The State of Missouri’s Streams
Summary of Chemistry Data, 1993-2010
Featuring over 75,000 volunteer-collected measurements
The Missouri Stream Team Watershed Coalition would like to thank Dan Obrecht and Tony Thorpe, University of Missouri Senior Research Associates, for compilation and interpretation of the Stream Team volunteer water quality data and creation of this report. Their expertise in working with volunteer data was instrumental in creating a publication that truly showcases volunteer efforts while describing water quality across the state. We would also like to thank the staff of the Missouri Stream Team Program at Missouri Department of Conservation and Missouri Department of Natural Resources for their guidance and assistance in this process. Appreciation is also given to Stream Team volunteers who have dedicated their time to monitoring our state's streams and playing an active role in protecting our state's water resources.

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Missouri Stream Team has trained over 5,700 water quality volunteers since 1993. This report features dissolved oxygen, temperature, nitrate, ammonia, phosphate, turbidity, pH, conductivity, and chloride data from over 13,000 sample events at 2,154 stream sites in Missouri.

Water quality in Missouri’s streams and rivers can vary dramatically during the course of a single year, from one year to the next (wet versus dry year), and among regions. Because of this variability, multiple measurements are required to assess individual sites. While the Stream Team chemistry dataset is large, the number of sites with sufficient monitoring to allow for site assessment is low. To put it into perspective, out of the 2,154 sites where water temperature readings have been recorded, only 12% of them had 10 or more measurements.

Rather than producing a report featuring a small percentage of sites in the program, all of the available data were used and regional comparisons were made for each of the water quality parameters. A description of the method used to aggregate the data can be found on page 6.

A summary of data from sites with more than 25 water quality measurements can be found on page 16.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Number of Samples (1993-2012)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dissolved Oxygen</td>
<td>12,014</td>
</tr>
<tr>
<td>Temperature</td>
<td>13,068</td>
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<tr>
<td>Nitrate</td>
<td>11,204</td>
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<td>Ammonia</td>
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<td>Conductivity</td>
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<tr>
<td>Chloride</td>
<td>1,223</td>
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</tbody>
</table>
There are many ways to measure the health of a stream.

Along with biological monitoring (which measures stream health based on the invertebrate population) many volunteers also take physical and chemical measurements (which can indicate why a stream site is unhealthy). While the parameters monitored may seem quite different, in many ways they are interrelated and when evaluated together they can provide us with a thorough assessment of water quality conditions.

**Water temperature** is important to measure because it affects many physical, chemical, and biological characteristics of streams and rivers. At the region-wide scale, season is the most important factor in influencing the water temperature but other factors such as water source (groundwater vs. runoff) and the amount of riparian cover can also play a role. Elevated temperature due to human influences can endanger fish and other aquatic life. Warmer temperatures also reduce the water’s ability to hold dissolved oxygen and increase the toxicity of ammonia to aquatic life.

**Dissolved oxygen** (DO) is a measure of the oxygen available in the water for aquatic life. Sources of oxygen include the air we breathe and the oxygen given off by algae and aquatic plants during photosynthesis. If DO levels are too low, fish and invertebrates may be stressed or eliminated from the stream. Low levels may occur when pollutants enter the stream and use up DO via decomposition or through chemical transformation. Not only are low DO levels harmful, high concentrations can also endanger fish. “Super-saturation” can occur in streams and rivers with high levels of algal growth.
Nitrate and ammonia are two forms of nitrogen found in streams and rivers. While nitrogen is a nutrient required by aquatic life, it acts as a fertilizer and promotes excess algal growth at elevated concentrations. Ammonia is a reduced form of nitrogen that will use up dissolved oxygen as it chemically changes form. Ammonia can also be toxic to aquatic life; its toxicity is dependent on both temperature and pH. Sources of nitrate and ammonia include effluent from wastewater treatment plants, poorly functioning septic systems, runoff from feedlots and excess fertilizer applied to lawns and croplands.

Phosphate, like nitrogen, is a nutrient required by aquatic life that acts as a fertilizer in aquatic systems. It tends to occur at much lower concentrations than nitrogen and is often the nutrient that limits the growth of algae and aquatic plants. The problem associated with excess phosphate is the same as for high nitrogen levels, nuisance algal growth. The sources of phosphate are generally the same as the sources of nitrogen, with one notable difference; phosphate binds to soil particles more readily than nitrogen does. Runoff with high levels of sediment entering a stream or river will likely have excess phosphate.

Turbidity is a measure of water clarity and is determined by the amount of suspended materials in the water. These suspended materials might be inorganic, like soil particles, or organic matter, like algae. Not only can high turbidity reduce a stream’s aesthetic appeal, it can also negatively affect aquatic life. High turbidity may result in sedimentation that fills in the interstitial spaces in the stream substrate. Sedimentation can reduce habitat for invertebrates and negatively affect fish reproduction. Turbidity associated with soil materials enters streams as runoff from disturbed areas such as developments, plowed fields, and stream bank erosion.
**Monitoring Water Chemistry**

**pH** is a measure of the concentration of hydrogen ions (H+) relative to hydroxide ions (OH−), measured on a scale from 0 (acidic) to 14 (basic). If there are equal concentrations of hydrogen and hydroxide ions then the pH is 7 and the water is considered neutral. If hydrogen ions outnumber hydroxide ions then the water is acidic and the pH will be less than 7. Most aquatic life requires a specific range of pH for good health. Changes in pH, both increases and decreases, can stress or even kill invertebrates and fish. This is especially true when pH levels drop and waters become acidic. In this scenario, heavy metals can be released from sediment and become available for uptake by aquatic life. Human influences that affect pH are generally associated with air pollution that can turn precipitation into weak acids such as nitric or sulfuric acid.

**Conductivity** is a measure of the ability of water to conduct an electronic current. In simple terms, it is dependent on the amount and types of dissolved materials (specifically ions) in the water. Because water is a great solvent, it readily picks up ions as it flows over rocks and soil, thus a stream’s conductivity often reflects the geology of the stream’s watershed. High conductivity may not be toxic to aquatic life like elevated levels of other parameters, but high conductivity readings may indicate the presence of pollution. Both non-point sources of pollution, such as urban runoff, and point sources, such as effluent from wastewater treatment plants, can elevate conductivity readings above normal levels.

**Chloride** is one of the most common ions in Missouri’s streams and rivers. Under normal conditions chloride is found in low concentrations relative to other ions such as calcium or magnesium. Human influences that can increase chloride include ice-melting road salt and effluent from sewage treatment plants (humans have a high salt diet and thus our wastewater is high in sodium-chloride). Chloride can be toxic to aquatic life both at high levels (acute toxicity >860mg/L) and at lower levels (230 mg/L) over a longer time period (chronic toxicity).
The following pages will address each parameter as a regional summary and highlight data from specific sampling locations. To examine variation in water quality we divided the state into 12 regions and created a graph for each parameter that shows the distribution of data in each region.

Data analysis began by ordering the values from the lowest to highest measured for each parameter. Since showing all of the data for a region would result in a very wide spread and the number of data points on top of one another would make it difficult to see where the bulk of the data lie (see graph to the right), we chose to show the middle 50% of the data for each region for each parameter.

The graph to the right shows this “mid-spread” as a dark blue bar. The dot inside the bar shows the median value for the region, representing the exact middle of the regional data set. The mid-spread approach eliminates the extreme low and high values and focuses on the normal range within each region. When looking at the graphs, keep in mind there are values above and below the range showed.

A second graph features data from one or more sites and shows how water quality can vary month to month (temperature and chloride), over a long period (nitrate, ammonia, and pH), or how sites within a region compare (dissolved oxygen, phosphate, turbidity, conductivity and chloride).
Dissolved Oxygen (DO)

Pierce and Sugar Creek Dissolved Oxygen

Pierce Creek (Franklin County, blue line and symbols) and Sugar Creek (St. Louis County, red line and symbols) are both located in the Meramec Region, but have notably different dissolved oxygen levels. Nearly all measurements from Pierce Creek (96%) were at or above 100% saturation, while only 24% of measures taken in Sugar Creek reached this level. These two streams drain very different watersheds, with Pierce Creek having a watershed that is a mix of forest, grassland and some cropland compared to Sugar Creek’s highly developed watershed located near Kirkwood in St. Louis County. Measurements that fall in to the gray portion of the graph are considered “poor” and have saturation values >125% or <60%.

Regional Summary

Six of the regions: Northwest, Northeast, Kansas City/Osage, Lower Missouri, Upper Mississippi/Cahokia and Ozark/Osage had mid-spread DO values below 80% saturation. All 6 six regions contain highly urbanized areas (St. Louis, Kansas City, St. Joseph and Joplin). In contrast, all mid-spread saturation values in the very rural Scenic Riverways region were higher than 90%. This does not mean that only urban streams have potential problems. The mid-spread for the St. Francis/Bootheel Region reached to 125% saturation, indicating a quarter of measures collected in this region exceeded that level. Dissolved oxygen super-saturation can harm aquatic life and usually indicates excessive algal growth due to nutrient enrichment.
Temperature

White River Region Water Temperature

The graph below shows water temperature data from seven sites in the White River Region. Data are plotted by month to show how temperatures vary across the year (multiple years of data were used). While the seasonal pattern is predictable given the influence of air temperature, the amount that water temperatures vary within any month is considerable. On average there is a 14 degree (Celsius) difference between minimum and maximum values, with differences ranging from 11 to 19 degrees in individual months.

Regional Summary

While there are a number of factors that influence regional differences in water temperature (e.g. riparian cover and urban runoff) latitude may be the most important. The regions with the lowest median temperature (Northwest, Northeast, KC/Osage and Lower Missouri) are the four northernmost regions in the state. In contrast, the regions with the highest median temperatures are the White River and St. Francis/Bootheel, both located in the southern part of the state.
Chloride

Regional Summary

Not all Stream Teams measure chloride; the sampling kits are reserved for those sites where problems are suspected. The number of chloride measurements in a region ranged from 0 to 384, so care should be taken when making comparisons. The St. Francis/Bootheel, Scenic Riverways, Gasconade and White River regions had fewer than 20 measurements, while the Lake Ozark/Pomme de Terre and Ozark/Neosho regions had between 20 and 30 measures. The low sample number and site selection based on suspected problems do not allow objective regional comparisons. The mid-spread data for the Upper Mississippi/Cahokia Region reaches 230 mg/L, the level at which chronic (long-term) toxicity can become a problem for aquatic life. Of the 1,223 measurements statewide, 15% exceeded 230 mg/L.

Deer Creek Chloride Values

Stream Team volunteers measured chloride at 3 sites on Deer Creek in St. Louis County between March 2007 and October 2008. While the time period is limited, the data indicate a chloride spike during the winter, most likely relating to the application of salt on roadways and sidewalks. It should be noted that values at the beginning of the sampling were elevated relative to those measured during the summer and fall of 2007, possibly reflecting salt use during the 2006-07 winter.
Nitrate in North Blackbird Creek

Volunteers on North Blackbird Creek (Putnam County) took 110 nitrate measurements between 2000 and 2005. Concentrations ranged from below the limit of detection (0.25 mg/L to 5.0 mg/L, with an average of 0.88 mg/L. After displaying some initial variation, the nitrate levels were fairly low and stable during most of 2001 and well into 2002, typically below 1 mg/L. In September 2002 nitrate concentrations increased steadily until there was a break in monitoring in early 2003. When monitoring resumed in 2004 the concentrations were again below 1 mg/L.

Regional Summary

The Ozark/Neosho and White River regions had the highest nitrate concentrations, with median values of 2.0 and 1.0 mg/L, respectively. The upper end of the mid-spread for both regions was 4.0 and 3.0 mg/L, respectively, and 25% of the data were higher still. The only other region that exceeded 1.0 mg/L with its mid-spread was the St. Francis/Bootheel. Median values in the two northern regions, where agricultural influences are common, were comparable to medians from most of the other regions.
Ammonia in the Little Blue River

Volunteers collected 164 ammonia measurements on the Little Blue River between 1993 and 2009. Concentrations generally varied between 0.2 and 0.6 mg/L for 11 years. In late 2004 the volunteer received new equipment and the values decreased considerably. During the last four years of monitoring the ammonia concentrations were generally between 0.05 and 0.2 mg/L.

Regional Summary

The highest median values of ammonia were found in the four northernmost regions (Northwest, Northeast, Kansas City, Lower Missouri). While the median values for the Ozark/Neosho and St. Francis/Bootheel regions were comparable to other southern regions, the mid-spread values for these two regions extended to levels >0.75 mg/L, indicating that elevated ammonia levels sometimes occur in these regions.
Phosphate

Regional Summary

Phosphate concentrations varied considerably among the 12 regions. The median phosphate value for the Northeast Region was more than twice as high as any of the other regions at 1.0 mg/L. The median value’s location at the top of the mid-spread indicates that the majority of the 993 measurements from the region are close to 1 mg/L. In contrast, the phosphate measurements taken in the Scenic Riverways Region were all low and very comparable (mid-spread is small). Note that there were only 33 phosphate measurements taken in the Scenic Riverways region.

Urban and Rural Phosphate Values

Phosphate data from the whole Northeast Region were divided into values from sites within St. Charles County (urban and suburban influences) and the rest of the region (generally more rural) then plotted by month. Note that there were 13 times more measurements taken in the urban group than the rural group (923 vs. 70). Urban sites had phosphate values exceeding 2 mg/L throughout the year, while values at the rural sites only exceeded 2 mg/L in April and October. This suggests the urban influences in this region are not seasonal, but consistent through the year.
Turbidity

Turbidity in the Neosho Region

Turbidity data from two sites in the Ozark/Neosho Region are shown to highlight the variability that can be found within a region. The 46 turbidity measures taken on Center Creek between 1998 and 2010 exceeded 10 NTU (minimum detectable value) on only four occasions. In contrast, Spring River had turbidity values that ranged from 25 to 425 NTU during the three years it was monitored (62 turbidity measurements).

Regional Summary

Nine of the twelve regions had median turbidity values of ≤ 10 NTU, with only the Northwest, Northeast and Kansas City/Osage regions having median values that exceeded this level. Three regions (Gasconade, White River and Scenic Rivers) did not have any of their mid-spread exceed 10 NTU, indicating that at least 75% of measured values in these regions were <10 NTU. In contrast, the mid-spread for the Ozark/Neosho Region reached 60 NTU, meaning a full 25% of values from this region had even higher turbidity.
Regional Summary

Median pH values for the 12 regions display relatively small differences, ranging between 7.7 and 8.0. The most notable feature of the regional data was the small mid-spread range in the White River Region. This consistency is especially striking given that the mid-spread for that region represents over 1000 pH measurements.

Missouri’s state-wide standard for pH is a minimum of 6.5 and a maximum of 9.0 for all streams. Fewer than 2.5% of all values (12,476) were outside this range.

Clear Creek pH

Data from Clear Creek (Greene County) show how pH values can vary over the long-term (1993-2010). The average pH for this site was 7.9, with measurements ranging from 7.1 to 8.9. The data shows a consistent increase in pH values during the 2008-2010 time period relative to data collected prior to 2008. Continued monitoring is important to determine if this trend will continue.
Conductivity

Conductivity in Two Southwest Missouri Streams

Urban influences on conductivity can be seen in the comparison of two sites from the White River Region. Wilsons Creek receives wastewater effluent from the City of Springfield while Swan Creek has no significant urban influences. Average conductivity values for Wilsons Creek and Swan Creek were 648 and 342 µS/cm, respectively. Values higher than 1200 µS/cm may indicate a need for further investigation.

Regional Summary

Median conductivity values for the four northernmost regions were greater than 400 µS/cm, while most of the other regions had median values below this level. One exception to this was the Upper Mississippi/Cahokia Region, which had the highest median (and highest mid-spread) of all regions. High conductivity values were consistent throughout the region, implying the (comparatively) high conductivity is naturally occurring. Sites located in St. Louis City, St. Louis County and the remainder of the region had average conductivity values of 1132, 886 and 510 µS/cm, respectively.
Site Assessments

Water quality in streams and rivers can vary considerably over time, meaning numerous measurements need to be made to allow for accurate evaluation of water quality. In order to assess water quality at individual Stream Team sites we have focused on those parameters in which the state has criteria, and those sites with at least 25 measurements.

Individual monitoring results were compared to the state's criteria, and sites were “graded” based on how often they met criteria. If a site met criteria 95% of the time or more it was graded as Excellent, 85% to 94% was considered Good, 75% to 84% was Fair, and those sites that failed to meet criteria at least 75% of the time were rated as Poor. The following table summarizes the results of this analysis for four different water quality parameters.

Overall, water quality in Missouri streams seems to be Good-Excellent when pH and Ammonia are considered. Results for Chloride were mixed, but it should be noted the total number of sites evaluated were limited to 7, representing only three streams located in urban areas.

The 86 sites assessed based on Dissolved Oxygen indicate that Missouri streams may have some problems, with only 9 sites (10% of those assessed) rating Excellent compared to 20 sites (23%) rated Poor. Some sites that failed to meet criteria on a recurring basis failed due to low dissolved oxygen values associated with either organic or chemical pollution, while others tended to have high dissolved oxygen levels indicating excessive algal growth associated with nutrient enrichment.

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<th>Parameter</th>
<th>Missouri Criteria</th>
<th>Water Quality Assessment</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>Excellent (95% met criteria)</td>
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<tr>
<td>D.O. %Saturation</td>
<td>60% - 125%</td>
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<tr>
<td>pH</td>
<td>6.0 - 9.5</td>
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<tr>
<td>Ammonia</td>
<td>Varies*</td>
<td>31</td>
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<tr>
<td>Chloride - chronic</td>
<td>230 mg/L</td>
<td>3</td>
</tr>
<tr>
<td>Chloride - acute</td>
<td>860 mg/L</td>
<td>7</td>
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</tbody>
</table>

* Ammonia criteria vary with water temperature and pH, ranging from 0.1 to 10.8 mg N/L depending upon ambient conditions.
Missouri Stream Team Associations

Big Piney River Stream Team Watershed Association (Big Piney Watershed)
Contact: Peter Maki
Email: petermaki@totorcd.org

Elk River Watershed Improvement Association (Elk River Watershed)
Contact: Drew Holt
Email: holtedm@missouri.edu
Website: www.erwia.org

Green Hills Riverwatch
(N. Central Mo. incl. Chariton & Grand River Basins)
Contact: Melody Torrey
Email: mrtmkt@nemr.net

Greenway Network, Inc. (St. Charles area)
Contact: Larry Ruff
Email: lufffo01@gmail.com
Website: www.greenwaynetwork.org

LaBarque Watershed Stream Team Association
(NW Jefferson County)
Contact: Bob Coffing
Email: robertcoffing@sbcglobal.net

Friends of LaBarque Watershed Association
(NW Jefferson County)
Contact: Sunny Oberkramer
Email: greenholelodge@yahoo.com
Website: friendsoflabarquecreek.com

Little Blue River Watershed Coalition
(Little Blue River Watershed & Kansas City Area)
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Email: turtle5@aol.com
Website: www.littleblueriverwc.org/

Mill Creek Watershed Coalition
(Mill Creek Watershed)
Contact: Jim Marstiller
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Missouri Bootheel Stream Team Association
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Contact: Vannessa Frazier
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Missouri River Communities Network
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Email: manitoubluffs@gmail.com
Website: www.moriver.org/

Missouri River Stream Team Association
(Missouri River Basin)
Contact: Jeff Barrow
Email: jeff@riverrelief.org

Northern Ozark Rivers Partnership (NORP)
(Meramec, Huzzah, Courtois, Big, & Bourbeuse Rivers)
Contact: Burt Stewart
Email: wedostreams@yahoo.com

Ozarks Water Watchers
(Upper White River Basin)
Contact: David Casaletto
Email: dcasaletto@ozarkswaterwatch.org
Website: www.ozarkswaterwatch.org

River Des Peres Watershed Coalition
(River Des Peres in Saint Louis)
Contact: Danielle Haake
Email: danelle.haake@gmail.com
Website: www.riverdesperes.org

Scenic Rivers Stream Team Association
(Current, Jacks Fork, Eleven Point & North Fork of White River)
Contact: Angel Kruzen
Email: pansgarden@hotmail.com
Website: www.srsta.com

Show-Me Clean Streams
(Boone, Callaway, Cole, Cooper, Howard, & Moniteau Counties)
Contact: Diane Oerly
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South Grand River Watershed Alliance
(Bates, Cass & Henry Counties)
Contact: Shari LaRoussa
Email: info@southgrandwatershed.com
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Stewards of Grand Glaze
(Grand Glaze Watershed)
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Email: corikeys@aol.com
Missouri Stream Team

The Missouri Stream Team Watershed Coalition (MSTWC) is a not-for-profit organization with the mission of promoting and supporting Stream Team Associations. Associations, in turn, are regional groups of individual Stream Teams. By working together as part of an Association, Stream Team members can tackle and conquer larger goals. There are currently 18 Associations located throughout Missouri participating in MSTWC (see list inside back cover). The MSTWC serves as a resource for information, education, stewardship and advocacy for these Associations and Stream Teams.

WWW.MSTWC.ORG

The Missouri Stream Team Program began educating about, encouraging stewardship of, and promoting advocacy for Missouri’s streams and rivers in 1989. In the subsequent 24 years it has been an incredible success, with an estimated 80,000 volunteers conducting trash pick-ups, planting riparian vegetation, monitoring water quality and mapping watersheds. Missouri Stream Team volunteers are enthusiastic guardians of the state’s 110,000 miles of flowing water.

WWW.MOSTREAMTEAM.ORG