1998. *ASAE Standards 1998: Standards Engineering Practices Data.* 45th edition. American Society of Agricultural Engineers, St. Joseph, Michigan.

Bicknell, B.R., J.C. Imhoff, J. Kittle, A.S. Donigian, and R.C. Johansen. 1996. *Hydrological Simulation Program - FORTRAN, User's Manual for Release H*. U.S. Environmental Protection Agency, Environmental Research Laboratory, Athens, GA.

Census. 2000. TIGER/Line Technical Documentation. 108th CD Census 2000 TIGER/Line® Files Technical Documentation/prepared by the U.S. Census Bureau, 2003.

CCREM. 1987. Canadian water quality guidelines. Canadian Council of Ministers of Resources and Environment. Ottawa, Ontario.

Dreher, G.B., and R. B. Finkelman. 1992. Selenium mobilization in a surface coal mine, Powder River basin, Wyoming, U.S.A. Enfiron. Geol. Water Sci. 19: 155-167

Evangelou, V.P. 1998. *Environmental Soil and Water Chemistry*. John Wiley, New York.

Haygarth, P.M. 1994. Global importance and global cycling of selenium. Pages 1-28 in *Selenium in the environment*. Edited by W.T. Frankenberger, Jr. and S. Benson. Marcel Dekker, Inc. New York.

Horsley & Witten, Inc. 1996. *Identification and Evaluation of Nutrient and Bacterial Loadings to Maquoit Bay, Brunswick, and Freeport, Maine*. Casco Bay Estuary Project.

Langmuir, Donald. 1997. *Aqueous Environmental Geochemistry*. Prentice Hall, Englewood Cliffs, NJ.

Long Island Regional Planning Board (LIRPB). 1978. *Long Island Comprehensive Waste Treatment Management Plan, Volume II: Summary Documentation*. Nassau-Suffolk Regional Planning Board, Hauppauge, NY, pp. 223-241.

McDonald, L.E., and M.M. Strosher. 1998. Selenium mobilization from surface coal mining in the Elk River basin, British Columbia: a survey of water, sediment and biota. Ministry of Environment, Lands and Parks. Cranbrook, British Columbia. 56 p.

McKnight, Diane M. and Kenneth E, Bencala. 1990. The Chemistry of Iron, Aluminum, and Dissolved Organic Material in Three Acidic, Metal-Enriched, Mountain Streams as Controlled by Watershed and In-Stream Processes. *Water Resources Research* 26:3087-3100.

McKnight, D.M., B. A.Kimball, and K.E. Bencala. 1988. Iron Photoreduction and Oxidation in an Acidic Mountain Stream. *Science* 240:637-640.

Metcalf and Eddy. 1991. *Wastewater Engineering: Treatment, Disposal, Reuse*. 3rd edition. McGraw-Hill, Inc., New York.

PADEP. 2000. *Coal Mine Drainage Prediction and Pollution Prevention in Pennsylvania*. Pennsylvania Department of Environmental Protection, Harrisburg, PA.

Rosgen, D. 1996. *Applied River Morphology*. Wildland Hydrology, Pagosa Springs, CO.

Stumm and Morgan. 1996. *Aquatic Chemistry*. John Wiley, New York.

U.S. Bureau of the Census. 1990. 1990 Census. http://factfinder.census.gov

US-EPA. 1987. Ambient water quality criteria for selenium. EPA Criteria and Standards Division. EPA/440/5-87/006. 130 p.

USDA. 2000. Forest Inventory and Analysis Retrevial System. Retrieved January, 2002. U.S. Department of Agriculture Forest Service. http://fia.fs.fed.us/dbrs_setup.htm, select Timber Product Output Retrieval System.

USEPA. 1991. *Guidance for Water Quality Based Decisions: The TMDL Process*. EPA 440/4-9 1-001. United States Environmental Protection Agency; Assessment and Watershed Protection Division, Washington, DC.

USEPA. 1991. *MINTEQA2 PRODEFA2: A Geochemical Assessment Model for Environmental Systems: Version 3.0 User's Manual*. EPA/600/3-91/021. United States Environmental Protection Agency.

USEPA. 1991. *Technical Support Document for Water Quality-based Toxics Control*. EPA/505/2-90-001. United States Environmental Protection Agency, Office of Water, Washington, D.C.

USEPA. 2002. *A Survey of the Water Quality of Streams in the Primary Region of Mountaintop Valley Fill Coal Mining*. United States Environmental Protection Agency, Region 3, Wheeling, WV.

USEPA. 2002. pH and Metals TMDLs for the Tug Fork River Watershed, West Virginia. United States Environmental Protection Agency, Region 3, Office of Watersheds, Philadelphia, PA.

USEPA. 2002. pH and Metals TMDLs for the West Fork River Watershed, West Virginia. United States Environmental Protection Agency, Region 3, Office of Watersheds, Philadelphia, PA.

USGS. 2003. Daily streamflow for the nation. http://waterdata.usgs.gov/nwis/discharge

WVDEP. 1998a. Decision Guidance for Listing Waterbodies on West Virginia's 1998 Draft 303(d) List. West Virginia Division of Environmental Protection, Charleston, WV.

WVDEP. 2000b. Personal communication with Dave Vande Linde, WVDEP OMR. October, 2000.

WVDEP. 2002. Personal communication with Steve Stutler, WVDEP OWR. January 2002.

WVDNR. 1983. West Fork River Subbasin Abandoned Mine Drainage Assessment, West Virginia Department of Natural Resources and Division of Water Resources.

WVDNR. 1985. Monongahela River Subbasin Abandoned Mine Drainage Assessment, West Virginia Department of Natural Resources and Division of Water Resources.

WVDNR. 1987. Guyandotte River Basin Plan. West Virginia Department of Natural Resources - Division of Water Resources, Charleston, WV.

WVGES. 1998. Http://www.wvgs.wvnet.edu/www/datastat/dataclyr.htmWVGES. 2002. Trace Elements in West Virginia Coals: Selenium http://www.wvgs.wvnet.edu/www/datastat/te/SeHome.htm

WVOMHST. 2002. West Virginia Mining Statistics 1996 to 2002. Coal Production by County 2000. Retrieved January 2002. WV Bureau of Commerce, Office of Miners' Health, Safety, and Training.

West Virginia University. 1995-1997. Rural Wastewater Treatment by Septic Systems. http://www.caf.wvu.edu/wvafes/water.htm

West Virginia University Extension Service. Overview of Passive Systems for Treating Acid Mine Drainage. http://www.wvu/edu/~agexten/landrec/passtrt/passtrt.htm.

WVWQS. 2003. Code of State Rules, Title 46: Legislative Rule Environmental Quality Board, Series 1, Requirements Governing Water Quality Standards. West Virginia Secretary of State, Charleston, WV.