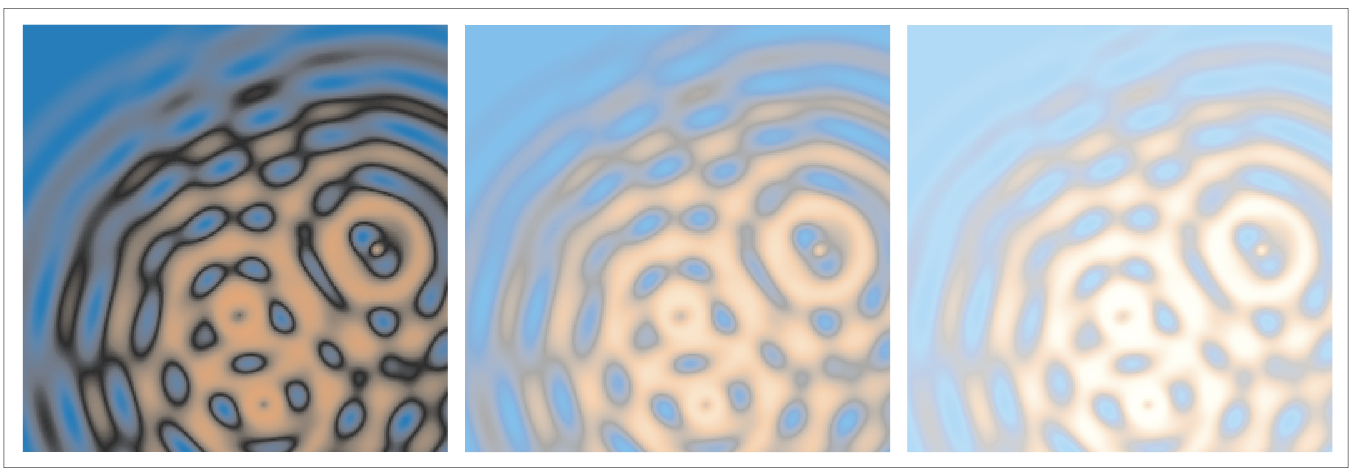
A Quantitative Inventory and Interpretive Review
of Water Quality on Active Mining Operations in West Virginia

West Virginia
Acid Mine Drainage Study
2000

prepared by
West Virginia Division of Environmental Protection
Office of Mining and Reclamation

March 2001



DEP
WEST VIRGINIA
Division of Environmental Protection

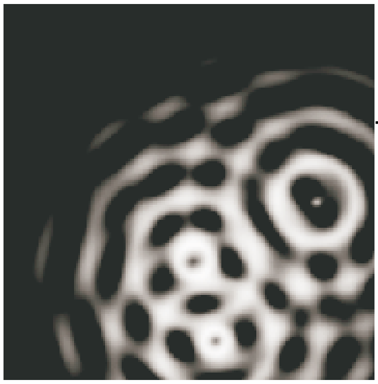
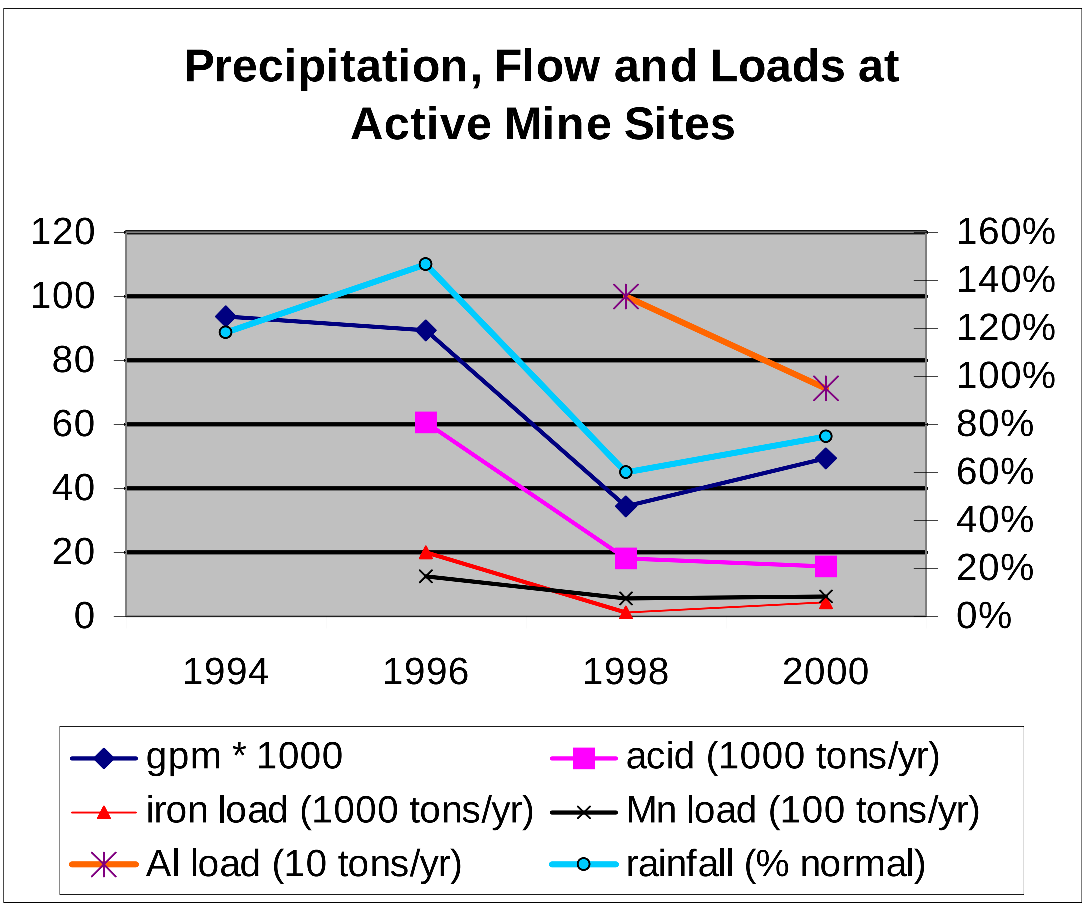


Table of Contents

Executive Summary

WVDEP has inventoried water quality at active coal mine operations every other year since 1994. This 4th study details trends since the original study. Inspectors collected raw water samples at problematic sources and described the cause, quantity, and means of treatment. Laboratory analyses for pH, acidity, total iron, manganese, and aluminum were tabulated. Although there have been new sources of poor water quality identified in each study, the quantity of sources, permits involved, flow, and metals loads have declined since 1994. The water quality at a large number of sources has improved, allowing them to be deleted from the inventory. A much smaller number have been revoked. Approximately 5% of all coal related outlets exhibit the potential to discharge poor water quality without some form of treatment. High volume, pumped, alkaline deep mine drainage dominates the flow but represents a small percentage of sources. Roughly half the current sources representing three quarters of the total flow are alkaline. Even though flows increased 45% since 1998 (largely from increased precipitation since the 1998 record drought) acid and aluminum loads have decreased, and iron and manganese loads have increased. Inspectors estimate 541 sources at 314 permits would prevent permit release and 460 of these sources would impact receiving streams if untreated by industry.



Study conducted by Ben B. Faulkner, Bratton Farm, Princeton, WV for West Virginia Division of Environmental Protection, Nitro, WV.

Operators at active mines dispense substantial volumes of strong neutralizers to neutralize acidity, and provide retention, floculant, and other active or passive treatment to remove metals concentrations from drainage from their operations. A great deal of active mining in West Virginia involves re-mining of existing surface and deep mine operations, as well as former refuse sites. As operators re-mine these sites, remove and properly handle pyritic materials, water quality generally improves. It is clear that operators have addressed problematic drainage as it remains at some sites and that over-treatment to ensure compliance has beneficial impacts to lightly buffered receiving streams, or streams affected by abandoned acid drainage.

This dataset provides information about short-term trends in AMD at active mines and a baseline for continued long-term study of water quality at active and completed sites. It is apparent that many sources of problematic water quality are short-lived. Since 1994, 219 sources have improved in water quality to where no additional treatment (including retention) was necessary. Additionally, of 241 acidic sites in 1996, 140 sources (58%) demonstrated reduced acidities, 67 sources (28%) have demonstrated a steady decrease in acidity (irrespective of the general flow trends of 96-wet, 98-dry, 00-normal), and 39 (16%) exhibited no acidity in the 2000 study. Many of the deep mines (38 sources) with elevated iron concentrations inventoried in 1994 have been removed because the iron concentrations have decreased to compliance levels. This last category alone eliminated over 26,000 gpm from the inventory. These observations are interesting evidence contrary to public perception that problematic mine drainage requires “perpetual” treatment.

Introduction

The purpose of this report is to acquaint those interested in water quality in West Virginia with the scope, impact, and trends of problem mine drainage from active coal mine sites in West Virginia. West Virginia's Division of Environmental Protection (DEP) regulates coal mining in the state and has voluntarily conducted this fourth inventory of mine sites with water quality issues. More information about the agency and specific mines it regulates may be found at its web page ***www.dep.state.wv.us.***

Surface mine operations in West Virginia are classified into three categories.

1. Abandoned Mine Lands, which are operations which completed operations prior to the Federal law (SMCRA) in 1977.
2. Active or completed operations, which were started or bond released since SMCRA's passage; and
3. Bond Forfeiture sites, which are operations where the permit was revoked and bonds forfeited.

A water discharge's origin is not always clear, and the quality of mine discharges is affected by a host of variables, including seasonal and geochemical influences.

Attempts to define the West Virginia's mine drainage problem have generally involved analyzing affected streams to obtain an estimation of acid load. A more valuable approach would be to inventory individual discharges identified as water quality concerns.

The DEP's Office of AML&R launched such a survey in 1981 when it started collecting water quality information in its problem area descriptions of abandoned mine lands.

Earlier attempts to identify problem mine drainage by other state agencies (including the DEP's Office of Water Resources) were noted in these in-house evaluations.

In 1988, AML&R's Special Reclamation Program began collecting water quality information where post-SMCRA bond forfeitures had occurred. This Acid Mine Drainage Bond Forfeiture (AMD-BF) inventory is updated regularly and prioritized yearly to implement mitigation of water quality at revoked sites.

The abandoned mine land (AML) eligible category inventory is incomplete. The DEP has collected water quality samples only at AML sites where land reclamation was a high priority. Until recent procedural changes, West Virginia's abandoned mine lands program, like other programs nationally, only concentrated on dangerous land configurations and hazards rather than water quality.

DEP has formed its own team of investigators to expedite the collection of water quality information, and to devise, implement and monitor innovative mitigation strategies at problem abandoned mine drainage in a watershed approach. As a more complete inventory of AML sites with water quality issues is developed, it will join Bond Forfeitures and Active Mine sites in DEP's Geographic Information System database, improving DEP's ability to spatially characterize water quality problems.

This report focuses on water quality at mine sites presently under permit. Permit holders are responsible for meeting effluent limits and minimizing impact to the receiving streams. If a permit is revoked, DEP implements water quality mitigation at the site on a priority basis.

Water quality improvement efforts at selected abandoned mine land sites are also considered on a cost-benefit and watershed approach.

Data Collection

During the summer of 1994, DEP Office of Mining and Reclamation (OMR) inspectors conducted field analysis on untreated mine-related drainages at actively permitted sites where water quality was a concern. State law prevents the release of permits where effluent does not meet National Pollutant Discharge Elimination System (NPDES) limits. Inspectors also reviewed all sites at the final discharge point to ensure compliance with the NPDES-established effluent limits.

Field analysis for pH, total iron, and total manganese was conducted in this early exercise. Flow was estimated using the best available means. Samples for field analysis were collected at the source or at a collection point prior to chemical, biological, or physical treatment. Where laboratory analyses were available, these values were reported on a form which was tabulated at the DEP Nitro office. This final report was published by WV DEP in December, 1995 as *"A Quantitative Inventory and Interpretive Review of Water Quality on Active Mining Operations in West Virginia."*

In October, 1996, this exercise was refined and inspectors revisited sites, collected raw water samples and submitted them to certified laboratories for analysis of acidity, total iron, total manganese, and pH. The study was repeated in 1998 and 2000, as total aluminum was added to the list of parameters analyzed.

The study included those sites where an inspector was concerned about water quality. The inventory included sites where established effluent limits were not being met without treatment for any established parameter, not just where pH was less than 6.0, or acidity greater than alkalinity (acid mine drainage).

National Pollutant Discharge Elimination System (NPDES) or Article 5 mining permits are issued for specific land areas and activities, and place limits on an outlet. Therefore, the inventory deals with point sources, or outlets. An Article 3 (land reclamation) permit may not bond the exact area defined in the NPDES permit. Often, one NPDES permit boundary may include many outlets located on several Article 3 (land reclamation) permits. An outlet may collect drainage from all or a very small portion of the Article 3 bonded area and off-site or unrelated drainage. ***More precisely, this inventory deals with specific raw (untreated) sources that flow to an NPDES outlet.***

The 1994 Inventory reported 516 Article 3 permits. Several of these permits were not visited during the 1996 survey due to permit consolidation, forfeiture, or improvement in water quality. Revoked permits are added to the AMDBF.

The 1996 Inventory included 466 Article 3 permits. In 1998, inspectors reported water quality concerns at 431 permits. The 2000 study involved 635 sources of water at 363 Article 3 permits.

Observations about Outlets

In 1994 there were over 16,800 outlets permitted at coal mine operations by the NPDES program in West Virginia. That year, DEP inspectors identified 890 sources to these outlets (5%) as having a water quality concern. Currently, the 635 sources constitute 5% of the 11,877 total outlets.

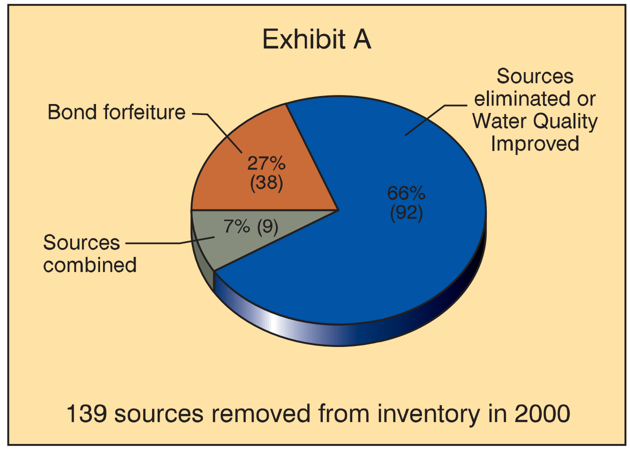
Inspectors added 107 new sources to the inventory in 1996. From 1994 to 1996, water quality improved enough at 83 sources to allow final release or such that they were no longer of concern, had been eliminated by regrading, or were determined to be of AML origin. During this period, 54 sources were revoked, and 44 duplicate sites were eliminated from the inventory.

Inspectors added 73 new sites in 1998, and eliminated 156 sources (including 17 bond forfeitures and 112 sources that had been eliminated or had improved quality removing them from the inventory). Changes in the inventory from 1998 to 2000 are summarized in ***Exhibit A and Appendix A.***

Flow estimation represents one of the most challenging obstacles in water quality diagnosis. DEP inspectors are expected to make better estimates of flow volume than most individuals, because they are familiar with a problem source's origin, history, and fluctuation. Considerably more time and money could be spent to refine both flow volumes and chemical parameters, but field flow estimates and field analysis of iron, manganese and pH in 1994 represented more complete information than ever collected previously.

In 2000 inspectors visually estimated flow at 577 sources (55% of the flow) and used weirs, pump logs, bucket/stopwatch, or cross-sectional area and flowmeters to calculate the balance of the flows. Analyzing samples in 1996 for acidity, iron and manganese by laboratory methods and adding aluminum to the list of parameters in 1998 and 2000 dramatically enhances the understanding of problem sources. Those familiar with water quality at mine sites recognize both flow and quality fluctuate widely at most sites, particularly those directly influenced by precipitation, and seasonal or operational variance.

Also, 1994's flows were estimated in July, a month typically influenced by localized precipitation and weather. Flows and samples in 1996, 1998 and



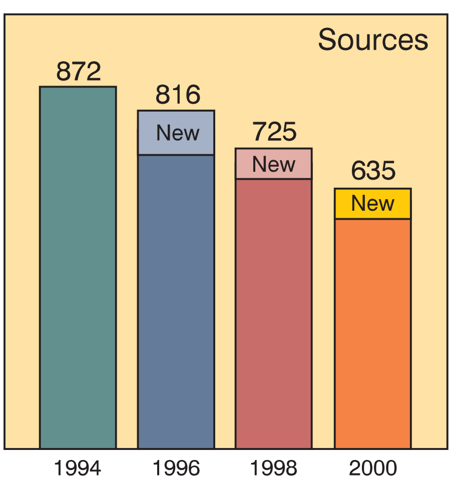
See Appendix, Exhibit A

2000 were collected in October, generally the driest time of the year and the official beginning of the federal "water year".

Since loadings were to be calculated in the later studies, samples were taken when flows were expected to approach base line conditions with limited precipitation influence, and when acidity and metals were expected to be at maximum concentrations.

Mine drainage quantity and quality, particularly pumped or seepage flow, varies substantially with season, response to precipitation, and mine pool management. To arrive at a meaningful and reliable flow volume and water quality, many site visits with flow gauging, and repeated laboratory analyses of selected parameters would be needed. Additionally, treatment of some type was occurring downstream of each source such that all outlets met effluent limits.

Summary of changes in inventory since 1994



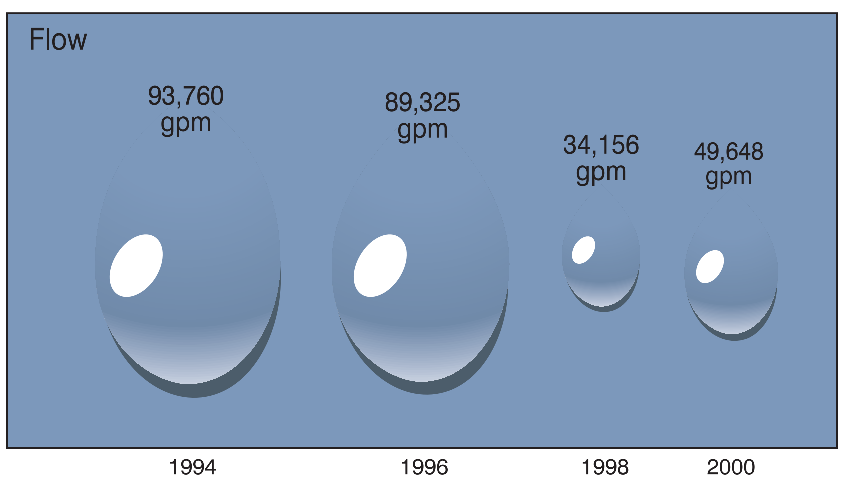
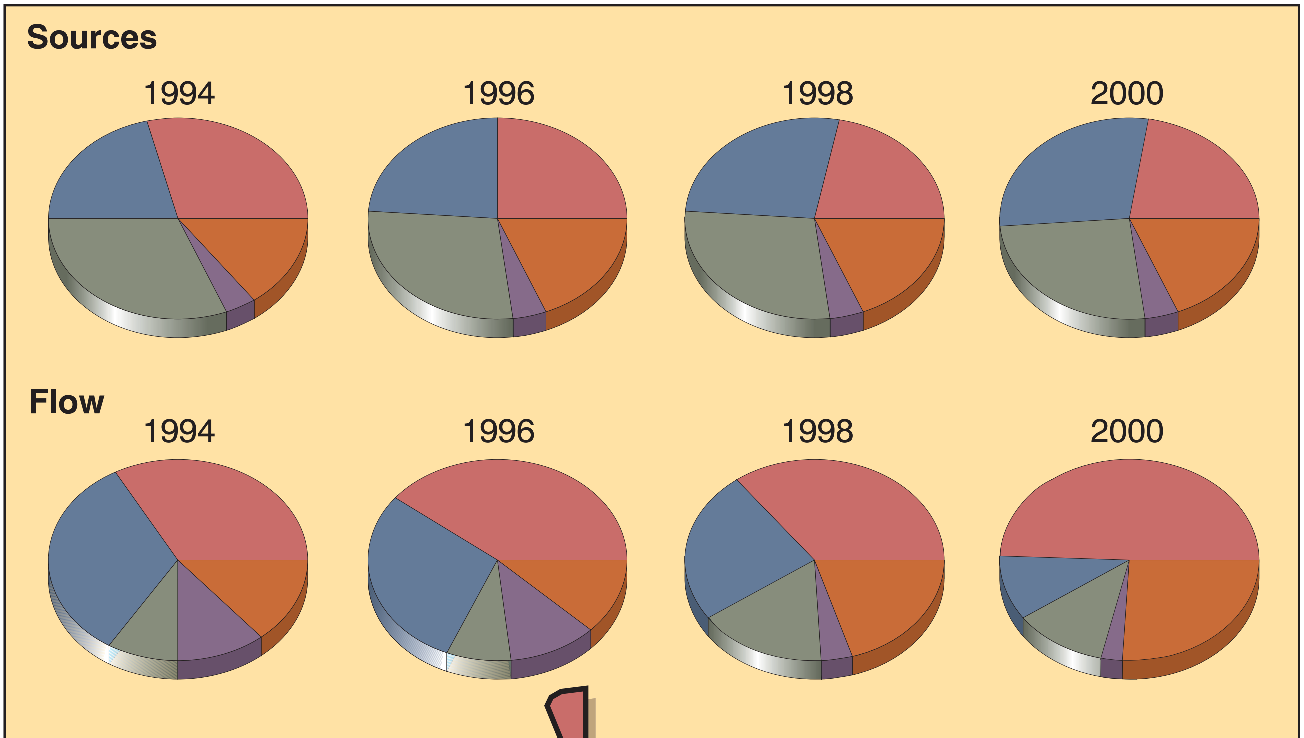
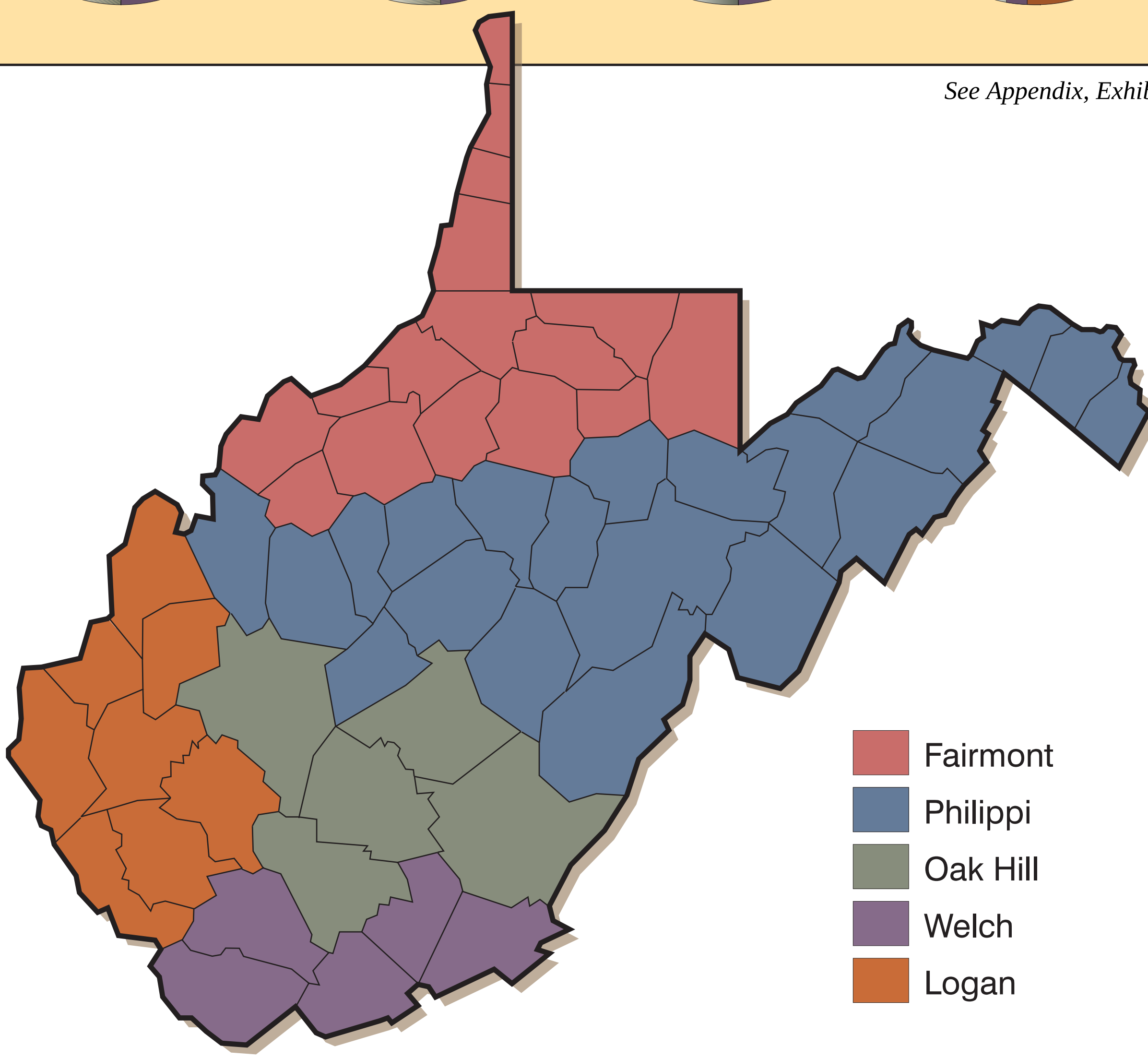


Exhibit B



See Appendix, Exhibit B



Distribution of Sources

When the distribution of sources is considered based on flow volume, the following observations may be made *(Exhibit B).*

- Fairmont exhibits a decreasing percentage of sources but dominates the flow volume.
- Philippi has maintained its number of sources, but their flow decreased dramatically since 1996 and exhibits a smaller portion of the statewide flow total.
- Oak Hill exhibits fewer sources than in previous years, and a smaller percentage of the statewide total flow.
- Welch has released several deep mines with large flows because of improved quality, decreasing its share of the state flow total.
- Logan's share of the statewide flow total is increasing although its number of sources has not changed dramatically.

Fairmont and Philippi offices have merged since the 1994 inventory, and together they dominate the flow volume (nearly 60%) with half the sources, largely due to several high flow deep mines.

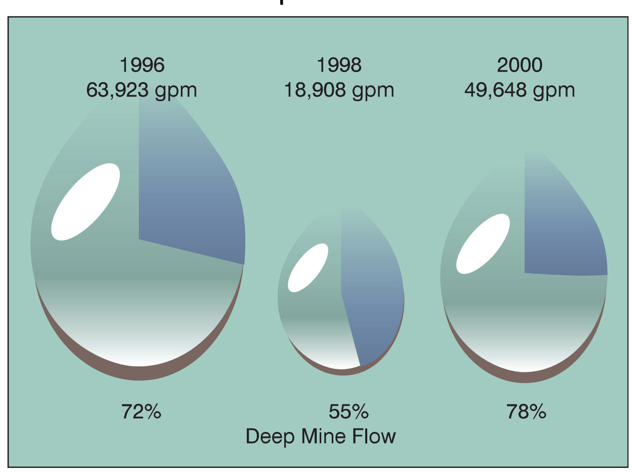
Total flow for the state has decreased remarkably since the initial study. The 4500 gpm decrease from 1994 to 1996 (5%) could be explained by the difference in season of the sampling (July, 1994 vs. October, 1996). The tremendous decrease (62%) from 1996 to 1998 cannot be attributed entirely to seasonal flow since both sampling programs occurred during October baseline conditions. October, 1996 followed a very wet summer, and October, 1998 was a very dry season, but nearly one hundred sources were eliminated from the inventory in 1998. Similarly, the 45% increase in flow from 1998 to 2000 cannot be attributed entirely to the increased precipitation in 2000. During this period, 139 sources were eliminated and 49 new sites (constituting 35% of the total flow in 2000) were added. Inspectors were asked to qualify soil conditions as "dry, moist or saturated" in 2000, and most indicated the soil was "dry" (309 sources) or "moist" (266 sources) at the time of sampling. *See "Precipitation During the Study" in Appendix Exhibit A.*

It is important to realize that deep mine drainage dominates the flow —64% in 1994, 72% in 1996, 55% in 1998, and 78% in 2000 while the number of deep mine sources represent only around 20% of the total sources ***(Exhibit C).***

Further, while approximately 8% of the sources represented actively pumped water, this flow constituted 20% to 67% of the total flow volume. Apparently, large volume deep mines (particularly those with gravity flow) were discharging far less flow in the 1998 study. Gravity flows decreased by 70% from 1996 to 1998, but pumped discharges decreased by only 35%. Gravity discharges increased only modestly during the wetter 2000 autumn, but new sources of deep mine flows resulted in substantial increases in total flow ***(Exhibit D****).*

While specific sources could be identified and presented spatially by latitude and longitude, a fair idea of distribution is seen when sources and flows are listed by county ***(Exhibit E).***

Exhibit C
Compare flows

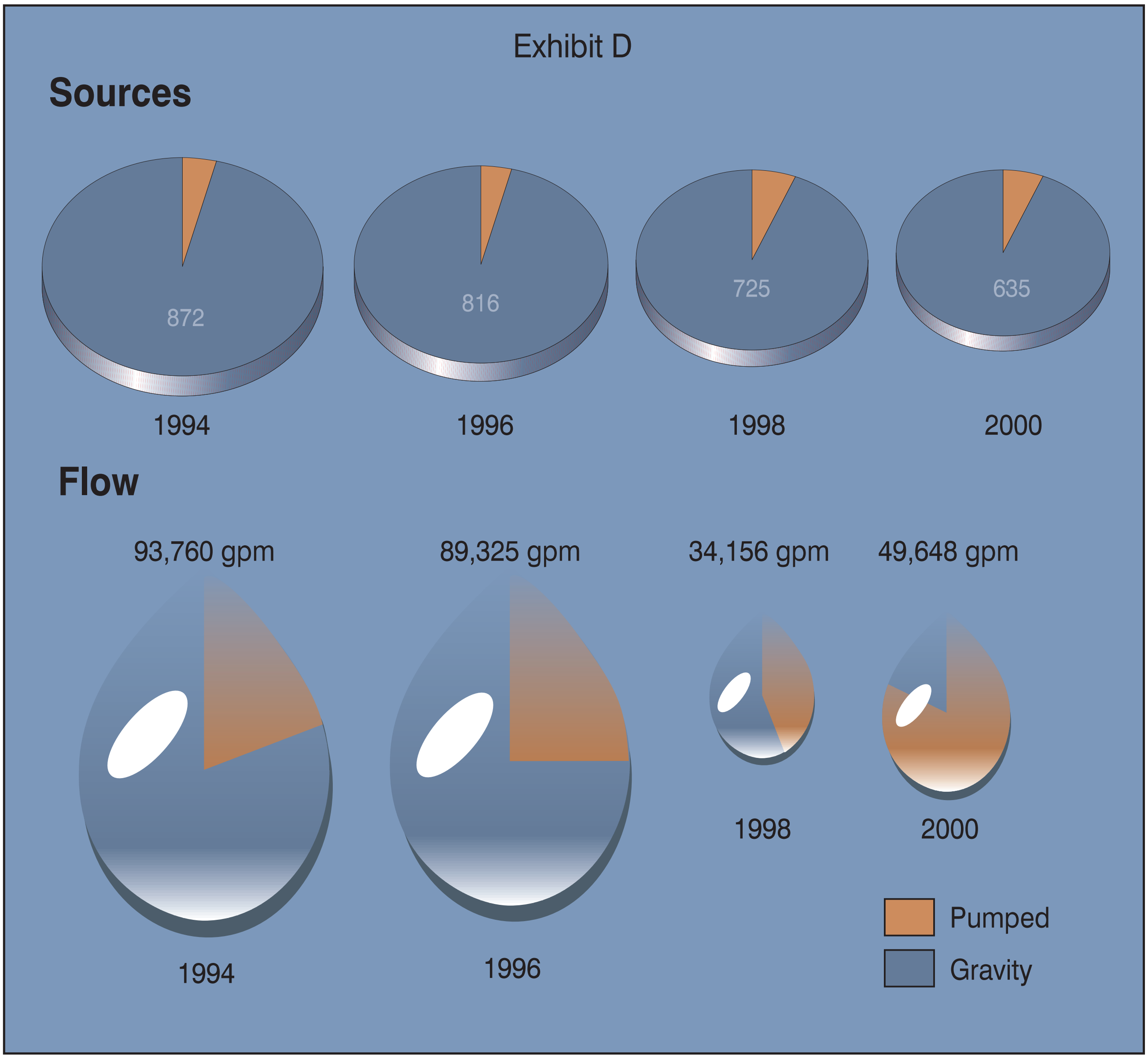


See Appendix, Exhibit C

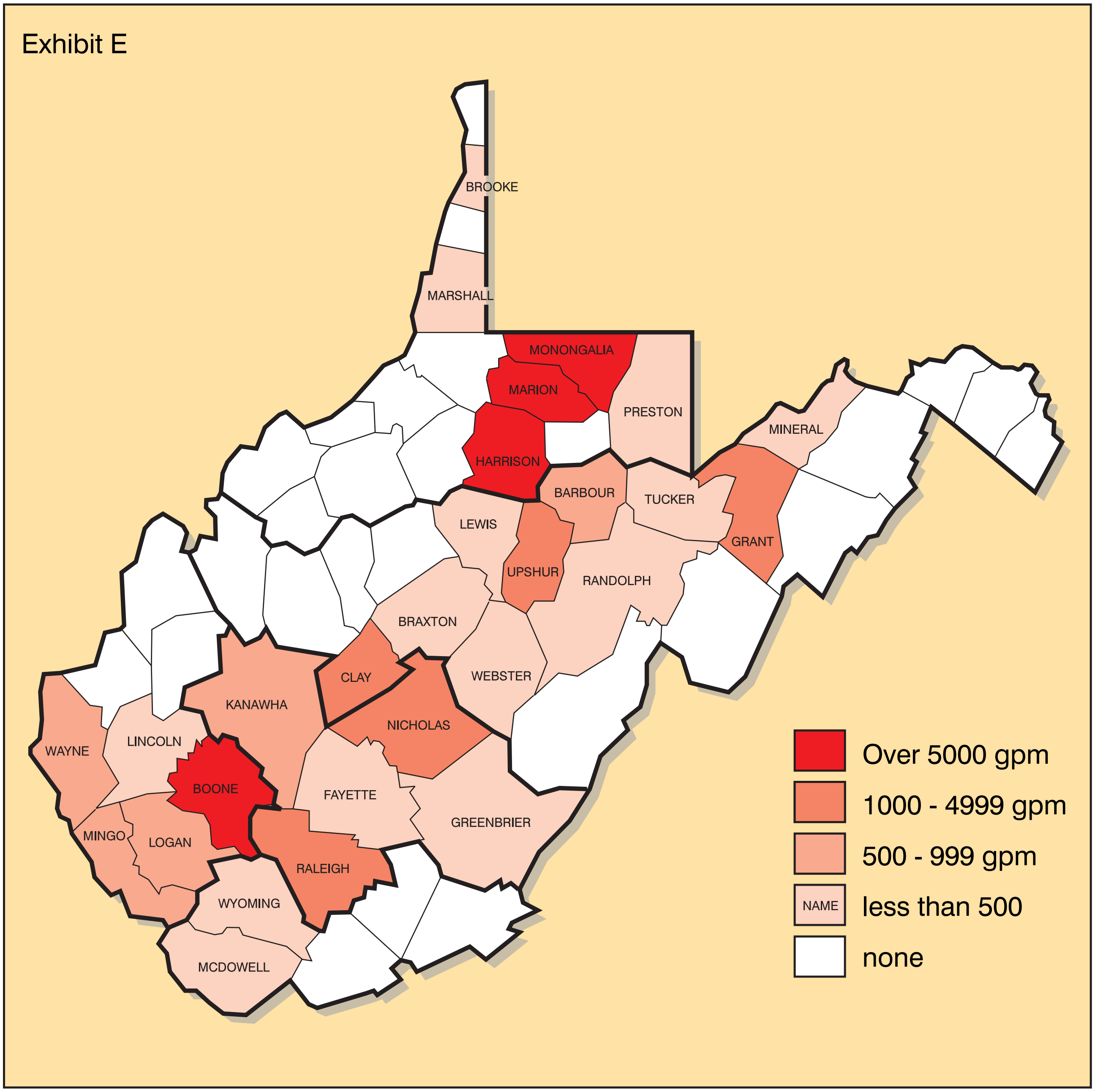
It is not surprising that Boone, Marion, Harrison and Monongalia, four counties with large underground mine complexes, dominate more than three-fourths the total flow. Several large deep mines in Harrison county were being pumped in 2000 which dramatically increased its percentage.

While Preston County reported 6% of the total state sources in 2000, it represented only 1% of the total flow. This may be due to the large number of surface mine sites with poor water quality and relatively low flows. A similar trend is seen in Nicholas County.

Conversely, Harrison County had only 2% of the sources, but the large deep mines dominating that county returned approximately 20% of the state's flow in 2000. McDowell county exhibited reduced flows from a reduced number of sources, while Harrison, Raleigh, Monongalia Boone, and Clay counties increased their problematic flow. Relocation of pumping discharges from large deep mine pools may have been the cause of some of these changes in the northern counties.



See Appendix, Exhibit D



See Appendix, Exhibit E

Frequency of Flow

DEP inspectors, based on their knowledge and experience of the mine site and source, estimated in 1994 that 45% of the sources discharged intermittently. During the very wet month of October, 1996, many of these were not flowing and some previously considered "continuous" were also dry. Since 1996, the ratio of "continuous" to "intermittent or weather dependent" has not changed dramatically. Again, large, underground mine complexes dominate water quality concerns as an increasing percentage of sources discharge continuously and constitute an increasing percentage of the state's total problematic flow volume.

Quality of Sources

Field analysis reveals only a limited amount of information to the investigator. Although more reliable field instruments have improved pH measurements, there is still concern over the calibration and accuracy of these instruments. Similar shortcomings of field instruments for analyzing iron and manganese are recognized.

NPDES permits require regular submission of qualified laboratory analyses of the ***discharge.*** Inspectors were interested in the raw (untreated) water quality which was not often well documented. Collecting water samples from very low flows (less than one gallon per minute) often results in sampling error and would not substantially alter the statistics on statewide flow. Therefore, only sources with greater than 1 gpm were considered in the discussion of chemical character. From the data summarized in the following table, the following observations may be made about 1994 field data vs. laboratory analyses collected in 1996, 1998, and 2000:

A quarter of the sources in 1994, representing a third of the total flow were neutral to alkaline drainage. In the 1994 report on active mining the statement was made "Laboratory analysis of these samples (where alkalinity greater than acidity could be verified) would likely not change these numbers appreciably."

This theory was supported by the 1996 laboratory analytical data. In fact, the 1996 data indicates that 37% of the sources representing 50% of the total flow of concern is alkaline (pH greater than 6 and acidity less than 1). DEP's water quality database of more than 12,000 samples at over 1000 bond forfeiture sites contains very few analyses where both the pH was greater than 5.9 and acidity exceeded alkalinity; one may conclude that most neutral pH mine water in West Virginia is net alkaline.

Further, roughly half the current sources representing three quarters of the total flow have pH levels greater than 5.9 and are therefore alkaline or not strongly acid. ***(Exhibit G in Appendix).***

In 1998 and 2000, water samples were also analyzed for total aluminum. These data indicate that aluminum is a problem at over half of the sites with water quality issues.

When manganese is considered, about 27% of the untreated pH neutral sources have the potential to discharge manganese at concentrations above the usual effluent limits of 2 parts per million (ppm). This represents approximately 24% of the problem drainage. When manganese is the only parameter of concern, (pH greater than 5.9, iron less than 3, manganese greater than 2), about 7% of the sources are being treated for manganese only. Since 1996, DEP evaluated the efficacy of this specialized treatment since elevated pH may be more detrimental than moderate concentrations of manganese. Procedural changes in the NPDES program have since allowed some sites to discharge higher concentrations of manganese while carefully monitoring the invertebrate stream populations to ensure no environmental damage ensues. This has dramatically reduced the percentage of flow where manganese is the only parameter of concern from 9% in 1996 to 2% in 2000.

An increasing percentage of sources and flow exhibited neutral to alkaline pH and iron concentrations greater than general effluent limits of 3 ppm. At present, 58% of the flow being treated in the state is of alkaline iron character. Large deep mines with circumneutral pH and elevated iron concentrations constitute a large portion of the water quality problem in the state. A remarkable number of sites exhibit alkaline aluminum problems.

Sources or Influences on Water Quality

The origin of water at the untreated (raw) sampling location is often unknown. DEP inspectors have the benefit of historic knowledge at most sites, particularly with the information assembled for the permit and adjacent permitted sites. Many subject drainages were suspected to be influenced by more than one source. More than a third of the drainage of concern is influenced by either surface runoff, seepage, or refuse. Nearly three quarters are influenced by underground works ***(Exhibit C).***

Treatment Strategies

Operators appear to have control over the quantity of flow at 8% of the sources, but these pump-manipulated discharges constitute an increasing portion of the total flow (20% in 1994, 25% in 1996, 43% in 1998, and 67% in 2000).

Mine operators employ a host of treatment strategies for managing water quality *(**Exhibit H, page 12**)*. The primitive treatment method of using soda ash briquettes in a hopper or ditch line, was used at about one-quarter of the water quality sites in 1994. These sources constituted less than 5% of the total flow. This is no surprise, since operators have historically used this method on low-volume, mild, or intermittent flows. This number reduced substantially since then, as operators become more sophisticated in dealing with water quality problems.

Caustic soda continues to dominate the number of sites where water is chemically treated. While 44% of the sources utilize caustic soda, this represents about 36% of the flow. Conversely, 20% of the sites use lime of some composition to treat 40% of the total flow.

Obviously several large deep mine and refuse complexes with capital intensive central treatment plants and very large flows dominate the chemical treatment arena. Anhydrous ammonia is used at a large number of sites and is responsible for a decreasing portion of the flow.

Calcium oxide use increased dramatically in site number and flow from 1994 to 1996. Since then, an equal number of sites are responsible for much less of the total flow. Calcium oxide is being dispensed at a number of sites because of its economic advantage and low toxicity. Many lime plants (typically capital intensive) and soda ash sites (labor intensive) have converted to calcium oxide.

A growing number of sites meet effluent limits by employing passive technologies such as anoxic limestone drains or wetlands, but many more stay in compliance (but may not be eligible for final release) by the effects of dilution with other drainage before discharge. In many cases, simply allowing for further detention time prior to discharge will facilitate the improvement of some parameters. A common observation of those experienced in water quality management is that each drainage and treatment scenario is unique, and several treatment strategies may be in use at a single site.

A more meaningful examination of treatment strategies is possible when both flow and chemical analyses are available and loadings can be calculated. The product of acidity or metals concentrations and flow can be expressed in load as tons of metals or acidity per year ***(Exhibit I).***

Because many sites use a variety or combination of chemicals depending on flow volume or quality, temperature, availability, and other factors— loads and flow cannot be summed. The entire matrix must be viewed as non-cumulative.

For the total treated drainage in 1996, similar flow volumes were addressed with lime, calcium oxide, and caustic, with caustic dominating the number of sites. In 1998, lime and caustic dominated the flow and number of sites even as the number of caustic sites decreased dramatically. The volume of flow treated with ammonia has steadily declined. In 2000, caustic use increased, perhaps at those sites where ammonia or other neutralizers had been used. A steady number of sites are treated passively or with dilution (only) involving an increasing volume of flow. Much of this flow is from pumped alkaline deep mines.

Most sites pumping large flows use lime or caustic to treat acidity and/or iron. Many more gravity discharges employ, lime, caustic or calcium oxide to deal with acidity or problem metals.

Several sites were revoked from 1994 to 2000, but the untreated discharge of only three, T&T, Omega, and Royal Scot represented significant threats to the environment to require the state to continue chemical treatment. Others have been addressed with passive efforts including backfilling and constructed wetlands, alkaline addition, and limestone drains. Similarly, many active sites met effluent limits by passive technologies. Passive strategies, including constructed mitigation structures, or encouraging dilution or retention, were employed at nearly 100 sources dealing with over 8,500 gpm.

In 1994, inspectors estimated that 576 sources, or 66% of the 872 sources considered, would have significant adverse impact on the receiving stream if left untreated. This represented 90% of the total flow considered ***(Exhibit J).***

This number has declined steadily since 1994. Currently, inspectors estimate approximately 460 sources would significantly impact the receiving stream if untreated, resulting in nearly 15,000 tons of acid per year.

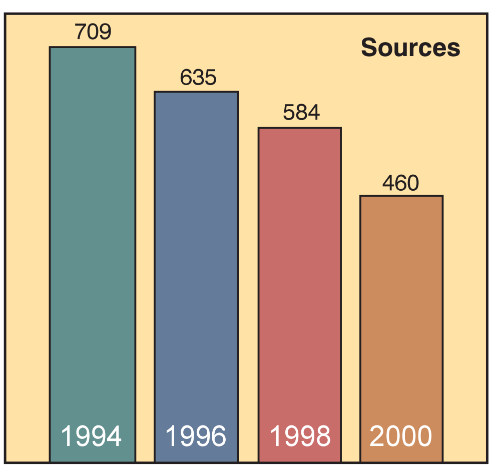
Bond Release Consideration

If treatment is not effective, violations are issued and efficacy is achieved or the permit is revoked.

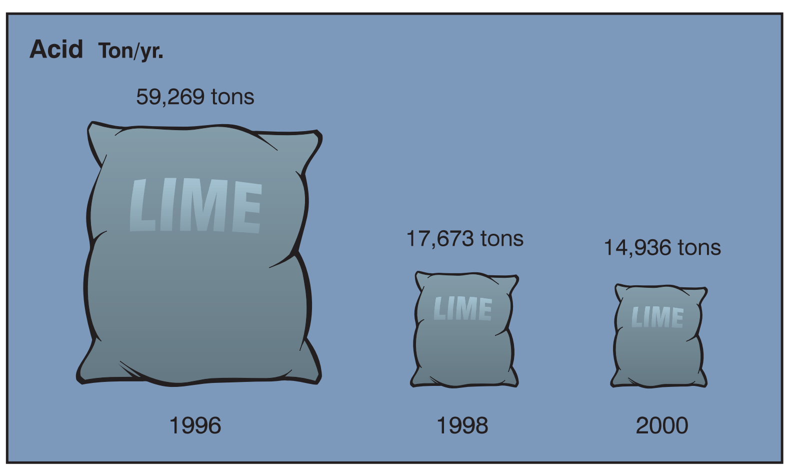
Several sites are not eligible for bond release solely on the basis of poor water quality. Inspectors were asked to comment on the likelihood that water quality would prevent release of securities held for the permit. In 1994, inspectors estimated that 395 of the 516 ***permits*** of concern would be affected. Apparently, water quality improved dramatically at many of these sites allowing their exclusion from the inventory and/or phase release, as the number of ***permits*** in this category in 2000 decreased to 314 and flow decreased by one-half.

Exhibit J:

Sources which would prevent release



Acid Load which would (if untreated) impact streams



See Appendix, Exhibit J

APPENDIX

EXHIBIT A:

CHANGES SINCE THE 1998 STUDY:

139 sources were eliminated from the study in 1998:

(27%) 38 sources at 18 permits were revoked (bond forfeitures)
24 Royal Scot sources, 9 Triple A sources
(only 20 of these were discharging in 1998; 289 gpm; 95 acid tons/yr.)
All sources (but Royal Scot) have no significant impact to streams.

(7%) 9 sources were found to be duplicates or combined with other sources

(66%) 92 sources were deleted because water quality had improved or source eliminated
(many of these were phase or final released)

49 new sources were added to the inventory.
they contained several large (>1000 gpm) flows, most of them alkaline.
This constituted 36% of the total flow in 2000, but only 9% of the acid and iron loads
9 of these accounted for 94% of the new flow; 1 new source for 73% of the new acid load.

SUMMARY OF CHANGES SINCE INITIAL STUDY:

Of the 872 sources in 1994, 446 (51%) remain in the database.
Of the 107 new sources in 1996, 79 (73%) remain in the database.
Of the 73 new sources in 1998, 62 (85%) remain in the database.

	sources	gpm	acid t/yr.	iron t/yr.	Mn t/yr.	Al t/yr.	soil moisture
New in 2000	49	17,786	1,449	415	85	123	
2000 total	635	49,648	15,733	4,322	645	711	75% normal
1998 total	725	34,147	18,254	1,259	568	1,049	60% normal
1996 total	816	89,325	60,646	20,247	1,235		147% normal
1994 total	872	93,760					118% normal

18 sources (5 new) account for 70% of the total flow, 7% of the acid load, 55% of the iron load, 20% of the manganese load, and 16% of the aluminum load.

PRECIPITATION DURING THE STUDY:

Yearly annual state precipitation (calendar year)

1994	49 inches	112% normal
1995	42 inches	96% normal
1996	59 inches	134% normal
1997	41 inches	93% normal
1998	45 inches	103% normal
1999	37 inches	85% normal
2000	40 inches	93% normal

Selected months (30 days prior to sampling)

July,August, 1994	118% normal
Sep-96	205% normal
Oct-96	90% normal
Sep-98	59% normal
Oct-98	60% normal
Sep-00	121% normal
Oct-00	29% normal

In early studies, 20% to 43% of the flow was pumped (67% in 2000). Most of this is deep mine drainage.
Surface mine discharges are likely more responsive to precipitation in the previous 30 days than large mine pools.
The study period in 1994 was wetter than normal.
The study period in 1996 was very wet to normal.
The study period in 1998 was quite dry.
The study period in 2000 was dry to normal.

EXHIBIT B

DISTRIBUTION OF OUTLETS BY REGION:

SOURCE

REGION	OFFICE	94 sources	94 % total	96 sources	96 % total	98 sources	98 % total	**00 sources**	**00 % total**
1	Fairmont	253	29%	200	25%	157	22%	**145**	**23%**
2	Philippi	183	21%	193	24%	195	27%	**185**	**29%**
3	Oak Hill	270	31%	230	28%	206	28%	**152**	**24%**
4	Welch	32	4%	34	4%	27	4%	**30**	**5%**
5	Logan	134	15%	159	19%	139	19%	**123**	**19%**
Total		872		816		724		**635**	

FLOW

REGION	OFFICE	94 gpm	94 % total	96 gpm	96 % total	98 gpm	98 % total	**00 gpm**	**00 % total**
1	Fairmont	30,945	33%	35,006	39%	12,005	35%	**21,941**	**44%**
2	Philippi	30,624	33%	26,213	29%	8,201	24%	**7,491**	**15%**
3	Oak Hill	8,793	9%	7,411	8%	5,479	16%	**6,833**	**14%**
4	Welch	10,070	11%	9,574	11%	1,526	4%	**1,367**	**3%**
5	Logan	13,328	14%	11,121	12%	6,936	20%	**12,016**	**24%**
Total		93,760		89,325		34,147		**49,648**	

EXHIBIT C

SOURCE OR INFLUENCES ON WQ OF DRAINAGE:

	SOURCE 1994		1996		1998		2000		FLOW 1994		1996		1998		2000	
	sources	%	sources	%	sources	%	**sources**	**%**	gpm	%	gpm	%	gpm	%	**gpm**	**%**
PITWATER	47	5%	48	6%	45	6%	**32**	**5%**	7,237	8%	5,815	7%	2,710	8%	**8,696**	**18%**
SURFACE RUNOFF	207	24%	231	28%	182	25%	**229**	**36%**	29,679	32%	32,280	36%	11,595	34%	**18,486**	**37%**
SEEPAGE	382	44%	385	47%	359	50%	**380**	**60%**	32,349	35%	29,742	33%	7,793	23%	**15,794**	**32%**
REFUSE	205	24%	204	25%	186	26%	**162**	**26%**	34,178	36%	35,226	39%	14,769	43%	**18,432**	**37%**
UNDERGROUND	192	22%	166	20%	145	20%	**130**	**20%**	60,063	64%	63,923	72%	18,908	55%	**38,494**	**78%**
OTHER	86	10%	69	8%	60	8%	**27**	**4%**	5,436	6%	2,206	2%	1,076	3%	**921**	**2%**
# OUTLETS, TOTAL gpm	872		816		725		**635**		93,760		89,325		34,152		**49,648**	

Note: WQ at many sources is influenced by more than one category; percentages are based on unique sources and their flow.

EXHIBIT H

TREATMENT STRATEGIES:

	SOURCE 1994		1996		1998		2000		FLOW 1994		1996		1998		2000	
	sources	%	sources	%	sources	%	**sources**	**%**	gpm	%	gpm	%	gpm	%	**gpm**	**%**
CAUSTIC (NaOH)	315	36%	305	37%	289	40%	**282**	**44%**	23,974	26%	27,840	31%	7,263	21%	**17,639**	**36%**
SODA ASH (NaCO3)	222	25%	180	22%	120	17%	**94**	**15%**	5,059	5%	6,945	8%	1,286	4%	**1,052**	**2%**
LIME (exc. CaO)	156	18%	121	15%	108	15%	**130**	**20%**	45,140	48%	26,086	29%	12,028	35%	**19,758**	**40%**
CALCIUM OXIDE (CaO)	51	6%	79	10%	70	10%	**73**	**11%**	1,766	2%	26,205	29%	3,937	12%	**3,241**	**7%**
AMMONIA (NH3)	124	14%	110	13%	103	14%	**70**	**11%**	15,120	16%	10,877	12%	3,334	10%	**2,420**	**5%**
PASSIVE	26	3%	70	9%	98	14%	**69**	**11%**	432	0%	2,094	2%	2,382	7%	**1,116**	**2%**
OTHER (incl. Floculants)	14	2%	22	3%	25	3%	**26**	**4%**	8,532	9%	8,764	10%	9,395	28%	**14,334**	**29%**
NONE (incl. Retention)	68	8%	92	11%	76	10%	**81**	**13%**	951	1%	1,877	2%	991	3%	**7,459**	**15%**
# UNIQUE SOURCES	872		816		725		**635**		93,760		89,325		34,152		**49,648**	

Note: Treatment at many sources is influenced by more than one chemical. percentages are based on unique sources and their flow.

EXHIBIT D

FLOW MANAGEMENT:

	SOURCE 1994		1996		1998		2000		FLOW 1994		1996		1998		2000	
	sources	%	sources	%	sources	%	**sources**	**%**	gpm	%	gpm	%	gpm	%	**gpm**	**%**
PUMPED	35	4%	30	4%	45	6%	**52**	**8%**	18,953	20%	22,756	25%	14,636	43%	**33,234**	**67%**
GRAVITY DISCHARGE	837	96%	786	96%	679	94%	**583**	**92%**	74,807	80%	66,569	75%	19,511	57%	**16,414**	**33%**
# UNIQUE SOURCES	872		816		725		**635**		93,760		89,325		34,152		**49,648**	

EXHIBIT E

DISTRIBUTION OF SOURCES BY COUNTY:

	SOURCE								FLOW							
	1994		**1996**		**1998**		**2000**		**1994**		**1996**		**1998**		**2000**	
	sources	%	sources	%	sources	%	**sources**	**%**	gpm	%	gpm	%	gpm	%	**gpm**	**%**
county																
Barbour	16	2%	17	2%	17	2%	**15**	**2%**	668	1%	666	1%	642	2%	**625**	**1%**
Boone	69	8%	82	10%	78	11%	**73**	**11%**	8,165	9%	7,241	8%	5,551	16%	**10,760**	**22%**
Braxton	12	2%	13	2%	8	1%	**5**	**1%**	1,592	2%	1,272	1%	275	1%	**324**	**1%**
Brooke/Ohio	1	0%	1	0%	2	0%	**2**	**0%**	500	1%	500	1%	200	1%	**110**	**0%**
Clay	32	4%	16	2%	34	5%	**35**	**6%**	403	0%	578	1%	726	2%	**1,041**	**2%**
Fayette	34	4%	31	4%	26	4%	**16**	**3%**	526	1%	221	0%	416	1%	**38**	**0%**
Gilmer	1	0%	1	0%	1	0%	**1**	**0%**	15	0%	0	0%	0	0%	**0**	**0%**
Grant	27	3%	35	4%	40	6%	**35**	**6%**	21,792	23%	24,470	27%	6,100	18%	**4,327**	**9%**
Greenbrier	38	4%	38	5%	38	5%	**10**	**2%**	929	1%	940	1%	373	1%	**130**	**0%**
Harrison	16	2%	16	2%	12	2%	**11**	**2%**	6,116	7%	8,564	10%	10	0%	**10,006**	**20%**
Kanawha	56	6%	39	5%	36	5%	**35**	**6%**	1,369	1%	845	1%	425	1%	**858**	**2%**
Lewis	6	1%	6	1%	0	0%	**0**	**0%**	35	0%	6	0%	0	0%	**5**	**0%**
Lincoln	1	0%	0	0%	0	0%	**1**	**0%**	50	0%	0	0%	0	0%	**18**	**0%**
Logan	15	2%	15	2%	15	2%	**14**	**2%**	566	1%	402	0%	387	1%	**594**	**1%**
Marion	32	4%	33	4%	26	4%	**20**	**3%**	3,171	3%	8,065	9%	6,328	19%	**5,216**	**11%**
Marshall	4	0%	4	0%	4	1%	**4**	**1%**	1,490	2%	550	1%	230	1%	**185**	**0%**
McDowell	8	1%	9	1%	7	1%	**5**	**1%**	8,717	9%	8,491	10%	210	1%	**214**	**0%**
Mineral	20	2%	21	3%	21	3%	**19**	**3%**	361	0%	150	0%	119	0%	**83**	**0%**
Mingo	35	4%	37	5%	29	4%	**25**	**4%**	3,672	4%	2,758	3%	719	2%	**706**	**1%**
Monongalia	96	11%	72	9%	60	8%	**63**	**10%**	17,601	19%	11,003	12%	3,212	9%	**5,410**	**11%**
Nicholas	113	13%	91	11%	81	11%	**74**	**12%**	2,252	2%	1,984	2%	1,040	3%	**1,195**	**2%**
Preston	91	10%	60	7%	39	5%	**35**	**6%**	1,496	2%	783	1%	506	1%	**301**	**1%**
Raleigh	27	3%	28	3%	22	3%	**17**	**3%**	3,657	4%	3,215	4%	3,196	9%	**4,693**	**9%**
Randolph	17	2%	20	2%	18	2%	**16**	**3%**	1,135	1%	393	0%	130	0%	**65**	**0%**
Taylor	4	0%	3	0%	3	0%	**0**	**0%**	19	0%	2	0%	1	0%	**0**	**0%**
Tucker	3	0%	5	1%	4	1%	**3**	**0%**	210	0%	405	0%	138	0%	**50**	**0%**
Upshur	30	3%	44	5%	43	6%	**45**	**7%**	4,468	5%	1,863	2%	1,193	3%	**1,279**	**3%**
Wayne	15	2%	25	3%	18	2%	**19**	**3%**	890	1%	720	1%	279	1%	**747**	**2%**
Webster	30	3%	29	4%	23	3%	**19**	**3%**	557	1%	2,155	2%	425	1%	**331**	**1%**
Wyoming	23	3%	25	3%	20	3%	**18**	**3%**	1,338	1%	1,083	1%	1,316	4%	**341**	**1%**
TOTAL:	872		816		725		**635**		93,760		89,325		34,147		**49,648**	

EXHIBIT F

FREQUENCY OF FLOW AT SOURCES (all flows):

	SOURCE								FLOW							
	1994		**1996**		**1998**		**2000**		**1994**		**1996**		**1998**		**1998**	
	sources	%	sources	%	sources	%	**sources**	**%**	gpm	%	gpm	%	gpm	%	**gpm**	**%**
intermittent	233	27%	269	33%	218	30%	**166**	**26%**	17,054	18%	15,637	18%	4,226	12%	**5,114**	**10%**
weather dependent	158	18%	143	18%	96	13%	**82**	**13%**	8,406	9%	751	1%	1,362	4%	**1,300**	**3%**
	----------		----------		----------		----------		----------		----------		----------		----------	
int. or weather dep.	391	45%	412	50%	314	43%	**248**	**39%**	25,460	27%	16,388	18%	5,588	16%	**6,414**	**13%**
continuous	481	55%	404	50%	411	57%	**387**	**61%**	68,300	73%	72,937	82%	28559	84%	**43234**	**87%**
	----------		----------		----------		----------		----------		----------		----------		----------	
total	872		816		725		**635**		93,760		89,325		34,152		**49,648**	

EXHIBIT G

QUALITY OF SOURCES (w/flow >1 gpm):

					SOURCE								FLOW							
					1994		**1996**		**1998**		**2000**		**1994**		**1996**		**1998**		**2000**	
	pH	Fe	Mn	Al	sources	%	sources	%	sources	%	**sources**	**%**	gpm	%	gpm	%	gpm	%	**gpm**	**%**
alkaline drainage	>5.9				219	25%	208	37%	183	45%	**191**	**45%**	31,918	34%	44,199	50%	21,881	64%	**37,799**	**76%**
weak acid drainage	>5.0				333	38%	263	47%	207	50%	**219**	**51%**	40,324	43%	49,361	55%	22,763	67%	**39,108**	**79%**
alkaline manganese	>5.9		>2		146	17%	99	18%	107	26%	**117**	**27%**	16,556	18%	17,482	20%	10,375	30%	**12,048**	**24%**
alkaline iron	>5.9	>3			118	14%	99	18%	100	24%	**118**	**28%**	24,073	26%	28,098	31%	16,299	48%	**28,774**	**58%**
alkaline aluminum	>5.9			>1					28	7%	**29**	**7%**					1,998	6%	**2,617**	**5%**
Mn only problem	>5.9	<3	>2				37	7%	29	7%	**34**	**7%**			7,900	9%	780	2%	**2,236**	**2%**
pH only problem	<6.0	<3	<2		48	6%	34	6%	14	3%	**8**	**2%**	2,049	2%	4,017	4%	994	3%	**246**	**0%**
alk-sl. acid w/ iron	>4.9	3-5			39	4%	23	4%	12	3%	**18**	**4%**	9,570	10%	9,814	11%	1,850	5%	**8,758**	**18%**
alk-sl. acid w/ iron	>4.9	5-10			147	17%	35	6%	31	8%	**22**	**5%**	16,913	18%	4,845	5%	9,797	29%	**5,213**	**11%**
alk-sl. acid w/ iron	>4.9	>10			11	1%	74	13%	73	18%	**98**	**23%**	4,635	5%	19,776	22%	5,307	16%	**16,293**	**33%**
alk-sl. acid w/ Mn	>4.9		<2		94	11%	126	22%	82	20%	**78**	**18%**	16,182	17%	27,283	31%	11,834	35%	**20,756**	**42%**
alk-sl. acid w/ Mn	>4.9		2-4		82	9%	54	10%	32	8%	**40**	**9%**	12,598	13%	12,121	14%	8,172	24%	**8,401**	**17%**
alk-sl. acid w/ Mn	>4.9		>4		157	18%	91	16%	100	24%	**104**	**24%**	11,544	12%	10,404	12%	2,866	8%	**4,507**	**9%**
alk-sl. acid w/ Mn	>4.9		>20		2	0%	5	1%	21	5%	**21**	**5%**	203	0%	116	0%	600	2%	**648**	**1%**
alk-sl. acid w/ Al	>4.9			>1					44	11%	**41**	**10%**					2,644	8%	**3,084**	**6%**
Aluminum				>1					227	55%	**238**	**56%**					13,660	40%	**13,466**	**27%**
discharging:					872		563		411		**427**		93,760		89,269		34,081		**49,614**	

EXHIBIT I

LOAD IN TONS PER YEAR						
and how ameliorated at sources discharging (>1 gpm)						
in 1996						
563 sources		80	65	267	87	106
TOTAL	Total	lime	CaO	caustic	ammonia	pass./none
gpm	89,269	26,078	26,204	27,828	10,871	3,952
acid load	60,646	35,975	21,604	31,284	6,579	319
iron load	20,287	6,764	12,287	6,196	1,433	54
Mn load	1,235	359	434	596	179	40
30 sources		13	1	9	2	2
PUMPED	Total	lime	CaO	caustic	ammonia	pass./none
gpm	22,755	10,688	25	8,428	450	15
acid load	9,629	1,800	25	7,717	0	6
iron load	2,064	275	8	1,757	22	2
Mn load	196	88	0	101	3	0
533 sources		67	64	258	85	104
GRAVITY	Total	lime	CaO	caustic	ammonia	pass./none
gpm	66,514	15,410	26,179	19,400	10,421	3,937
acid load	51,016	34,175	21,579	23,567	6,579	314
iron load	18,223	6,489	12,279	4,439	1,410	52
Mn load	1,039	271	434	495	176	40
in 1998						
411 sources		60	50	185	67	102
TOTAL	Total	lime	CaO	caustic	ammonia	pass./none
gpm	34,081	12,014	3,933	7,236	3,321	3,363
acid load	18,136	8,590	5,337	6,047	6,900	363
iron load	4,250	2,028	710	993	1,570	66
Mn load	566	131	173	248	99	43
Al load	1,046	492	273	315	371	34
28 sources		13	1	5	3	3
PUMPED	Total	lime	CaO	caustic	ammonia	pass./none
gpm	14,634	6,955	800	509	635	60
acid load	6,109	883	194	542	4,827	110
iron load	2,171	803	48	206	1,208	14
Mn load	122	54	8	11	21	4
Al load	380	93	10	14	258	7
383 sources		47	49	180	64	99
GRAVITY	Total	lime	CaO	caustic	ammonia	pass./none
gpm	19,447	5,059	3,133	6,727	2,686	3,303
acid load	12,027	7,707	5,143	5,505	2,073	254
iron load	2,078	1,225	663	787	363	52
Mn load	444	77	165	238	78	39
Al load	665	400	263	301	112	26
in 2000						
427 sources		**85**	**67**	**212**	**49**	**55 / 47**
TOTAL	**Total**	**lime**	**CaO**	**caustic**	**ammonia**	**pass./none**
gpm	**49,614**	**19,749**	**3,240**	**17,623**	**2,418**	**1113/ 7457**
acid load	**15,717**	**11,698**	**2,377**	**3,835**	**2,197**	**494 / 115**
iron load	**4,321**	**3,051**	**343**	**1,143**	**470**	**42 / 67**
Mn load	**644**	**199**	**186**	**311**	**99**	**42 / 44**
Al load	**709**	**427**	**149**	**244**	**106**	**49 / 40**
41 sources		**21**	**1**	**13**	**3**	**0 / 4**
PUMPED	**Total**	**lime**	**CaO**	**caustic**	**ammonia**	**pass./none**
gpm	**33,230**	**17,116**	**100**	**7,811**	**1,180**	**0 / 6083**
acid load	**3,290**	**2,200**	**164**	**930**	**875**	**0**
iron load	**3,127**	**2,447**	**10**	**560**	**245**	**0 / 45**
Mn load	**142**	**73**	**2**	**32**	**15**	**0 / 21**
Al load	**204**	**182**	**0**	**17**	**13**	**0 / 1**
386 sources		**64**	**66**	**199**	**46**	**55 / 43**
GRAVITY	**Total**	**lime**	**CaO**	**caustic**	**ammonia**	**pass./none**
gpm	**16,384**	**2,633**	**3,140**	**9,812**	**1,238**	**1113/1374**
acid load	**12,427**	**9,499**	**2,214**	**22,905**	**1,322**	**494 / 115**
iron load	**1,194**	**604**	**333**	**583**	**225**	**42 / 22**
Mn load	**502**	**125**	**184**	**279**	**84**	**42 / 17**
Al load	**505**	**245**	**149**	**227**	**93**	**49 / 38**

EXHIBIT J

Inspectors estimated the following:

in 1994					**in 1994**			**in 1994**		
WQ problem is:	sources	% total	gpm	% total flow	**would prevent release**		acid load	**impact stream**		acid load
Minimal	264	30%	6,366	7%	sources	gpm	tons/year	sources	gpm	tons/year
Moderate	296	34%	20,392	22%	709	70,572		576	83,808	
Severe	312	36%	67,032	71%						
total	872		93,790							
in 1996					**in 1996**			**in 1996**		
WQ problem is:	sources	% total	gpm	% total flow	**would prevent release**		acid load	**impact stream**		acid load
Minimal	261	32%	4,823	50%	sources	gpm	tons/year	sources	gpm	tons/year
Moderate	266	33%	17,161	20%	635	62,736	53,967	523	80,786	59,269
Severe	289	35%	67,331	75%						
total	816		89,315							
in 1998					**in 1998**			**in 1998**		
WQ problem is:	sources	% total	gpm	% total flow	**would prevent release**		acid load	**impact stream**		acid load
Minimal	208	29%	3,310	10%	sources	gpm	tons/year	sources	gpm	tons/year
Moderate	229	31%	4,033	12%	584	30,629	17,171	485	29,919	17,673
Severe	288	40%	26,804	78%						
total	725		34,147							
					in 2000			**in 2000**		
					would prevent release		**acid load**	**impact stream**		**acid load**
					sources	**gpm**	**tons/year**	**sources**	**gpm**	**tons/year**
					541	**42,557**	**14,658**	**460**	**47,915**	**14,936**