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Water Environment | Scientists Engineers

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November 7, 2019

Missouri Department of Natural Resources
Attention: Robert Voss
Water Protection Program
P.O. Box 176
Jefferson City, MO 65102-0176
robert.voss@dnr.mo.gov

RE: Missouri Section 303(d) Impaired Waters List

Dear Mr. Voss:

On behalf of The Doe Run Company ("Doe Run"), LimnoTech collected water and sediment samples to inform Missouri Section 303(d) Impaired Waters List impairment determinations for streams in the Viburnum Trend. As you are aware, Doe Run has constructed water treatment plants at mine and mill facilities, leading to improved water quality. The sampling was conducted consistent with a Sampling and Analysis Plan (SAP) and Quality Assurance Project Plan (QAPP) that had submitted to and approved by Missouri DNR in 2017. An Addendum to the SAP, describing proposed 2019 sampling, was provided to Missouri DNR in April 2019. Missouri DNR provided approval of the Addendum to the SAP in an email dated April 26, 2019. The sampling was conducted June 26-27 and September 4-5, 2019, and focused on stream reach segments and parameters that had previously been included as impaired on past Missouri 303(d) lists.

Attached to this letter is a sampling report presenting a summary of the data collection activities, results of field measurements and laboratory analyses, and quality control / quality assurance review. The laboratory Electronic Data Deliverable (EDD) reports are also being provided to you via email. We request that Missouri DNR include these data in assessments to develop the 2020 303(d) list, as well as future assessments.

Additionally, based on the results of these recent samples, the following impairments from the 2018 303(d) list should be removed from the forthcoming 2020 list:

- Courtois Cr. (WBID 1943): lead in sediment
    - A treatment plant has been constructed at the Doe Run Viburnum facility which discharges into Indian Creek, upstream of Courtois Cr. and began operation in October, 2016.
    - 2017-2019 data indicate lead levels in sediment are below the probable effect level (PEL), which represents 150% of the probable effects concentration (PEC) and is the value used by MDNR to assess impairment of sediments. In addition, the probable effects concentration quotient (PECQ), which MDNR uses to estimate the synergistic effects of multiple metals in sediments, is below the threshold of 0.75, as shown in the table below.

Courtois Creek Lead in Sediments

Location	Date	Lead (mg/kg)	PECQ
1943/29.0	9/4/2019	12.4	0.077
1943/29.0	6/26/2019	40.6	0.146
1943/29.0	9/29/2017	66.1	0.236
Geometric mean		**32.2**	**0.134**
Probable Effect Level Threshold		**192**	**0.75**

- Indian Cr. (WBID 1946): lead and zinc in sediment.
  - As stated above, a treatment plant has been constructed at the Doe Run Viburnum facility which discharges into Indian Cr., and a previous outfall to a tributary to Indian Cr. has been eliminated. The treatment plant began operation in October, 2016.
  - 2017-2019 data indicate lead and zinc levels in sediment are below the PELs, and the PECQ for the suite of metals in sediment is below the threshold, as shown in the table below.

Indian Creek Lead and Zinc in Sediments

Location	Date	Lead (mg/kg)	Zinc (mg/kg)	PECQ
1946/0.1	9/4/2019	132	286	0.450
1946/0.1	6/26/2019	89.2	56.8	0.179
1946/0.1	9/29/2017	110	326	0.477
Geometric mean		**109**	**174**	**0.312**
Probable Effect Level Threshold		**192**	**689**	**0.75**

- Crooked Cr. (WBID 1928): cadmium and lead in sediment, copper in water
  - Doe Run previously discharged into Crooked Cr. from the Casteel Mine and BRRF. Regular discharges were eliminated in May, 2014 and March, 2016 respectively.
  - 2017-2019 data indicate cadmium and lead levels in sediment are below the PELs, and the PECQ for the suite of metals in sediment is below the threshold, as shown in the table below.

Crooked Creek Cadmium and Lead in Sediments

Location	Date	Cadmium (mg/kg)	Lead (mg/kg)	PECQ
1928/0.5	9/4/2019	2.3	33.7	0.181
1928/0.5	6/26/2019	4.2	39.8	0.258
1928/0.5	9/29/2017	4.3	62.4	0.306
Geometric mean		**3.5**	**43.7**	**0.241**
Probable Effect Level Threshold		**7.5**	**192**	**0.75**

- 2019 data indicate copper concentrations in water below the lowest calculated hardness-based water quality criterion, as shown in the table below.

Crooked Creek Copper in Water

Location	Date	Copper (µg/L)
1928/0.5	9/4/2019	0.78
1928/0.5	6/26/2019	0.77
1928/0.5	9/29/2017	0.58
1928/3.5	9/4/2019	0.75
1928/3.5	6/26/2019	1.1
1928/3.5	9/29/2017	0.75
Chronic Water Quality Criterion		11

- Bee Fk. (WBID 2760): lead in water
  - Doe Run previously discharged mine and tailings water to Bee Fork from the Fletcher Mine and Mill facility. Mine water and tailings water discharges at Fletcher have been discontinued; discharges to Bee Fork are now stormwater only.
  - 2017-2019 data indicate dissolved lead concentrations in water well below the lowest hardness-based chronic criterion, as shown in the table below.

Bee Fork Lead in Water

Location	Date	Lead (µg/L)
2760/8.6	9/5/2019	0.13
2760/8.6	6/27/2019	0.25
2760/8.6	9/26/2017	1.9
Chronic Water Quality Criterion		2.6

- West Fk. Black R. (WBID 2755): lead and nickel in sediment
  - 2017-2019 data indicate geometric mean lead and nickel levels in sediment are below the PELs, and the geometric mean PECQ for the suite of metals in sediment is below the threshold, as shown in the table below.

West Fork Black River Lead and Nickel in Sediments

Location	Date	Lead (mg/kg)	Nickel (mg/kg)	PECQ
2755/21.5	9/5/2019	136	22.4	0.332
2755/21.5	6/27/2019	8.6	4.2	0.049
2755/21.5	9/27/2017	264	34.6	0.597
2755/22.3	9/5/2019	23.7	7.8	0.093
2755/22.3	6/27/2019	96	31.1	0.356
2755/22.3	9/27/2017	1430	126	2.818
2755/22.5	9/5/2019	53.2	18.9	0.269
2755/22.5	6/27/2019	37.1	12.7	0.125
2755/22.7	9/27/2017	9.8	3.2	0.041
Geometric mean		**64.5**	**16.2**	**0.205**
Probable Effect Level Threshold		**192**	**73**	**0.75**

Additionally, there is a TMDL for lead and zinc in water for Indian Creek and Courtois Creek. The data collected during the 2017 and 2019 surveys show compliance with water quality standards for both lead and zinc in Indian Creek, as shown in the table below. Doe Run requests that MDNR withdraw the TMDL, or alternatively, accept the existing Viburnum permit as a permit in lieu of the TMDL.

Lead and Zinc Concentrations in Water in Indian Creek

Location	Date	Lead (µg/L)	Zinc (µg/L)
1946/0.1	9/4/2019	<0.13	4.6
1946/0.1	6/26/2019	<0.1	<10
1946/0.1	9/29/2017	0.36	16.9
Chronic water quality criterion		4.2	175

Please contact us if you have questions.

Sincerely,
LimnoTech

Hans Holmberg
Associate Vice President, Senior Engineer

Attachments:
Sampling Report
Electronic Data Deliverables submitted via email

Metropolitan St. Louis Sewer District
Division of Environmental Compliance
10 East Grand Avenue
St. Louis, MO 63147-2913
314-768-6200 www.stlmsd.com

February 10, 2020

Robert Voss
Missouri Department of Natural Resources
Water Protection Program
P.O. Box 176
Jefferson City, Missouri 65201

Dear Mr. Voss:

The Metropolitan St. Louis Sewer District has reviewed the St. Louis area streams included on the proposed 2020 Section 303(d) listings and de-listings for Missouri. We would like to take the opportunity to provide the Missouri Department of Natural Resources (MDNR) with the following comments.

303(d) List Comments

Comment #1: Little Antire Creek (WBID 4115.00) was listed as impaired by *E. coli* for WBC B in 2016. Since MDNR sent out the data solicitation request, MSD has collected additional data for this waterbody. Review of this additional data shows compliance with the water quality standard for the past three (3) years. MSD is requesting that MDNR consider the data collected during 2017, 2018 and 2019. Review of this data indicates that Little Antire Creek is attaining water quality standards and should be delisted for impairment by *E. coli*. Supporting data will be provided to the Department in an electronic format.

Comment #2: MDNR's 2020 data review worksheet for River des Peres (WBID 1710.00) does not include the 2017 or 2018 data that was submitted by MSD during the data solicitation. This data will not affect the listing status, but MSD requests that the data be added to MDNR's water quality database for future use. Data will be re-submitted to the Department in an electronic format.

Comment #3: MDNR's 2020 data review worksheet for Spring Branch (WBID 5007.00) does not include the 2017 or 2018 data that was submitted by MSD during the data solicitation. This data will not affect the listing status, but MSD requests that the data be added to MDNR's water quality database for future use. Data will be re-submitted to the Department in an electronic format.

Comment #4: MDNR's 2020 data review worksheet for Watkins Creek (WBID 1708.00) does not include the 2017 or 2018 data that was submitted by MSD during the data solicitation. This data will not affect the listing status, but MSD requests that the data be added to MDNR's water quality database for future use. Data will be re-submitted to the Department in an electronic format.

Comment #5: Gravois Creek tributary (WBID 4051.00) was listed as impaired by *E. coli* for WBC B in 2016. Since the time of the original listing, EPA has approved a Total Maximum Daily Load (TMDL) for the Gravois Creek Watershed. Implementation of this TMDL will address the water quality issues throughout the watershed, including the Gravois Creek tributary. MSD is proposing WBID 4051.00 be delisted and placed in Category 4A – TDML approved or established by EPA.

The Metropolitan St. Louis Sewer District appreciates the MDNR's commitment to transparency and the use of sound data and analysis in protecting Missouri's waterways. Thank you for the opportunity to provide comments during this process.

If you have any questions or comments, please feel free to contact me at (314) 436-8714 or Austin Nieman at (314) 436-8700.

Sincerely,

Jason Peterein
Program Manager – Department of Environmental Compliance
Metropolitan St. Louis Sewer District

cc: Jay Hoskins
Austin Nieman

Washington University in St. Louis
SCHOOL OF LAW
Interdisciplinary Environmental Clinic

February 20, 2020

Robert Voss
Missouri Department of Natural Resources
Water Protection Program
P.O. Box 176
Jefferson City, MO 65102-0176
VIA email: robert.voss@dnr.mo.gov

Re: Missouri 2020 Section 303(d) Impaired Waters List

Dear Mr. Voss,

On behalf of the Missouri Coalition for the Environment ("MCE"), the Washington University Interdisciplinary Environmental Clinic is submitting this letter to comment on the proposed Missouri 2020 Section 303(d) Impaired Waters List ("303(d) list"). Our comments specifically focus on the proposed lakes that are added under the new nutrient criteria. MCE is an environmental advocacy organization with offices in St. Louis City and Columbia. MCE has over 800 members throughout Missouri. MCE's members have advocated since 1969 for the protection of all streams, rivers, wetlands, and floodplains throughout the State of Missouri. MCE's members frequently pursue various activities which involve drawing drinking water from, swimming and fishing in, and floating on Missouri's waters. Thus, MCE has a substantial interest in MDNR's proposed 303(d) list.

Section 303(d) of the Clean Water Act requires states to develop a list of impaired waters ("303(d) list") by April 1st of every even-numbered year that do not meet the state's Water Quality Standards. Missouri Department of Natural Resources ("MDNR") published the Draft 2020 Section 303(d) Impaired Waters List on November 15, 2019. While the 303(d) list covers all pollutants for all waters of the state, we have reviewed and will be commenting based only on the new nutrient criteria for lakes. We previously testified at MDNR's public hearing on the 303(d) list draft proposal on February 13, 2020 and will expand upon our testimony in the following comments.

Lakes added under the new nutrient criteria make up over 75% of all new waterbody additions to the proposed 2020 303(d) list. For this reason, we believe MDNR should pay special attention to how it implements its nutrient criteria plan and monitors lakes for impairment. MCE's specific concerns and recommendations for the 303(d) list focus on three major points. First, MCE has noticed deficient collections of data and recommends MDNR comply with all data collection requirements. Second, MCE recommends MDNR improve transparency in the 303(d) listing methodology and process. Finally, MCE has found five additional lakes that show sufficient impairment qualifying them for 303(d) listing. MCE asks MDNR to consider adding these lakes

to the list.

I. MISSING INFORMATION FROM DATA COLLECTION AND RECOMMENDATIONS FOR IMPROVEMENT

There is a significant amount of data that has not been collected as required. First, according to the Department's Nutrient Criteria Implementation Plan, a minimum of four samples/grabs must be taken each year considered.[1] The following lakes have missing grabs for at least one of the most recent three years of data:

- Busch W.A. Kraut Run Lake: missing 1 grab in 2015; missing 3 grabs in 2014
- Rocky Hollow Lake: missing 1 in 1996
- Cameron Lake #4: missing 2 grabs in 2018; missing 1 in 2015
- Garden City New Lake: missing 1 grab in 2018

Second, each sample must include data for Chl-a, TN, TP, and Secchi depth.[2] Many lakes are missing one or more of these data requirements in sample years used to analyze these lakes. Missing data includes:

- Chl-a: Busch W.A. Kraut Run Lake (2015, 2014, 2010), Coot Lake (2010), Catclaw Lake (2010), Monroe City Lake (2010), New Marceline Lake (2010)
- TN + TP: Busch W.A. Kraut Run Lake (2015, 2014)
- Secchi depth: Lake Killarney (2003)

Additionally, a general review of a sample of unlisted lakes reveals that the amount of data collected by MDNR is insufficient. There are many non-impaired lakes on MDNR's Water Quality Assessment System that only have data for specific analytes without any nutrient data or only have fish tissue analysis without any water testing data. While most of the missing data points come from grabs prior the new nutrient criteria, MDNR is still using data from these years to determine whether a lake should be placed on the list. Under the new nutrient criteria, we hope to see all required data and grabs for each lake.

Under the third requirement, MDNR must consider at least three years of data and any data over seven years old may not be used to assess impairment.[3] As stated in the Implementation Plan, "a duration of three or more years is necessary to account for natural variations in nutrient levels due to climatic variability."[4] In its Methodology for the Development of the 2020 Section 303(d) List in Missouri, DNR states that "[f]or assessing present conditions, more recent data are preferable; however, older data may be used to assess present conditions if the data remains

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[1] *Nutrient Criteria Implementation Plan*, MO. DEP'T OF NAT. RES. 8 (July 27, 2018).
[2] *Id*.
[3] *Id*.
[4] *Id.* at 4.

representative of present conditions."[5] Based on the information available from DNR's Water Quality Data Search, there are many waterbodies for which there is a significant gap in years between sample collections.[6] Additionally, on numerous occasions after a lake exceeded an impairment or screening threshold, there was no sampling undertaken in the subsequent years.[7] Following each lake is the three most recent years that water quality data was collected:

- Butler Lake (2017, 2015, 2006)
- Drexel Lake (2017, 2015, 2011)
- Edina Reservoir (2012, 2008, 2006)
- Edwin A. Pape Lake (2016, 2009, 2005)
- Fredericktown City Lake (2017, 2014, 2008)
- Green City Lake (2016, 2012, 2009)
- Harrisonville City Lake (2017, 2015, 2007)
- Labelle Lake #2 (2017, 2015, 2011)
- Monroe City Lake (2014, 2011, 2010)
- New Marceline City Lake (2016, 2010, 2009)
- Willow Brook Lake (2015, 2006, 2005)
- Catclaw Lake (2017, 2011, 2010)
- Ella Ewing Community Lake (2012, 2008, 2007)
- King Lake (2009, 2006, 2005)
- Lake Killarney (2018, 2007, 2005)
- Rocky Hollow Lake (2012, 2008, 2005)
- Vandalia Community Lake (2012, 2005, 2002)

A. Prioritization of Data Collection for Lakes where Recent Data Indicates Impairment

We first recommend that DNR prioritize data collection for lakes where a recent collection of data showed that screening values and/or impairment thresholds were exceeded. Understandably, MDNR is limited in its capacity to collect data due to resource constraints. While we commend MDNR for adding lakes to 303(d) even though it requires using data from years before 2011, we are concerned that through their discretion of whether or not to consider old data, other lakes are left off of the protected list because of insufficient data. For example, if a lake has "good" criteria for years 2008 and 2009, and then the lake is sampled in 2016 and exceeds the Chl-a threshold, MDNR has the authority to keep a lake off the 303(d) list simply by not testing it after 2016. Thus, to mitigate the potential for impaired lakes being left off the list due to lack of

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[5] *Methodology for the Development of the 2020 Section 303(d) List in Missouri, Mo. Dep't of Nat. Res. 17 (Apr. 6, 2016).*

6 *Water Quality Assessment System*, MO. DEP'T. OF NAT'L RES., https://apps5.mo.gov/mocwis_public/wqa/waterbodySearch.do

7 MDNR considered data taken before 2011 for these lakes, 2011 representing 7 years before 2018 when is the most recent year any data was published for proposed additions to the 2020 303(d) list. Missouri Department of Natural Resources, 2020 Section 303(d) Listed Waters Proposed List for Public Notice (November 15, 2019), https://dnr.mo.gov/env/wpp/waterquality/303d/docs/2020-303d-list-public-notice-attachments.pdf.

sampling, MDNR should direct resources towards those lakes that have already exceeded impairment thresholds at least once.

For example, we reviewed data for Lamar Lake (Barton County) (WBID:7356.00) and found that its Chl-a data from 2018, 2017 and 2016 are 27.8, 26.5 and 28.7 respectively. These all exceeded the Chl-a screening value but failed to exceed the Impairment Response Threshold. The only assessment endpoint noted was Secchi depth data which indicated no impairment. But Secchi data alone does not verify that the lake is not impaired, and more data is needed to assess whether it should be included on the 303(d) list. Thus, there is a possibility that if more assessment endpoint data was collected, it would show that Lamar Lake is impaired and requires protection through inclusion on the 303(d) list.

B. Use of Discretion To Be Over-Inclusive In The Use Of Older Data

Additionally, we recommend that MDNR continue to use its discretion to be over-inclusive, rather than under-inclusive, when adding lakes using data older than 7 years and consider several additions to the list that rely on older data. A failure to collect an adequate amount of recent data does not justify the non-inclusion of waters that older data indicates as being impaired or trending towards being impaired.

II. RECOMMENDATIONS TO INCREASE TRANSPARENCY

MDNR's proposed 303(d) list seriously lacks transparency. The purpose of the 303(d) public hearing is to give the public the opportunity to comment on the newly added lakes, and potentially suggest new additions. But, if the public is to have any meaningful opportunity to do this, they must have access to the proper data and information.

A. Inclusion of A Narrative Justification For 303(d) Additions

Due to the complexity of the new nutrient criteria, MDNR should include a narrative for each newly proposed 303(d) waterbody addition describing why a lake was added to the list. While MDNR does provide a link to an Excel sheet with data on each lake, this data often does not provide the entire picture.[8] Additionally, MDNR failed to provide Excel format data for the lakes that were not placed on the 303(d) list. Excel data should be provided for the lakes that MDNR decided were not impaired, along with a narrative analysis and conclusion explaining why the lake was or was not judged to be impaired. If a lake has two or more years of Chl-a data that exceeds the nutrient response impairment threshold, then the reason for its addition is apparent. For the lakes that did not exceed the response threshold but rather had three years of data that exceed one of the nutrient screening thresholds (triggering consideration of the response assessment endpoints), it is less clear whether the lake should be added to the 303(d) list. The Excel documents contain very little information about any of the response assessment endpoints, such as if there were documented fish kills or excessive turbidity. MDNR should include all

[8] 2020 Section 303(d) Listed Waters Proposed List for Public Notice, *supra* note 7.

assessment endpoints data and a written narrative that describes MDNR's analysis and conclusion. If a lake is added to the list (or not added), the public should know exactly why it was added (or not) so that individuals have the proper knowledge to submit comments and understand the lake's condition with respect to water quality. Missouri decided not to use numeric nutrient criteria to determine impairment, and instead uses a system that requires consideration of several parameters before impairment can be demonstrated. Having chosen this system, Missouri must now explain how it is using these multiple data points when it communicates impairment decisions to the public.

B. Expansion of Access to Basic Waterbody Information

MDNR should make available basic information about Missouri lakes so that the public can monitor lakes that are not on the 303(d) list. While MDNR has the Water Quality Assessment System (WQAS), which allows the public to search a lake by name and find a list of all data taken from that lake, it does not have a list of all lakes and reservoirs under its jurisdiction in Missouri. As such, there is no list that an individual can go to and in order to determine if a particular body of water is protected by the state. In addition, if an individual does find the data on a particular lake on the WQAS, there is no definite way to know what criteria applies to that lake. Missouri has three different sets of criteria based on which region (Plains, Ozark Highlands, and Ozark Border) a lake is located. The WQAS documents on a particular lake do not contain information about which region the lake falls into and there is no map showing the boundaries of each region. So, if an individual sees that the Chl-a concentration of a particular lake averages to about 17, then it would be impaired if it were in the Ozark Highlands, but would not be at all if it were located in the Plains. Thus, with no basis to assess data against, there is no way for the public to know definitively if a particular lake should be considered impaired or at least be subject to stricter monitoring. The MDNR should do a better job of compiling data and providing information for these lakes. The data collected by the same program in the same year should be complied into one Excel file, making it easier for the public to review.

C. Written Justification For The Use Of Older Data

MDNR should publish written justifications for using or not using data older than seven years alongside the proposed 303(d) list. As mentioned in the previous section, MDNR has discretion to use older data and according to the MDNR's own listing methodology, "If the department uses data older than seven years to make a Section 303(d) list decision, a written justification for the use of such data will be provided." Without such information, the public may assume that every lake with data showing impairment for one year or more, regardless of when the data was collected, has the potential to be added to the 303(d) list.

D. Water Quality Assessment Tool Update

MDNR should consider updating its Water Quality Assessment tool website/database. While the database is immensely helpful in accessing water quality data, it should be noted that there are frequent error messages and time periods where the data is inaccessible. If the public is to have

the ability to monitor and provide comments on MDNR's activities, they must be able to consistently access the information.

E. Written Analysis and Conclusion of Potentially Impaired Lakes

There is a list of lakes placed on the 305(b) list named as potentially impaired lakes, but there is no available Excel data provided for this list that is similar to the data provided for the lakes placed on the 303(d) List. The MDNR should include Excel data and a narrative analysis with a conclusion for these lakes. This would allow the public to know that a certain lake has indicators of impairment and that it has the potential of becoming impaired. It is also important that the public know which lakes are showing signs of impairment so that they can provide oversight of MDNR to ensure that they are conducting the extra testing that is required.

III. CURRENT UNLISTED LAKES THAT SHOULD BE INCLUDED ON 2020 303(d) LIST

A. Jackrabbit Lake (Jackson County) (WBID:7391.00)

Jackrabbit Lake's most recent data is from 2017, 2011, and 2010. In 2010, the available data indicates that the lake was below the screening threshold. Again in 2011, the available data was just slightly under the screening threshold, with a geometric mean of 16.67 for Chlorophyll-a, but showing a clear upward trend. In 2017, six years later, the geometric mean for Chlorophyll-a had increased more than three-fold to 60.23. Had data been collected within the 6-year timeframe between 2011 and 2017, it is more than likely that another year's data would have exceeded the impairment threshold and Jackrabbit Lake would have automatically been added to the 303(d) list based on the requirements of the listing methodology.

B. Shelbyville Lake (Shelby County) (WBID:7036.00)

Shelbyville Lake has data from year 2010 and 2014. In 2014, Shelbyville Lake had a Chl-a geometric mean of 73.027, which is higher than the Plains Response Impairment Threshold. And the data from 2010 only had the data of Total Chlorophyll, the geometric mean of Total Chlorophyll was 94.775. Even assuming that Total Chlorophyll is 120% of the Chl-a (which normally would not reach that high), the estimated geometric mean of Chl-a is still 78.979, still higher than the Response Impairment Threshold. Up to now the lake was still not listed on the 303(d) list.

C. Montrose Lake (Henry County) (WBID:7208.00)

Montrose Lake has data from year 2007 and 2008. In 2007, the geometric mean of Chl-a was 54.976. In 2007, the geometric mean of Chl-a was 53.496. Both years' data had exceeded the Response Impairment Threshold for the plains region. Thus, the lake should be placed on the 303(d) list.

D. **Cameron Lake #1 (Dekalb County) (WBID:7120.00)**

Cameron Lake #1 has data from 1998 and 2016. In 2016, the geometric mean for Cameron Lake #1's Chlorophyll-a was 49.11. The last time Cameron #1 was tested before 2016 was 1998, and the sample did not include values for Chlorophyll-a, Phosphorus, or Nitrogen. Had additional data been collected before or after 2016, it is more than likely that another year's data would have exceeded the impairment threshold and Cameron #1 would have automatically been added to the 303(d)list based on the requirements of the listing methodology.

E. **Cameron Lake #2 (Dekalb County) (WBID:7121.00)**

Cameron Lake #2 is similar to Cameron Lake #1 and has data from 1998 and 2016. In 2016, the geometric mean for Cameron Lake #2's Chlorophyll-a was 33.92. The last time Cameron Lake #2 was tested before 2016 was 1998, and the sample did not include values for Chlorophyll-a, Phosphorus, or Nitrogen. Had additional data been collected before or after 2016, it is more than likely that another year's data would have exceeded the impairment threshold and Cameron Lake #2 would have automatically been added to the 303(d)list based on the requirements of the listing methodology.

IV. CONCLUSION

In summation of our public testimony and written commentary, we ask MDNR to implement the following recommendations: (1) Comply with the implementation plan requirements including collecting all prescribed data and ensuring that such data is up to date; (2) Include lakes that indicate impairment even if MDNR was unable to collect two years of data from the past seven years; (3) Improve transparency by making the 303(d) list information and reasoning more publicly available. This includes adding written narratives that describe why each lake was added to the list; (4) Consider adding the lakes detailed above. In this letter, we have further supported upon and explained these recommendations. While we understand the limits of MDNR's resources, we strongly encourage MDNR to ensure that all required data is collected moving forward, to improve transparency with the public, and to consider adding the lakes detailed above. We are glad to have the opportunity to weigh in on the 2020 303(d) list and appreciate MDNR considering our comments.

Sincerely,

Elizabeth Hubertz
Clinic Attorney

KC WATER

REGULATORY COMPLIANCE DIVISION
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February 19, 2020

Mr. Robert Voss
Water Protection Program
Missouri Department of Natural Resources
P.O. Box 176
Jefferson City, MO 65102-0176

Subject: Comments on Proposed 2020 303(d) List for Missouri

Mr. Voss,

The City of Kansas City (City) submits the following comments on the proposed 2020 303(d) List of impaired waters which the Missouri Department of Natural Resources (MDNR or Department) placed on public notice on November 15, 2019.

The 2020 303(d) List identifies Brush Creek (3986) as impaired for total polycyclic aromatic hydrocarbons (PAHs) in the sediment. This listing is based on sediment data collected from 2006 through 2015 at three monitoring locations: 1) Brush Creek upstream of Rockwell Ln (Site 3986/5.1), 2) Brush Creek at Park Road (3986/6.2), and 3) Brush Creek downstream of Tomahawk Rd (Site 3986/7.9). However, sites 3986/6.2 and 3986/7.9 are both located in the State of Kansas and are upstream of Missouri Waterbody ID (WBID) 3986.

Total PAH sediment data from Missouri site 3986/5.1 is below the probable effects concentration (PEC) used to determine the need for further evaluation. The Listing Methodology Document (LMD) for the 2020 Section 303(d) List states that "pollutant geometric means will be compared to 150% of the recommended PEC values." The geomean of total PAH sediment data at Missouri site 3986/5.1 is 19.2 mg/kg, which is below 150% of the PEC value of 22.8 mg/L (i.e., below 34.2 mg/kg) recommended by MacDonald et al. (2000). Furthermore, PECs are not regulatory standards and are only intended to be used as part of a weight of evidence analysis.

In summary, the draft listing of Brush Creek (3986) for total PAHs in sediment is based solely on 1) data collected upstream of the listed segment in the State of Kansas, and 2) a threshold value intended only to trigger a weight of evidence analysis. Total PAH sediment data from the only site within the listed segment does not even meet the threshold for further analysis. Therefore, the City requests the Department remove Brush Creek from the 303(d) List for total PAHs.

Thank you for considering our comments on the proposed 2018 303(d) list. Please contact me at 816-513-0601 if you have any questions or would like to discuss these issues further.

Sincerely,

Sherri Irving

Sherri Irving, Regulatory Compliance Division Manager

cc: Terry Leeds, Director
David Nelsen, Wastewater Utility Officer
Matt Bond, Deputy Director
Brent Herring, Wastewater Treatment Division Manager

INDEPENDENCE
★ WATER POLLUTION CONTROL ★

February 19, 2020

Department of Natural Resources
Water Protection Program
Attn: Mr. Robert Voss
P.O. Box 176, Jefferson City, MO 65102-0176

RE: Draft Missouri 2020 Section 303(d) Impaired Waters List Public Comment

The City of Independence (City) would like to request that the following streams listed in the Draft Missouri 2020 Section 303(d) Impaired Waters List be re-evaluated for Escherichia coli (E. coli):

Little Blue River, WBID 0422.00
Little Blue River Tributary, WBID 4107.00
Burr Oak Creek, WBID 3414.00
Crackerneck Creek, 3962.00
Rock Creek, WBID 4106.00
Spring Branch, WBID 5004.00

It is believed that these streams have been misclassified as impaired, based on data collected by the United States Geological Survey (USGS) through a joint founding agreement with the City of Independence, Missouri. The purpose of this agreement is to meet compliance with the City's Municipal Separate Storm Sewer System (MS4) Permit. The MS4 permit requires sampling during storm events. Results from these storm flow sampling events were included in the data set used by MDNR for the 303(d) list determination.

The Methodology for the Development of the 2020 Section 303(d) List in Missouri, states on page 49 under *Other Statistical Considerations* that "Data sets composed mainly or entirely of storm water data or data collected only during a season when water quality problems are expected could result in a biased estimate of the true exceedance frequency. In these cases, the department may use methods to estimate the true annual frequency and display these calculations whenever they result in a change in the impairment status of a water body".

At the request of the City, USGS calculated the geometric mean of E. coli for Rock Creek, Little Blue River, and Spring Branch, Attachments 1, 2, and 3 respectfully. The analysis was conducted with and without the addition of storm flow samples in the data set. Their calculations show~~s~~ a significant bias in E. coli counts when storm flow samples are included.

The City respectfully requests that the Missouri Department of Natural Resources review the data used in the determination of impairment for the previously mentioned streams and calculate the E. coli geometric mean without storm flow samples included in the data set.

Thank you for the opportunity to comment on this matter and if you have any further questions regarding this comment please feel free to contact us.

Sincerely,

Josh Eis
Environmental Compliance Supervisor
City of Independence - Water Pollution Control
jeis@indepmo.org
816.325.7054
9600 Norledge Ave.
Independence MO 64051

Attachments
Attachment 1 - Rock Creek, WBID 4106.00
Attachment 2 - Spring Branch, WBID 5004.00
Attachment 3 - Little Blue River, WBID 422.00

Missouri Department of Natural Resources

Rock Creek - WBID 4106.00

US Geological Survey-WRD, Mo.
HUC 8: 10300101

Org	Site Code	Site Name	Sample Type	Yr	Mo	Dy	Time	Rec Season	Sample ID	Qualifier	Ecoli (#/100ml)	Stormflow sample
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	CompWOP	2011	6	27	0400	Y	211809		54000.00	
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	CompWOP	2011	8	19	0015	Y	211811		27000.00	
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2011	4	13	0815	Y	211806		160.00	
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2011	9	15	0700	Y	211813		390.00	
2011 Recreational Season Geometric Mean - No Data Qualifier Adjustment:										**Sample Count = 4**		
2011 Recreational Season Geometric Mean:												

**Sample is the average of two or more duplicate samples.*

USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	CompWOP	2012	6	11	0415	Y	222848		88000.00	
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2012	5	22	0800	Y	222847		150.00	
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2012	9	12	1015	Y	231704		500.00	
2012 Recreational Season Geometric Mean - No Data Qualifier Adjustment:										**Sample Count = 3**		
2012 Recreational Season Geometric Mean:												

**Sample is the average of two or more duplicate samples.*

USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2014	4	10	1145	Y	243836		140.00	
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2014	7	22	0715	Y	243837		1000.00	
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2014	8	26	1300	Y	250811		1900.00	
2014 Recreational Season Geometric Mean - No Data Qualifier Adjustment:								**1794.72**		**Sample Count = 3**		
2014 Recreational Season Geometric Mean:										-		

**Sample is the average of two or more duplicate samples.*

USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	CompWOP	2015	4	22	0445	Y	269948		300.00	
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	CompWOP	2015	5	18	0445	Y	269949		7600.00	
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2015	6	16	0800	Y	255440		21000.00	
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2015	7	6	1805	Y	255441		250000.00	X
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2015	7	6	2020	Y	255442		100000.00	X
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2015	7	6	2230	Y	255443		120000.00	X
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2015	7	20	1015	Y	255444		60000.00	X
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2015	8	10	0615	Y	255445		1400.00	
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2015	9	22	0600	Y	255446		740.00	
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2015	10	13	0530	Y	255447		86.00	
2015 Recreational Season Geometric Mean - No Data Qualifier Adjustment:								**7736.21**		**Sample Count = 10**		**geomean without stormwater sample:**
2015 Recreational Season Geometric Mean:										**7736.21**		**1273.51**

**Sample is the average of two or more duplicate samples.*

USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2016	4	27	0945	Y	269952		18000.00	X
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2016	5	2	1200	Y	269953		310.00	
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2016	6	15	1200	Y	269954		380.00	
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2016	7	19	1230	Y	269956		440.00	
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2016	8	8	0910	Y	269957		2000.00	
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2016	8	24	2045	Y	269959		34000.00	X
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2016	8	25		Y	269961		34000.00	X
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2016	8	25	0200	Y	269962		3100.00	X
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2016	9	7	0945	Y	269963		300.00	
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2016	10	13	1200	Y	269964		380.00	X

2016 Recreational Season Geometric Mean - No Data Qualifier Adjustment:								**3088.53**		**Sample Count = 11**		**geomean without stormwater sample:**
2016 Recreational Season Geometric Mean:										**1941.84**		**499.52**
**Sample is the average of two or more duplicate samples.*												
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2017	4	12	1215	Y	276106		280.00	
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2017	5	22	1045	Y	276111		410.00	
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2017	6	26	1200	Y	276112		420.00	
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2017	7	20	1230	Y	276113		200.00	
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2017	8	16	1100	Y	276118		34000.00	
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2017	9	21	1230	Y	276119		860.00	
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2017	9	25	1400	Y	276120		360.00	
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2017	10	17	1150	Y	276121		370.00	
2017 Recreational Season Geometric Mean - No Data Qualifier Adjustment:								**663.50**		**Sample Count = 8**		
2017 Recreational Season Geometric Mean:										**663.50**		
**Sample is the average of two or more duplicate samples.*												
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2018	4	16	1045	Y	277215		460.00	
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2018	5	8	0930	Y	277216		13.00	
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2018	6	19	1145	Y	277217		260.00	
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2018	7	16	1040	Y	277218		630.00	
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2018	8	16	1110	Y	277219		200.00	
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2018	8	19	1945	Y	277220		8000.00	X
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2018	9	20	1110	Y	277221		630.00	
USGS	4106/1.8	Rock Cr. @ Kentucky Rd.	Grab	2018	10	16	1100	Y	277222		630.00	
2018 Recreational Season Geometric Mean - No Data Qualifier Adjustment:								**397.40**		**Sample Count = 8**		**geomean without stormwater sample:**
2018 Recreational Season Geometric Mean:										**397.40**		**258.80**
**Sample is the average of two or more duplicate samples.*												

Summary

Year	All records	No storm
2014		
2015	7736.21	1273.51
2016	1941.84	499.52
2017	663.50	
2018	397.40	258.80

Bacteria

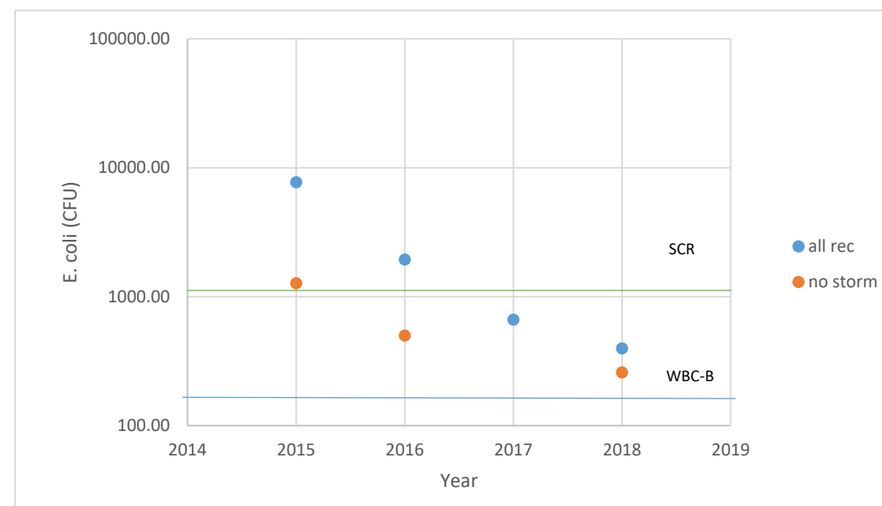
Rock Creek is a Class B Whole Body Contact recreational water with an E. coli standard of 206 colonies/100 ml. This standard is interpreted as the geometric mean of at least five samples taken during the recreational season, April 1 to October 31, of any given year. A water body is judged to be impaired if the standard is exceeded in any of the last three years for which there is adequate data. Rock Creek is also a Secondary Contact recreational water with an E. coli standard of 1134 colonies/100 ml. This standard is interpreted as the geometric mean of at least five samples taken during the recreational season, April 1 to October 31, of any given year. A water body is judged to be impaired if the standard is exceeded in any of the last three years for which there is adequate data.
Rock Creek has exceeded one or both criterion at least once in the last three years of available data.
Thus Rock Creek is judged as impaired for Escherichia coli.

Missouri Department of Natural Resources, Water Protection Program, (573)751-1300, www.dnr.mo.gov

http://www.dnr.mo.gov/mocwis_public/wqa/waterbodySearch.do

http://dnr.mo.gov/env/esp/wqm/biologicalassessments.htm

09/19/2019 MES



Missouri Department of Natural Resources

Spring Branch - WBID 5004.00

US Geological Survey-WRD, Mo.
HUC 8: 10300101

Org	Site Code	Site Name	Sample Type	Yr	Mo	Dy	Time	Rec Season	Sample ID	Qualifier	Ecoli (#/100ml)	Stormflow sample
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2011	4	13	0930	Y	211949		340.00	
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2011	8	19	0015	Y	211953		30000.00	
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2011	9	15	0815	Y	211955		390.00	
2011 Recreational Season Geometric Mean - No Data Qualifier Adjustment:										**Sample Count = 3**		
2011 Recreational Season Geometric Mean:												
**Sample is the average of two or more duplicate samples.*												
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2012	5	22	1100	Y	222896		810.00	
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2012	6	11	0845	Y	222897		28000.00	
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2012	9	17	0930	Y	238498		410.00	
2012 Recreational Season Geometric Mean - No Data Qualifier Adjustment:										**Sample Count = 3**		
2012 Recreational Season Geometric Mean:												
**Sample is the average of two or more duplicate samples.*												
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2014	4	10	1100	Y	243922		77.00	
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2014	7	22	1015	Y	243923		260.00	
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2014	8	26	0815	Y	250904		440.00	
2014 Recreational Season Geometric Mean - No Data Qualifier Adjustment:										**Sample Count = 3**		
2014 Recreational Season Geometric Mean:												
**Sample is the average of two or more duplicate samples.*												
USGS	*5004/2.2*	*Spring Branch @ Holke Road*	*FieldDupl**	*2015*	*7*	*6*	*1900*	*Y*	*255628*		39000.00	X
USGS	*5004/2.2*	*Spring Branch @ Holke Road*	*FieldDupl**	*2015*	*7*	*6*	*1901*	*Y*	*255629*		67000.00	X
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2015	4	22	1030	Y	255625		290.00	
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2015	6	16	1100	Y	255627		9000.00	
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2015	7	6	2050	Y	255630		86000.00	X
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2015	7	6	2140	Y	255631		77000.00	X
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2015	7	20	1130	Y	255632		15000.00	X
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2015	8	10	1030	Y	255633		520.00	X
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2015	9	22	0945	Y	255634		1300.00	
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2015	10	13	0900	Y	255635		210.00	
2015 Recreational Season Geometric Mean - No Data Qualifier Adjustment:								**6284.96**		**Sample Count = 10**		**geomean without stormwater samples**
2015 Recreational Season Geometric Mean:										**6284.96**		**918.76**
**Sample is the average of two or more duplicate samples.*												
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2016	4	27	0830	Y	270030		14000.00	X
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2016	5	2	0935	Y	270031		100.00	
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2016	6	15	0915	Y	270032		1100.00	
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2016	7	19	0915	Y	270033		1900.00	
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2016	8	8	0800	Y	270034		740.00	
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2016	8	24	2130	Y	270036		20000.00	X
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2016	8	24	2350	Y	270037		24000.00	X
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2016	8	25	0100	Y	270038		9900.00	X
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2016	9	7	0745	Y	270039		630.00	
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2016	10	6	0845	Y	270040		6900.00	X
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2016	10	13	0815	Y	270041		490.00	X

2016 Recreational Season Geometric Mean - No Data Qualifier Adjustment:								**2480.93**		**Sample Count = 11**		**geomean without stormwater samples**
2016 Recreational Season Geometric Mean:										**2480.93**		**627.69**

**Sample is the average of two or more duplicate samples.*

USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2017	4	12	0915	Y	276196		370.00	
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2017	5	22	0945	Y	276201		850.00	
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2017	6	26	1000	Y	276202		1800.00	
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2017	7	20	1115	Y	276203		2200.00	
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2017	8	16	1030	Y	276208		17000.00	
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2017	9	21	1100	Y	276209		630.00	
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2017	9	25	1345	Y	276210		56.00	
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2017	10	17	1000	Y	276211		600.00	
2017 Recreational Season Geometric Mean - No Data Qualifier Adjustment:								**904.55**		**Sample Count = 8**		
2017 Recreational Season Geometric Mean:										**904.55**		

**Sample is the average of two or more duplicate samples.*

USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2018	4	16	1015	Y	277278		86.00	
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2018	5	8	1000	Y	277279		400.00	
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2018	6	19	1000	Y	277280		500.00	
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2018	7	16	1010	Y	277281		2800.00	
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2018	8	16	1030	Y	277282		1200.00	
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2018	8	19	2115	Y	277283		9100.00	X
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2018	9	20	1030	Y	277284		200.00	
USGS	5004/2.2	Spring Branch @ Holke Road	Grab	2018	10	16	1030	Y	277285		860.00	
2018 Recreational Season Geometric Mean - No Data Qualifier Adjustment:								**740.55**		**Sample Count = 8**		**geomean without stormwater samples**
2018 Recreational Season Geometric Mean:										**740.55**		**517.50**

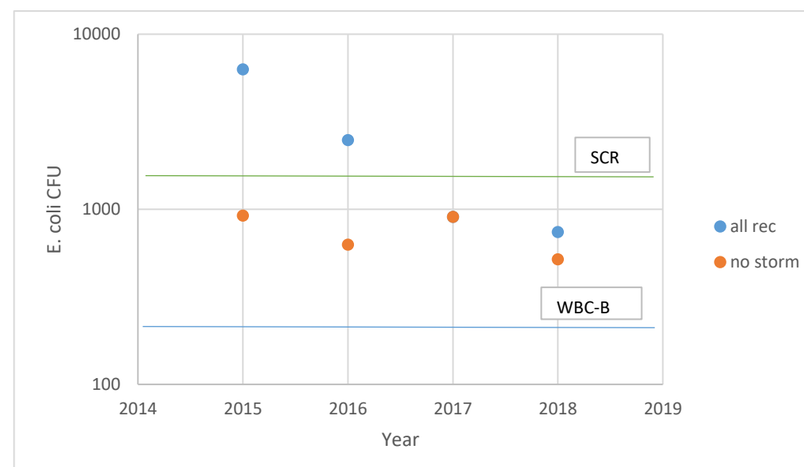
**Sample is the average of two or more duplicate samples.*

Summary

Year	All records	no storm
2015	6284.96	918.75727
2016	2480.93	627.68783
2017	904.55	904.55
2018	740.55	517.50403

Bacteria

Spring Branch is a Class B Whole Body Contact recreational water with an E. coli standard of 206 colonies/100 ml. This standard is interpreted as the geometric mean of at least five samples taken during the recreational season, April 1 to October 31, of any given year. A water body is judged to be impaired if the standard is exceeded in any of the last three years for which there is adequate data. Spring Branch is also a Secondary Contact recreational water with an E. coli standard of 1134 colonies/100 ml. This standard is interpreted as the geometric mean of at least five samples taken during the recreational season, April 1 to October 31, of any given year. A water body is judged to be impaired if the standard is exceeded in any of the last three years for which there is adequate data.
Spring Branch has exceeded one or both criterion at least once in the last three years of available data.
Thus Spring Branch is judged as impaired for Escherichia coli.



Missouri Department of Natural Resources, Water Protection Program, (573)751-1300, www.dnr.mo.gov

http://www.dnr.mo.gov/mocwis_public/wqa/waterbodySearch.do

http://dnr.mo.gov/env/esp/wqm/biologicalassessments.htm

09/19/2019 MES

Missouri Department of Natural Resources

L. Blue R. - WBID 422.00

US Environmental Protection Agency, Region VII, US Geological Survey-WRD, Mo.

HUC 8: 10300101

Org	Site Code	Site Name	Sample Type	Yr	Mo	Dy	Time	Rec Season	Sample ID	Qualifier	Ecoli (#/100ml)	Stormflow collection
USEPA-7	*422/11.5*	*L. Blue R. nr Lake City @ Hwy 78 br*	*FieldDupl**	*2011*	*6*	*2*	*0837*	*Y*	*244809*		133.25	
USEPA-7	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2011	6	8	0821	Y	244811		23.80	
USEPA-7	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2011	6	2	0904	Y	244812		182.90	
USEPA-7	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2011	6	8	0903	Y	244813		19.50	
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2011	4	13	1030	Y	211932		53.00	
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2011	9	15	1015	Y	211938		150.00	
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2011	4	13	0700	Y	211982		63.00	
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2011	6	27	1115	Y	211985		11000.00	X
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2011	9	15	1100	Y	211988		86.00	
2011 Recreational Season Geometric Mean - No Data Qualifier Adjustment:								**120.51**		**Sample Count = 10**		**geomean without stormflow samples:**
2011 Recreational Season Geometric Mean:										**120.51**		**68.54**

**Sample is the average of two or more duplicate samples.*

USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2012	5	22	1015	Y	222890		65.00	
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2012	5	22	1400	Y	222907		9.00	
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2012	6	11	1045	Y	222908		23000.00	
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2012	9	13	0900	Y	231759		330.00	
2012 Recreational Season Geometric Mean - No Data Qualifier Adjustment:								**-**		**Sample Count = 4**		
2012 Recreational Season Geometric Mean:										**-**		

**Sample is the average of two or more duplicate samples.*

USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2014	4	10	0900	Y	243918		31.00	
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2014	7	22	0825	Y	243919		76.00	
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2014	8	26	0745	Y	250899		110.00	
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2014	4	10	1030	Y	243928		43.00	
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2014	7	22	1145	Y	243929		230.00	
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2014	8	26	0930	Y	250914		320.00	
2014 Recreational Season Geometric Mean - No Data Qualifier Adjustment:								**477.59**		**Sample Count = 6**		
2014 Recreational Season Geometric Mean:										**96.75**		

**Sample is the average of two or more duplicate samples.*

USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2015	6	16	1120	Y	255614		5700.00	
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2015	7	6	2145	Y	255616		490000.00	X
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2015	7	7	0115	Y	255617		23000.00	X
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2015	7	7	0900	Y	255618		31000.00	X
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2015	7	20	1145	Y	255619		14000.00	X
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2015	8	10	1100	Y	255620		3100.00	X
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2015	9	22	1030	Y	255621		310.00	
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2015	10	13	0950	Y	255622		41.00	
USGS	422/12.4	Little Blue River near Truman Road	Grab	2015	4	22	1445	Y	270013		160.00	
USGS	422/12.4	Little Blue River near Truman Road	Grab	2015	5	18	1250	Y	270014		470.00	
USGS	422/12.4	Little Blue River near Truman Road	Grab	2015	6	16	1310	Y	270015		2200.00	
USGS	422/12.4	Little Blue River near Truman Road	Grab	2015	7	20	1300	Y	270016		18000.00	X
USGS	422/12.4	Little Blue River near Truman Road	Grab	2015	8	10	1325	Y	270017		100.00	X

USGS	422/12.4	Little Blue River near Truman Road	Grab	2015	9	22	1230	Y	270018		410.00	
USGS	422/12.4	Little Blue River near Truman Road	Grab	2015	10	13	1247	Y	270019		41.00	
USGS	422/12.9	Little Blue River near Little Blue Parkway	Grab	2015	4	22	1250	Y	270020		130.00	
USGS	422/12.9	Little Blue River near Little Blue Parkway	Grab	2015	5	18	1200	Y	270021		2300.00	
USGS	422/12.9	Little Blue River near Little Blue Parkway	Grab	2015	6	16	1215	Y	270022		3800.00	
USGS	422/12.9	Little Blue River near Little Blue Parkway	Grab	2015	7	20	1220	Y	270023		17000.00	X
USGS	422/12.9	Little Blue River near Little Blue Parkway	Grab	2015	8	10	1230	Y	270024		310.00	X
USGS	422/12.9	Little Blue River near Little Blue Parkway	Grab	2015	9	22	1155	Y	270025		200.00	
USGS	422/12.9	Little Blue River near Little Blue Parkway	Grab	2015	10	13	1200	Y	270026		63.00	
USGS	422/15.5	L. Blue R. @ Mize Rd.	Grab	2015	4	22	1045	Y	270043		430.00	
USGS	422/15.5	L. Blue R. @ Mize Rd.	Grab	2015	5	18	1040	Y	270044		1700.00	
USGS	422/15.5	L. Blue R. @ Mize Rd.	Grab	2015	6	16	1105	Y	270045		5000.00	
USGS	422/15.5	L. Blue R. @ Mize Rd.	Grab	2015	7	20	1040	Y	270046		17000.00	X
USGS	422/15.5	L. Blue R. @ Mize Rd.	Grab	2015	8	10	1100	Y	270047		840.00	X
USGS	422/15.5	L. Blue R. @ Mize Rd.	Grab	2015	9	22	1050	Y	270048		200.00	
USGS	422/15.5	L. Blue R. @ Mize Rd.	Grab	2015	10	13	1053	Y	270049		73.00	
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2015	4	22	1300	Y	255647		170.00	
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2015	5	18	1300	Y	255648		750.00	
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2015	6	16	0700	Y	255649		4300.00	
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2015	7	6	2030	Y	255651		1200000.00	X
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2015	7	7	0200	Y	255652		26000.00	X
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2015	7	7	0830	Y	255653		24000.00	X
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2015	7	20	0940	Y	255654		43000.00	X
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2015	8	10	0840	Y	255655		9600.00	X
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2015	9	22	0645	Y	255656		1300.00	
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2015	10	13	0630	Y	255657		180.00	
USGS	422/22.5	L. Blue R. nr 39th Street	Grab	2015	4	22	0945	Y	255659		330.00	
USGS	422/22.5	L. Blue R. nr 39th Street	Grab	2015	5	18	1000	Y	255660		1100.00	
USGS	422/22.5	L. Blue R. nr 39th Street	Grab	2015	6	16	1015	Y	255661		2400.00	
USGS	422/22.5	L. Blue R. nr 39th Street	Grab	2015	7	20	0950	Y	255662		26000.00	X
USGS	422/22.5	L. Blue R. nr 39th Street	Grab	2015	8	10	1010	Y	255663		5000.00	X
USGS	422/22.5	L. Blue R. nr 39th Street	Grab	2015	9	22	1010	Y	255664		100.00	
USGS	422/22.5	L. Blue R. nr 39th Street	Grab	2015	10	13	1000	Y	255665		41.00	
USGS	422/23.3	Little Blue River @ Jackson Drive	Grab	2015	4	22	0845	Y	270087		190.00	
USGS	422/23.3	Little Blue River @ Jackson Drive	Grab	2015	5	18	0845	Y	270081		2000.00	
USGS	422/23.3	Little Blue River @ Jackson Drive	Grab	2015	6	16	0915	Y	270082		1600.00	
USGS	422/23.3	Little Blue River @ Jackson Drive	Grab	2015	7	20	0900	Y	270091		24000.00	X
USGS	422/23.3	Little Blue River @ Jackson Drive	Grab	2015	8	10	0920	Y	270083		4100.00	X
USGS	422/23.3	Little Blue River @ Jackson Drive	Grab	2015	9	22	0920	Y	270084		200.00	
USGS	422/23.3	Little Blue River @ Jackson Drive	Grab	2015	10	13	0910	Y	270085		97.00	
USGS	422/24.8	Little Blue River @ Hwy 291	Grab	2015	4	22	0800	Y	270086		380.00	
USGS	422/24.8	Little Blue River @ Hwy 291	Grab	2015	5	18	0745	Y	270088		1400.00	
USGS	422/24.8	Little Blue River @ Hwy 291	Grab	2015	6	16	0750	Y	270089		1300.00	
USGS	422/24.8	Little Blue River @ Hwy 291	Grab	2015	7	20	0810	Y	270090		22000.00	X
USGS	422/24.8	Little Blue River @ Hwy 291	Grab	2015	8	10	0815	Y	270092		6500.00	X
USGS	422/24.8	Little Blue River @ Hwy 291	Grab	2015	9	22	0810	Y	270093		630.00	
USGS	422/24.8	Little Blue River @ Hwy 291	Grab	2015	10	13	0810	Y	270094		140.00	
USGS	422/8.5	Little Blue River @ Hwy 24	Grab	2015	4	22	1000	Y	270095		140.00	
USGS	422/8.5	Little Blue River @ Hwy 24	Grab	2015	5	18	1440	Y	270096		2700.00	

USGS	422/8.5	Little Blue River @ Hwy 24	Grab	2015	6	16	1445	Y	270097		5000.00	
USGS	422/8.5	Little Blue River @ Hwy 24	Grab	2015	7	20	1450	Y	270098		15000.00	X
USGS	422/8.5	Little Blue River @ Hwy 24	Grab	2015	8	10	1415	Y	270099		200.00	X
USGS	422/8.5	Little Blue River @ Hwy 24	Grab	2015	9	22	1400	Y	270100		620.00	
USGS	422/8.5	Little Blue River @ Hwy 24	Grab	2015	10	13	1425	Y	270101		10.00	
USGS	422/9.9	Little Blue River @ Bundshu Road	Grab	2015	4	22	1745	Y	270102		130.00	
USGS	422/9.9	Little Blue River @ Bundshu Road	Grab	2015	5	18	1340	Y	270103		2800.00	
USGS	422/9.9	Little Blue River @ Bundshu Road	Grab	2015	6	16	1345	Y	270104		4400.00	
USGS	422/9.9	Little Blue River @ Bundshu Road	Grab	2015	7	20	1400	Y	270105		16000.00	X
USGS	422/9.9	Little Blue River @ Bundshu Road	Grab	2015	8	10	1515	Y	270106	<	100.00	X
USGS	422/9.9	Little Blue River @ Bundshu Road	Grab	2015	9	22	1320	Y	270107		630.00	
USGS	422/9.9	Little Blue River @ Bundshu Road	Grab	2015	10	13	1335	Y	270108		85.00	
2015 Recreational Season Geometric Mean - No Data Qualifier Adjustment:								**130.89**		**Sample Count = 74**		geomean without stormflow samples:
2015 Recreational Season Geometric Mean:										**1300.89**		**457.69**

**Sample is the average of two or more duplicate samples.*

USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2016	4	27	0715	Y	269998		15000.00	X
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2016	5	2	0915	Y	269999		200.00	
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2016	6	15	1130	Y	270000		70.00	
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2016	7	19	0945	Y	270001		86.00	
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2016	8	8	0845	Y	270002		2000.00	
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2016	8	24	2130	Y	270003		13000.00	X
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2016	8	24	2145	Y	270004		18000.00	X
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2016	8	25	0730	Y	270005		20000.00	X
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2016	8	25	1100	Y	270006		12000.00	X
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2016	9	7	0715	Y	270007		190.00	
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2016	10	6	1045	Y	270008		98.00	
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2016	10	13	0730	Y	270009		140.00	X
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2016	4	27	1315	Y	270064		9600.00	X
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2016	5	2	0745	Y	270065		100.00	
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2016	6	15	1215	Y	270066		20.00	
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2016	7	19	1100	Y	270067		110.00	
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2016	8	8	1215	Y	270068	<	100.00	
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2016	8	24	2215	Y	270069		3500.00	X
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2016	8	25	0500	Y	270070		45000.00	X
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2016	8	25	0515	Y	270071		33000.00	X
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2016	8	25	0850	Y	270072		6300.00	X
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2016	9	7	0815	Y	270073		120.00	
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2016	10	6	1130	Y	270074		300.00	
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2016	10	13	1000	Y	270075		200.00	X
2016 Recreational Season Geometric Mean - No Data Qualifier Adjustment:								**945.91**		**Sample Count = 24**		geomean without stormflow samples:
2016 Recreational Season Geometric Mean:										**918.99**		**134.65**

**Sample is the average of two or more duplicate samples.*

USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2017	4	12	1130	Y	276125		65.00	
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2017	5	22	0915	Y	276130		590.00	
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2017	6	26	1030	Y	276131		180.00	
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2017	7	20	1030	Y	276132		86.00	

USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2017	7	27	1200	Y	276136		12000.00	X
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2017	8	16	1000	Y	276137		200.00	
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2017	9	21	1015	Y	276138		200.00	
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2017	9	25	1320	Y	276139		47.00	
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2017	10	17	1030	Y	276140		170.00	
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2017	4	12	1030	Y	276155		100.00	
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2017	5	22	0730	Y	276159		590.00	
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2017	6	26	0900	Y	276160		130.00	
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2017	7	20	0815	Y	276161		360.00	
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2017	7	27	1435	Y	276165		17000.00	X
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2017	8	16	0845	Y	276166		1300.00	
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2017	9	21	0845	Y	276167		200.00	
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2017	9	25	1200	Y	276168		36.00	
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2017	10	17	0800	Y	276169		93.00	
2017 Recreational Season Geometric Mean - No Data Qualifier Adjustment:								**277.14**		**Sample Count = 18**		**geomean without stormflow samples:**
2017 Recreational Season Geometric Mean:										**277.14**		**169.31**

**Sample is the average of two or more duplicate samples.*

USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2018	4	16	0945	Y	277225		25.00	
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2018	5	8	1030	Y	277226		39.00	
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2018	6	19	0930	Y	277227		140.00	
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2018	7	16	0935	Y	277228		300.00	
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2018	8	16	0925	Y	277229		400.00	
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2018	8	19	2230	Y	277230		4200.00	X
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2018	9	20	0945	Y	277231		98.00	
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2018	10	9	1530	Y	277232		3500.00	X
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2018	10	9	1645	Y	277233		3400.00	X
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2018	10	9	1815	Y	277234		4800.00	X
USGS	422/11.5	L. Blue R. nr Lake City @ Hwy 78 br	Grab	2018	10	16	0950	Y	277235		310.00	
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2018	4	16	0810	Y	277247		63.00	
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2018	5	8	0830	Y	277248		91.00	
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2018	6	19	0800	Y	277249		38.00	
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2018	7	16	0745	Y	277250		270.00	
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2018	8	16	0750	Y	277251		52.00	
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2018	8	20	0100	Y	277252		3400.00	X
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2018	9	20	0740	Y	277253		98.00	
USGS	422/21.3	L. Blue R. @Lees Summit Rd.	Grab	2018	10	16	0800	Y	277254		630.00	
2018 Recreational Season Geometric Mean - No Data Qualifier Adjustment:								**293.50**		**Sample Count = 19**		**geomean without stormflow samples:**
2018 Recreational Season Geometric Mean:										**293.50**		**117.35**

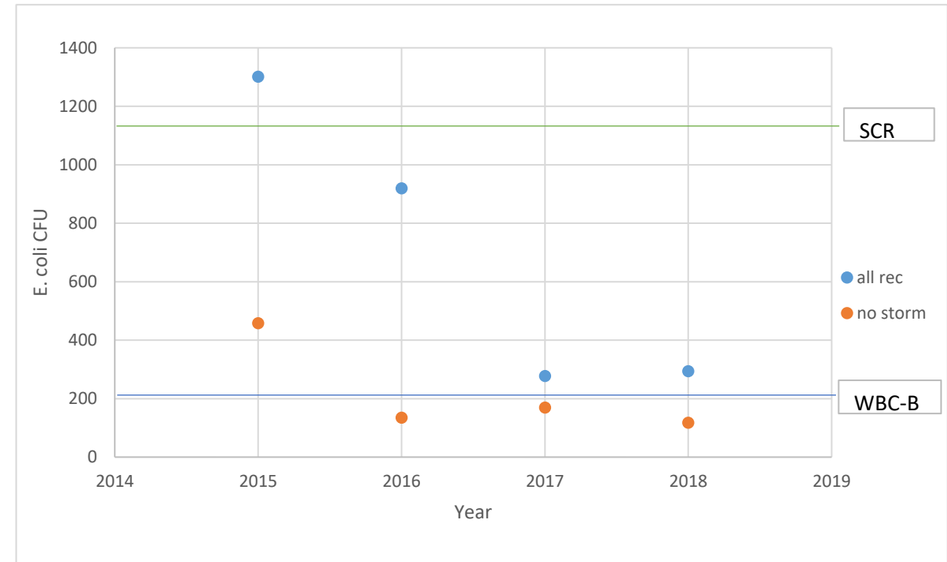
**Sample is the average of two or more duplicate samples.*

Summary

Year	all records	no storm
2015	1300.88966	457.693469
2016	918.99	134.64703
2017	277.14	169.3119006
2018	293.5	117.35

Bacteria

L. Blue R. is a Class B Whole Body Contact recreational water with an E. coli standard of 206 colonies/100 ml. This standard is interpreted as the geometric mean of at least five samples taken during the recreational season, April 1 to October 31, of any given year. A water body is judged to be impaired if the standard is exceeded in any of the last three years for which there is adequate data. L. Blue R. is also a Secondary Contact recreational water with an E. coli standard of 1134 colonies/100 ml. This standard is interpreted as the geometric mean of at least five samples taken during the recreational season, April 1 to October 31, of any given year. A water body is judged to be impaired if the standard is exceeded in any of the last three years for which there is adequate data.
L. Blue R. has exceeded one or both criterion at least once in the last three years of available data.
Thus L. Blue R. is judged as impaired for Escherichia coli.



Missouri Department of Natural Resources, Water Protection Program, (573)751-1300, www.dnr.mo.gov

http://www.dnr.mo.gov/mocwis_public/wqa/waterbodySearch.do

http://dnr.mo.gov/env/esp/wqm/biologicalassessments.htm

09/18/2019

Multiple Criteria Decision Analysis for Prioritizing Pollution Sources

Springfield-Greene County Integrated Plan

Springfield, Missouri
December 28, 2017

ACKNOWLEDGEMENTS

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Special thanks should be given to Errin Kemper, whose leadership and guidance has been has been key throughout this entire process. The Integrated Planning Task Force provided a deep understanding of local issues and priorities, which combined with their technical expertise has been invaluable. Special acknowledgement also goes out to Jane Clary and Jon Jones of Wright Water Engineers and Dr. Robert Pitt, who not only served on the Expert Panel, but provided excellent technical and editorial feedback on the draft report.

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1. Introduction

The City of Springfield (City), Greene County (County) and City Utilities of Springfield (CU) have developed an approach for integrated planning to best protect local environmental resources in an evolving regulatory landscape. The Integrated Plan (IP), titled "A Citizen Focused Approach," provides a holistic plan designed to prioritize investments based on the most effective solutions to address the most pressing problems that matter most to the community. Implementation of the IP includes a four-phased approach, which is designed to be iterative:

- **Phase I** – This is the Assessment Phase which evaluates the current status of local environmental resources across air, land and water. A component of this phase is to create a large, comprehensive environmental database to enable a "Big Picture" look at local environmental resources.

- **Phase II** – The second phase is the Vision Phase and answers the question "Where do we want to be?" Success to this question is largely defined when community resources are directed towards managing environmental issues using the most effective solutions to address the most significant problems in a way that is affordable to the citizens. Additional measures of success include:

    - Local governments comply with federal and state regulations while addressing the specific needs of the community.
    - Local governments have the ability to address water, air, and solid waste issues holistically allowing both the community and the regulators to operate more efficiently.
    - There is a community culture that understands and supports the goal of high-quality environmental resources and supports these efforts through stakeholder involvement. The community has a high level of trust that resources are being used to address environmental issues efficiently and effectively.
    - The community has a clear understanding of how funding and other resources will be used to improve environmental quality.

- **Phase III** – This is the Tactical Phase and answers the question, "How will we get there?" During this phase, stakeholder groups prioritize their community's environmental needs based on four key elements:

    - Capturing the community's priorities,
    - Identifying and prioritizing the most significant sources of pollution,
    - Identifying and prioritizing the most effective solutions using the Sustainable Return on Investment (SROI) approach, and
    - Assessing the community's financial capability.

- **Phase IV** – This is the Adaptive Management phase.

The focus of this report is on identifying and prioritizing the most significant sources of pollution, which is a key element of Phase III. To accomplish this task, the IP partners enlisted a team of consultants led by HDR (HDR Team) to develop a Multiple Criteria Decision Analysis (MCDA) toolset. The HDR Team included Wright Water Engineers, Dr. Robert Pitt, Black & Veatch, and Shockey Consulting. MCDA is a decision support tool for solving complex problems that are characterized as a choice among alternatives

(NRLI 2016). It is ideal for group decision making as it promotes consideration and discussion of trade-offs among alternatives. In effect, MCDA facilitates the critical thinking process in an open and transparent manner.

The five basic components of an MCDA are as follows (NRLI 2016):

1. **Goal** - The goal is defined by Element 1 of Phase III of the IP, which is to prioritize the most significant sources of pollution in the Springfield-Greene County region.
2. **Decision maker or group of decision makers with opinions** - The decision makers for the MCDA includes leaders from the City, County and CU with key input from the Environmental Priorities Task Force.
3. **Decision alternatives** – The decision alternatives are defined here by the different pollution sources. As described in greater detail within this report, an initial set of 16 pollution sources was identified for this MCDA.
4. **Evaluation criteria** – Evaluation criteria represent the interests of the decision makers. They are defined here by the community's priorities and the pollutants or conditions that impact those priorities. For example, safe drinking water is a community priority and waterborne pathogens potentially impact that priority.
5. **Outcomes or consequences associated with alternatives** – Outcomes are defined here by the ratings and scores for each pollution source as determined by the evaluation criteria. Scores are used to prioritize the different pollution sources.

A decision framework that explicitly links the goal to the alternatives forms the basis of the MCDA model. Indicators, sometimes referred to as sub-criteria or sub-interests, are critical to the decision framework. The indicators provide an objective means of linking alternatives to the community priorities. Figure 1 illustrates the IP MCDA framework with the linkages between the community priorities, indicators, and 16 pollution sources. Once established, the framework enables decision makers to understand how the overall goal is linked to the individual alternatives and helps facilitate the scoring process.

Using the decision framework described above, alternatives are scored based on the following three sets of values: 1) priority weight, 2) indicator weight, and 3) alternative rating. For purposes of this project, priority weights reflect the Task Force findings summarized in the Community Priorities Section of this report. Indicator weights and alternative ratings were decided by a multi-disciplinary team of environmental experts and IP partners. Pollution source scores represent the sum product of the weights and ratings across all the priorities and indicators as described by the following equation:

$$Pollution\ source\ score = \sum W_P \times W_I \times R_A$$

where, W_P = community priority weight (0-1), W_I = indicator weight (0-1), and R_A = alternative rating (0-3).

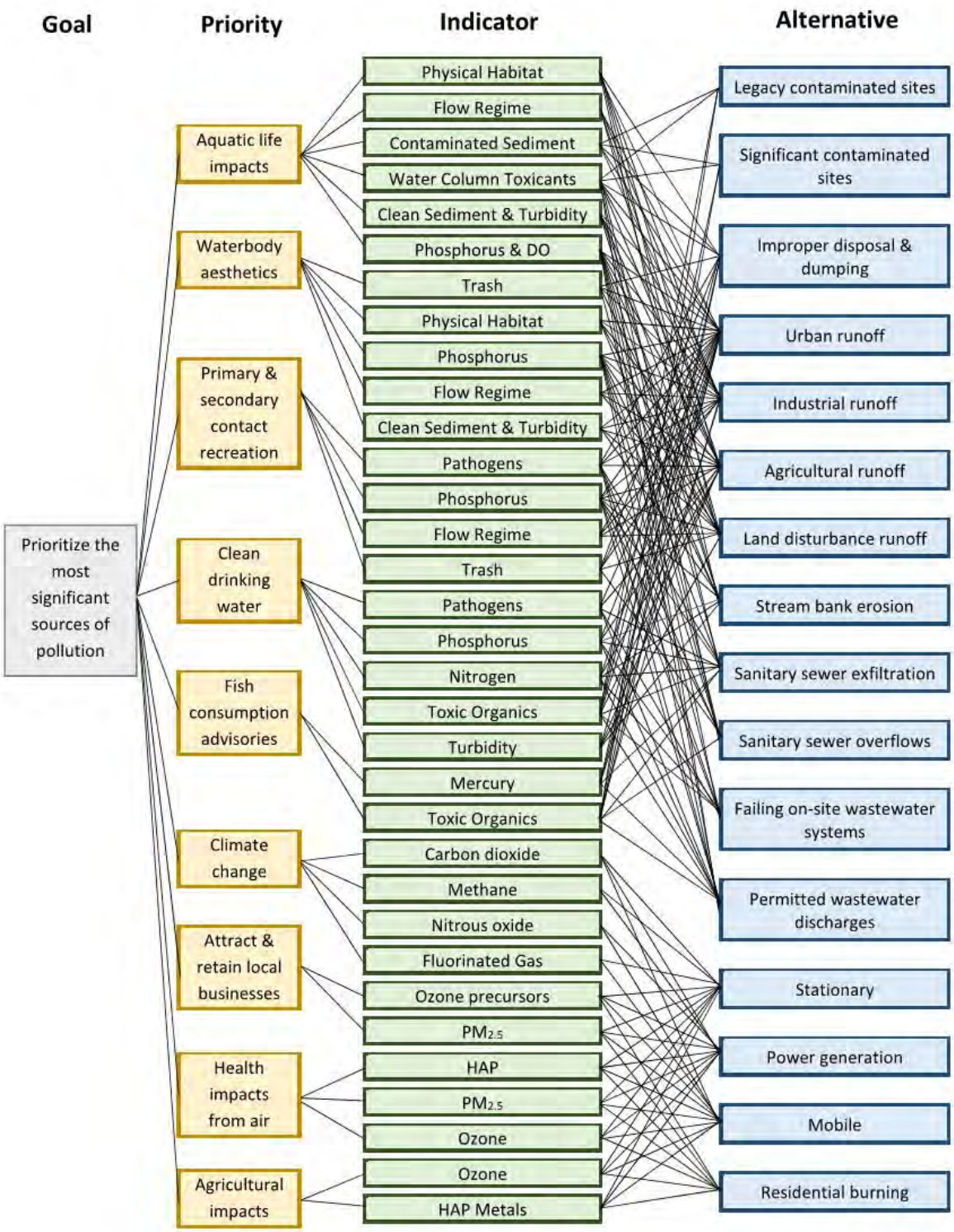


Figure 1. IP MCDA Decision Framework for Prioritizing Pollution Sources.

HDR assembled a multi-disciplinary panel of national experts to provide technical input in the selection of MCDA indicators and to assist in the scoring process. The team consisted of experts in elements of water and air pollution sources and resource impacts as detailed in the Expert Panel bios presented in Appendix A. These experts represent national knowledge leaders that were critical to drawing links between pollution sources and resource impacts. The professional judgment of the Expert Panel was also leveraged to address data gaps, where possible. The experts met with IP partner staff representing local knowledge and expertise to finalize development of the MCDA over two separate workshop events. The first workshop focused on water and land resource issues and was conducted over two days from January 17-18, 2017. The second workshop focused on air resource issues and was held on July 20, 2017. Minutes for the water and air workshops are provided for in Appendices B and C, respectively.

The purpose of this report is to document the process and results of the MCDA with respect to the identification and prioritization of the most significant sources of pollution. To this end, the report is organized as follows:

- **Section 2 - Database Development:** This section describes the development of a comprehensive environmental database. Development of this database was critical to informing the MCDA process.
- **Section 3 - Community Priorities**: This section describes how community priorities were established and weighted. This is a key element of the MCDA decision framework and scoring process.
- **Section 4 - Pollution Sources**: This section describes those pollution sources identified as alternatives for the MCDA.
- **Section 5 – Indicators:** This section describes those pollution indicators that serve as the link between the community priority and pollution sources in the MCDA decision framework.
- **Section 6 - Indicator Weights:** This section describes the process for weighting indicators and lists the final indicator weights.
- **Section 7 – Ratings:** This section describes the process for rating pollution sources and lists the final pollution source ratings.
- **Section 8 – Results:** This section presents the final MCDA scores and prioritizes the pollution sources based on those scores.
- **Section 9 - Uncertainty Analysis:** This section evaluates uncertainties associated with the MCDA ratings and its impacts on the final MCDA scores.
- **Section 10 - Data Gap Analysis**: This section discusses data gaps identified during the Expert Panel workshops.
- **Section 11 – Summary:** This section includes a summary of the MCDA and how it fits within the overall IP.

2. Database Development

Phase I of the IP represents the Assessment Phase and calls for the development of a comprehensive environmental database. Understanding existing environmental data in a holistic and comprehensive manner is essential to informing the IP process. For this reason, HDR was tasked with compiling environmental data from multiple sources into a comprehensive database for the Springfield and Greene County area. Based on discussion with the IP partners, objectives of the database include:

- Serve as a central repository of local data to support IP efforts
- Maintain data quality and comparability

- Accommodate input from multiple sources
- Provide for efficient analysis, such as trend analysis
- Easily integrate with a Geographic Information System (GIS) to allow users to view information spatially
- Key attributes – forward-looking, flexible, simple and cost-effective

HDR worked closely with the IP partners to develop a database approach that closely meets these objectives in a timely and cost-effective manner. Initial discussions focused on the pros and cons of different types of approaches ranging from simple spreadsheets through complex enterprise level geospatial databases. Recognizing that an enterprise level geospatial database is largely beyond the scope of this project but may be needed in the future, HDR ultimately recommended a two-phased approach:

- Phase 1 – Store environmental data (e.g., water quality laboratory analytical data) in an MS Access database and store geospatial information separately in a file geodatabase.
- Phase 2 – Migrate the MS Access database and geospatial data into a single enterprise geodatabase at a later date, if necessary and practicable.

Based on this recommendation, HDR developed an MS Access database and compiled relevant GIS data into a file geodatabase. As water quality data comprised the bulk of the environmental data, HDR based the database schema (structure) off of the Missouri Department of Natural Resources' MoCWIS Water Quality Assessment System. The data were spatially attributed within the database by geographic coordinates and by Task Force watershed. The Task Force watersheds were defined based on community priorities and serve as a framework for assessing water quality data. Task force watersheds include the following:

- Upper James River
- Fellows & McDaniel Lakes
- Sac River
- Wilson's Creek
- Little Sac River
- Middle James River
- Pomme de Terre River

In total, the database includes approximately 330 water quality monitoring stations and 187,000 water quality data records collected by over a dozen different entities in the Task Force watersheds (Figure 2). Air data was obtained from the U.S. Environmental Protection Agency's (USEPA) Air Quality System (AQS) and National Emissions Inventory (NEI). Since air data are fundamentally different from water quality data, these data were maintained in a separate database schema. Detailed information regarding the database was provided to the City in prior memos entitled "Database Framework Recommendation" and "Database Population Guidance".

HDR used the environmental database to compile pollutant maps, figures and tables in support of the Expert Panel workshops. Environmental data summarized for the water and air Expert Panels is provided for in Appendices D and E, respectively.

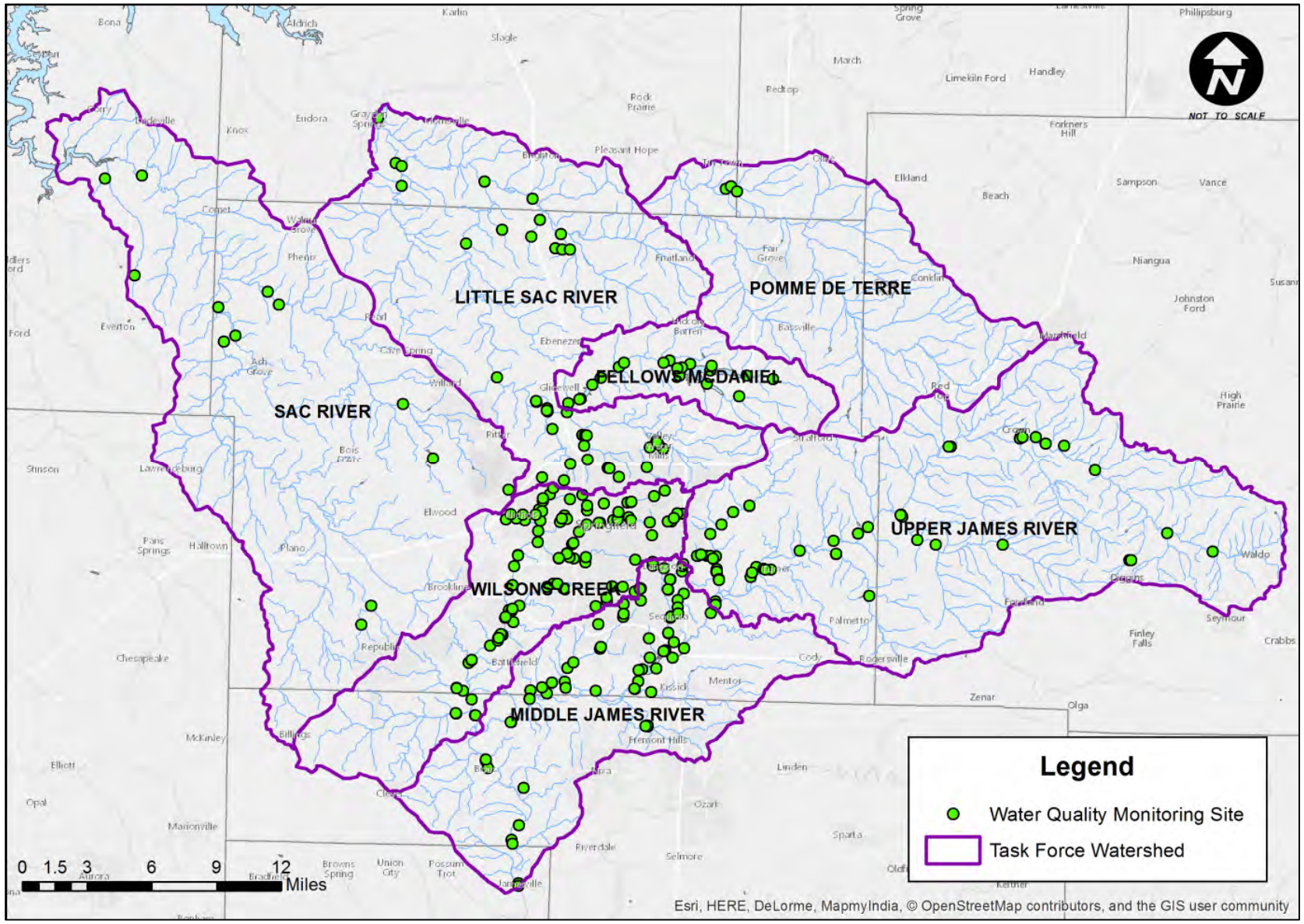


Figure 2. Task Force Watersheds and Water Quality Monitoring Stations.

3. Community Priorities

The MCDA model is designed to ensure that the decision making process reflects the community priorities. To help identify these priorities, in 2014 the Task Force met for a series of several workshops and were presented information on a variety of environmental topics. In addition, the City conducted a community survey that had 694 respondents. The survey included a variety of questions about the community's environmental concerns. Based on the information presented, the Task Force identified, ranked, and scored a number of different community priorities into four different tiers. Results from this assessment ultimately formed the basis for the final set of community priorities and weightings identified for the MCDA (Table 1).

In two instances, community priority categories were grouped for purposes of the MCDA. Waters clean enough to swim and boat in were combined into a single category. Similarly, reduction of air quality impacts on food supply and clean water for crop irrigation, livestock and wildlife watering were re-categorized as agricultural impacts. These groupings were deemed appropriate as they are closely related and share the same indicator links to pollution sources.

Table 1. Community Priority Weights.

Community Priority	Task Force Tier	Task Force Numerical Score	MCDA Priority Weight
Clean Drinking Water	1	124	0.18
Primary and Secondary Contact Recreation	2	104	0.15
Health Impacts from Air Pollution (Air)	2	92	0.13
Climate Change (Air)	3	80	0.11
Aquatic Life Impacts	2	73	0.10
Agricultural Impacts (Air)	3	63	0.09
Ability to Attract and Retain Businesses (Air)	2	59	0.09
Fish Consumption Advisories	4	57	0.08
Waterbody Aesthetics	4	51	0.07

The nine community priorities selected for the MCDA are defined below.

3.1. Clean Drinking Water

Clean and safe water was identified as the most important priority in the Task Force report. Drinking water sources targeted for protection in the Task Force report included McDaniel Lake, Fellows Lake, Upper James River, Fulbright Spring Recharge Area, and the Upper Little Sac. CU pulls its raw water supply from these sources plus Stockton Lake and deep groundwater wells. Additionally, tens of thousands of residents in Greene County rely on groundwater for their drinking water. Potential threats to the drinking water sources identified in the Task Force report include pathogens, nutrients and increased sediment load. Toxicants from industrial sources, urban runoff and underground storage tanks also represent a potential threat to drinking water.

3.2. Primary and Secondary Contact Recreation

Streams or lakes that are clean enough to swim in (primary recreation) and boat and wade in (secondary recreation) were identified as Tier II and IV priorities, respectively, in the Task Force report. Specifically, the Task Force report prioritized protecting water from pollution in the Lower James River, Upper James River, Sac River, and Little Sac River in areas where people swim. These rivers are classified for both Whole Body Contact Recreation (WBCR) – Class A and Secondary Contact Recreation (SCR) designated use protections. WBCR Class A protections apply to waters that have been established by the property owner as public swimming areas welcoming access by the public for swimming purposes

and waters with documented existing whole body contact recreational use(s) by the public. SCR uses include fishing, wading, commercial and recreational boating, any limited contact incidental to shoreline activities, and activities in which users do not swim or float in the water. WBCR and SCR waters are protected in state regulations by *E. coli* criteria.

3.3. Health Impacts from Air Pollution (Air)

Air pollution can contribute to a variety of human health issues, affecting a number of different systems and organs. Health related issues range from minor upper respiratory irritation to chronic respiratory and heart disease, lung cancer, acute respiratory infections in children and chronic bronchitis in adults, aggravating pre-existing heart and lung disease, or asthmatic attacks (Kampa and Castanas 2008). To protect for health related issues, the Clean Air Act requires USEPA to set National Air Quality Standards (NAAQS) for six common air pollutants also known as “criteria pollutants”. These include particle pollution, photochemical oxidants and ground-level ozone, carbon monoxide, sulfur oxides, nitrogen oxides, and lead. Man-made sources of air pollutants can include emissions from automobiles, factories, power plants, construction equipment, small businesses, and open burning. The reduction in health related air quality issues was identified as a Tier II priority in the Task Force report.

3.4. Climate Change (Air)

Climate change refers to any substantial change in measures of climate lasting for an extended period of time such as major changes in temperature, precipitation, or wind patterns (USEPA 2016a). Global warming is one important aspect of climate change and refers to an average increase in the temperature of the atmosphere near the Earth’s surface. Scientists believe that increases in greenhouse gases associated with human activities are contributing to climate change and global warming. Anthropogenic sources of greenhouse gases include the burning of fossil fuels to generate electricity, heat and cool buildings, and power vehicles. The major greenhouse gases emitted into the atmosphere are carbon dioxide, methane, nitrous oxide, and fluorinated gases. The reduction of greenhouse gases was identified as a Tier III priority in the Task Force report.

3.5. Aquatic Life Impacts

Aquatic life impacts refer to the altering or impairment of fish and other aquatic life in streams, rivers, ponds and lakes due to pollutants and habitat modification. Missouri regulations at 10 CSR 20-7.031 provide for aquatic life protections through the designation of aquatic habitat uses. Warm water habitat protections apply to most all surface waters in the Springfield-Greene County region, which are defined in state regulations as waters in which naturally-occurring water quality and habitat conditions allow the maintenance of a wide variety of warm water biota. The protection of fish and other aquatic life was identified as a Tier II priority in the Task Force report.

3.6. Agricultural Impacts (Air)

Agricultural impacts refers to impacts on food supply from the reduction of air quality. These impacts may be due to climate change and ozone pollution. Both these issues were identified as a Tier III priority in the Task Force report.

3.7. Ability to Attract and Retain Local Businesses (Air)

The Task Force report identified that attainment of air quality standards to attract and retain businesses as a Tier II priority. The Task Force report noted that potential nonattainment could limit the types of businesses attracted to the region or place additional restrictions on existing businesses. The Task Force

report also included an overall goal of protecting the environment to attract/retain business and maintain a high quality of life.

3.8. Fish Consumption Advisories

Fish that are safe to eat was identified as a Tier IV priority in the Task Force report. Each year, the Missouri Department of Health and Senior Services (DHSS) create a fish consumption advisory based on an evaluation of contaminants in Missouri sport-caught fish. The advisory is based on annual fish-tissue studies by the Missouri Department of Conservation (MDC) and the Missouri Department of Natural Resources (MDNR) at various Missouri lakes, ponds, rivers, and streams (DHSS 2016). In the Springfield-Greene County region, the 2016 fish advisory includes Lake Springfield due to elevated levels of polychlorinated biphenyls (PCBs) being found in catfish and carp. There is also currently a statewide advisory for mercury.

3.9. Waterbody Aesthetics

Aesthetics of streams and lakes was identified as a Tier IV priority in the Task Force report. The Task Force report also called for improving the aesthetics of Wilsons Creek noting that there is an important trail system in this watershed and it is positioned upstream of important recreational uses. Pollutants linked to aesthetic issues in the Task Force report included sediment, trash, nutrients, and bank erosion.

4. Pollution Sources

A key task in developing the MCDA was to identify and rank sources of water, land and air pollution. Within the MCDA framework, the pollution sources define the alternatives. Pollution sources were selected in consultation with key City personnel and based on feedback from the March 28, 2016 MCDA workshop. Considerations in the selection of pollution sources included the ability to control the source, regulatory emphasis, and impact. A total of 16 pollution sources were identified, which are identified below. Fact sheets summarizing each pollution source, potential impacts and key statistics are also included in Appendix F.

4.1. Water Pollution Sources

Agricultural Runoff – Agricultural runoff is water leaving farm fields because of precipitation runoff, melted snow, or excess irrigation. As runoff moves across the land, pollutants can be mobilized and transported into streams, ponds, and lakes. Agricultural runoff can include pollution from soil erosion, feeding operations, tillage, animal waste (e.g., horses, cattle and poultry), and fertilizer. Overgrazing leads to high runoff volumes, increased erosion and water quality impacts. Livestock waste deposited in or adjacent to waterways may also lead to increased pollutant loading from agricultural runoff. Livestock with direct access to streams for watering can also degrade riparian and instream habitat.

Failing On-Site Wastewater Systems – Where central sewer services are not available, on-site (or decentralized) wastewater treatment systems are used to treat wastewater from a home or business and disperse it on the property where it is generated. Frequently referred to as septic systems, when functioning properly, on-site systems prevent human contact with sewage, and prevent contamination of surface and groundwater. Failing on-site systems allow the sewage to leave the property and may contribute bacteria and nutrient contamination to surface water and groundwater. Factors that affect the proper functioning of on-site systems include the site and soil conditions, design, installation, operation and maintenance. Surveys have shown that 70% of all septic systems in Missouri are not functioning properly (Schultheis 2001).

Urban Runoff – Stormwater runoff is surface water that originates from precipitation events such as snow, ice melt, and more commonly direct rainfall events that travels across the land rather than seeping into the ground. The runoff discharge comes from sources, such as rooftops, lawns, parking lots, roads, restaurants, golf courses, parks and driveways. Stormwater will mobilize pollutants from the land surface and contributions from land use activities and material exposure, and then transport pollutants to waterways. In addition, urbanization generally increases runoff and reduces groundwater recharge. Common urban pollutants include sediment, heavy metals, toxic organics, salts, nutrients, bacteria, herbicides, pesticides, trash, and pet waste.

Industrial Runoff – Industrial stormwater runoff comes from industrial sites regulated under the National Pollutant Discharge Elimination System (NPDES) industrial stormwater program. These sites are typically regulated due to having industrial activities and materials exposed to stormwater. Common industrial pollutants include equipment deposits (oil, grease, and metals), dust deposits, chemicals, organic waste and pollutants associated with outdoor materials storage.

Land Disturbance Runoff – As stormwater flows over a construction site, it can pick up pollutants like sediment, debris, and chemicals and transport them to nearby storm sewer systems or directly into streams, rivers, and lakes. The NPDES stormwater program requires permits for discharges from construction activities that disturb one or more acres, and discharges from smaller sites that are part of a larger common plan of development or sale.

Permitted Wastewater Discharges – Permitted direct discharges include facilities designed and operated to effectively treat municipal and industrial wastewater. Permitted direct dischargers include publicly owned wastewater treatment plants, industrial facilities and power plants. Discharges includes treated cooling, industrial and municipal wastewater. Effluent from wastewater treatment facilities is discharged to nearby streams. Treatment levels are based upon technology and water quality based requirements. Water quality based effluent limitations are set to meet water quality standards, which are established to protect designated uses such as aquatic life and swimming. Extensive pollutant removal occurs at the facilities; however, some pollutants remain within treatment plant effluent. Common pollutants that are allowed to be discharged by current USEPA rules include small amounts of metals, nutrients, bacteria, suspended solids and organics. The regulatory pollutant limits and the number of pollutants monitored change over time, typically based on federal and state recommendations informed by scientific research.

Sanitary Sewer Exfiltration – Sanitary Sewer Exfiltration occurs when untreated sewage is discharged from a leaking sanitary sewer into the surrounding geology. Exfiltration may occur due to cracks and defects in pipes, manhole defects, defective laterals and other sources within a sanitary sewer system. Exfiltration can increase during extended dry weather periods as a result of the regional groundwater table lowering. Depending on the configuration and condition of sanitary and storm sewers, exfiltrated sewage may also enter storm sewers and be transported to streams.

Sanitary Sewer Overflows – Sanitary Sewer Overflows (SSOs) occur when untreated sewage is discharged from a sanitary sewer to the ground surface or the surface water environment prior to reaching wastewater treatment facilities. The discharge comes from manholes, lift stations, emergency relief outlets, and other sources within a sanitary sewer system. SSOs are typically caused by wet weather events, blockages (e.g., tree roots), power outages and vandalism. When caused by rainfall, it is also known as a wet weather SSO.

Stream Bank Erosion – Streambank erosion refers to the removal of soil, rock and vegetation from the streambank. Streambank erosion is a natural process, but the rate at which it occurs is often increased

by human activities such as urbanization and agriculture. Acceleration of this natural process leads to a disproportionate sediment supply, stream channel instability, and habitat loss. Activities that contribute to increased streambank erosion include the urbanization of watersheds and loss of riparian forests or buffers (e.g., removal of trees or vegetation, mowing to the edge of waterway). Potential stream bank erosion resulting from livestock activities are captured within the Agricultural Runoff pollution source.

4.2. Land Pollution Sources

Improper Disposal & Dumping – Improper disposal and dumping includes discarded trash, furniture, appliances, household chemicals, yard waste, electronics, tires and other waste streams that are not recycled or disposed at a licensed facility. When discarded on land, these sources may impact water quality, wildlife, aesthetics and lead to a reduction in property values. Debris may be washed into the storm sewer system causing blockages and accumulation of trash in water quality treatment facilities or be washed into local streams and impact terrestrial and aquatic habitats. Sinkholes also are used for improper disposal, which may place pollution sources in a direct connection to groundwater.

Legacy Contaminated Sites – Legacy pollution refers to pollution that remains from historical activities. Legacy pollution is often associated with historic unlined landfills, former salvage operations, brownfields, hazardous waste dumping sites, rail yards, leaking underground storage tanks, mine tailings and former manufacturing sites. Collectively referred to as legacy contaminated sites, such areas pose environmental and health risks from a variety of pollutants (e.g., toxic organic compounds, metals, and other toxics) and exposure pathways (e.g., air, groundwater, soil).

Significant Contaminated Sites – Several significant contaminated sites are present within Springfield and Greene County. These sites are regulated by the Resource Conservation and Recovery Act (RCRA) or Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) programs. RCRA is the public law that creates the framework for the proper management of hazardous and non-hazardous solid waste. The law describes the waste management program mandated by Congress that gave USEPA authority to develop the RCRA program. CERCLA or Superfund is a federal law designed to clean up sites contaminated with hazardous substances and pollutants. The National Priorities List (NPL) is the list of hazardous waste sites eligible for long-term cleanup financed under the federal Superfund Program. There are 57 Superfund sites on the National Priorities List (NPL) in Greene County (5 active, 16 active non-NPL and 36 archived). A total of seven significant contaminated sites that may impact water quality were identified within the study area.

4.3. Air Pollution Sources

Mobile – Mobile sources include cars, trucks, buses, off-road engines, equipment and other vehicles. Mobile sources are responsible for emissions of greenhouse gases, air toxics and precursor emissions that react to form secondary pollutants. Examples of mobile source air toxics include benzene, 1,3-butadiene, formaldehyde, acetaldehyde, acrolein, polycyclic organic matter (POM), naphthalene, and diesel particulate matter.

Residential Wood Burning – Pollutants from wood stoves and fireplaces include fine particulates, nitrogen oxides, sulfur oxides, carbon monoxide, volatile organic compounds, dioxins, and furans. Pollution from wood burning is a particular concern in the winter when cold, stagnant air and temperature inversions limit air movement. Smoke from wood burning is generated primarily by incomplete combustion, which can be caused by a number of different factors related to the wood burning device efficiency. With proper burning techniques and well-seasoned wood, emissions can be significantly reduced, even in older wood burning appliances.

Power Generation Facilities – Power generation facilities, also referred to as power plants, are industrial facilities for the generation of electric power. The primary power plants operated by City Utilities of Springfield (CU) are the James River Power Station and the John Twitty Energy Center (JTEC). Both facilities have coal burning units, but the James River Power Station recently switched to natural gas as its source of fuel. Collectively, CU power plants serve a population of approximately 249,000 with a combined capacity of 1,120 megawatts. Emissions typically associated with power generation facilities include sulfur dioxide, nitrogen oxides, particulates, carbon dioxide, and mercury.

Stationary Sources – Stationary pollution sources are defined here to mean point sources that generally require an air permit, but excludes power generation facilities. There are a variety of stationary pollution sources including the airport, landfills, hospitals, rail yards, dry cleaners, auto body shops, printers and manufacturing facilities. Stationary industrial sources are widely distributed across an area, thus tending to have some persistent (usually lower) level of impacts across the broader area. The largest producers in the county include manufacturing and automotive repair related industries. USEPA's National Air Toxics Assessments indicates hydrogen fluoride, toluene, and sulfuric acid dominate the toxic air releases in the Springfield metropolitan area. Other air pollution releases identified on USEPA's National Emissions Inventory (NEI) include fine particulates, carbon dioxide, ozone and certain other chemicals generally related to smog. Stationary sources generally not related to industrial or manufacturing such as dirt roads and residential burning are not included within this source description.

5. Pollution Indicators

Indicators are pollutants or conditions that provide the linkages between community priorities and pollution sources in the MCDA framework. For example, urban stormwater runoff (i.e., pollution source) increases nutrients and adversely impacts physical aquatic habitat (i.e., indicators), both of which can adversely impact aquatic life (i.e., community priority). Although the number of potential indicators is numerous, only the most critical indicators were selected during the Expert Panel workshops and in some instances were consolidated (e.g., water column toxicants represents metals and a variety of other pollutants). The intent of limiting the number of indicators was to avoid diluting out their impact on the community priorities. Rationale for the selection of the indicators is provided for in the workshop meeting minutes (Appendices C and D). Indicators selected for the MCDA are defined below.

5.1. Physical Aquatic Habitat

Typical physical characteristics used to assess habitat quality include epifaunal substrate, pool substrate characterization, pool variability, sediment deposition, channel flow, channel alteration, channel sinuosity, bank stability, and vegetative protection. Land disturbance activities, stream bank erosion and runoff can have a profound impact on the quality of habitat and a stream's ability to support aquatic life. Physical habitat modifications, particularly loss of the riparian corridor or stream widening, may result in elevated stream temperature due to shading loss and ultimately impact aquatic life. Physical aquatic habitat impacts may also detrimentally impact stream aesthetics (e.g., loss of riparian corridor, unstable banks, and concrete channels).

***Linked Community Priorities*:** Aquatic Life Impacts, Waterbody Aesthetics

5.2. Flow Regime

Flow regime refers to the magnitude, frequency, duration, and rate of change of of a stream's discharge in response to precipitation and drainage basin characteristics. Changes in both low flows and high flows due to increased runoff can detrimentally impact several community priorities. Aquatic life may be impacted by scour during high flows and lack of habitat and decreased dissolved oxygen due to reduced

baseflows. Increased temperature from pavement and roof runoff during summer events may also detrimentally impact aquatic life. Stream aesthetics and recreational uses may also be impacted due to excessive high flows and decreased baseflows.

Linked Community Priorities: Aquatic Life Impacts, Waterbody Aesthetics, Primary and Secondary Contact Recreation

5.3. Contaminated Sediments

The USEPA defines contaminated sediment as "soil, sand, organic matter, or other minerals that accumulate on the bottom of a water body and contain toxic or hazardous material at levels that may adversely affect human health or the environment" (USEPA 1998). Types of contaminants found in sediment can include oil and grease, halogenated hydrocarbons or persistent organics (e.g., polychlorinated biphenyls [PCBs] and some pesticides like DDT), polycyclic aromatic hydrocarbons (PAHs), and metals (USEPA 1999). Organic matter (e.g., leaves and grass clippings) can also cause decreased oxygen levels in sediments where they can accumulate and degrade. All of these pollutants, acting independently or synergistically with multiple pollutants, may cause aquatic life toxicity. Contaminated sediment can originate from a variety of sources including stormwater runoff and atmospheric deposition (e.g., mercury). Another source is the discharge of contaminated groundwater flowing through sediments to the overlying surface water.

***Linked Community Priorities*:** Aquatic Life Impacts

5.4. Uncontaminated Sediment & Turbidity

The USEPA lists sediment as one of the most common pollutants in rivers, streams, lakes and reservoirs.[1] It is composed of mineral particles such as clay, silt, sand, assorted-sized rocks and other non-organic materials. Sedimentation and excessive turbidity are caused by normal fluvial processes, but are greatly increased by human impacts on land. Any activity that leaves land exposed, such as agriculture and construction, can greatly increase erosion of sediment into streams. Increased sedimentation and turbidity can adversely impact aquatic life in a number of ways such as disrupting food chains, clogging fish gills, and affecting fish egg and larvae development. Excessive turbidity can impact water treatment processes and filtration by reducing effectiveness of coagulation/flocculation/sedimentation processes and could result in less effective pathogen removal.

***Linked Community Priorities*:** Aquatic Life Impacts, Waterbody Aesthetics, Clean Drinking Water (turbidity only)

5.5. Water Column Toxicants

Water column toxicants refer to a variety of toxic elements and compounds found in the water column that can have an adverse effect on aquatic life. Such pollutants can include heavy metals, ammonia, chlorides, nitrates, pH, petroleum hydrocarbons, polycyclic aromatic hydrocarbons, solvents, and compounds of emerging concern. Heavy metals are known for being potentially toxic and include, among others, arsenic, cadmium, lead, mercury, copper and zinc. Water column toxics can originate from many sources including mining, industry, contaminated sites, agricultural production, improper dumping, domestic effluents, atmospheric sources, and urban stormwater runoff (industrial, commercial, and residential).

[1] Based on USEPA's Assessment and Total Maximum Daily Load Tracking and Implementation System (ATTAINS).

***Linked Community Priorities*:** Aquatic Life Impacts

5.6. Toxic Organics

Toxic organics is a subset of water column toxicants and includes such compounds as pesticides, petroleum hydrocarbons, chlorinated solvents, chlorine disinfection byproducts and pharmaceuticals. Several toxic organics have been associated with adverse human health impacts such as increased carcinogenic risk and endocrine disruption. Toxic organics can potentially originate from a number of pollution sources including legacy contaminated sites, stormwater runoff, livestock production, and wastewater.

***Linked Community Priorities*:** Clean Drinking Water, Fish Consumption Advisories

5.7. Mercury

Mercury is a toxic heavy metal, which is included on the World Health Organization's list of 10 chemicals of major concern (WHO 2017). Mercury exposure can cause neurological and developmental disorders in humans. The most common route of exposure for humans is from eating mercury contaminated fish, which tend to bioaccumulate mercury. While mercury in the environment can originate from natural processes, it largely originates from human activities. Industrial processes such as coal combustion can release mercury into the atmosphere where it can be deposited globally through precipitation. Because mercury in the atmosphere can travel great distances, it is considered a global issue. However, mercury can also enter the environment through the improper disposal of such mercury-containing products as thermometers and batteries. Therefore, municipal wastewater and urban stormwater runoff also represent potential sources of mercury.

***Linked Community Priorities*:** Fish Consumption Advisories

5.8. Pathogens

Pathogens include a broad category of bacteria, viruses and protozoans that can cause human diseases. Many classes of pathogens excreted in feces are able to initiate waterborne infections. There are bacterial pathogens, including enteric and aquatic bacteria, enteric viruses, and enteric protozoa, which are strongly persistent in the water environment and resistant to most disinfectants. Indicator bacteria, namely *Escherichia coli* (*E. coli*), generally do not cause illness directly, but demonstrate the presence of fecal contamination. Infectious diseases caused by waterborne pathogens are the most common and widespread health risk associated with drinking water. The main route of human exposure to illness-causing pathogens in recreational waters is through direct contact with swimming, most commonly through accidental ingestion of contaminated water.

If ingested, pathogens may cause:

- Bacterial infections (e.g., gastroenteritis, cholera, salmonellosis, and shigellosis)
- Viral infections (e.g., infection hepatitis, gastroenteritis, and intestinal diseases caused by enteroviruses)
- Protozoan infections (e.g., cryptosporidiosis, amoebic dysentery, and giardiasis)

Sources of pathogens include animal and human waste from pets, wildlife, livestock, sanitary sewer overflows, improperly functioning septic systems and wastewater treatment facilities.

***Linked Community Priorities*:** Primary and Secondary Contact Recreation, Clean Drinking Water

5.9. Aquatic Life Pathogens

Aquatic life pathogens are distinguished here from waterborne pathogens that adversely impact drinking water and primary and secondary contact recreation. Aquatic life pathogens include bacteria, viruses, protozoans, and parasites that can adversely impact the health of aquatic life or human health from fish consumption. For example, in high numbers, fish roundworms can cause illness or death in fish, but typically do not represent a risk for humans consuming fish if properly prepared. Also, parasites from crayfish can cause severe lungworm disease in people if consumed raw. The Expert Panel determined that further literature-based research is needed to determine the sources and risks associated with aquatic life pathogens with respect to both aquatic life health and fish consumption advisories. Therefore, aquatic life pathogens are included here as a potential pollution indicator, but were not factored into the final MCDA analysis.

***Linked Community Priorities*:** Aquatic Life Impacts, Fish Consumption Advisories

5.10. Nutrients (Nitrogen and Phosphorus)

Nutrients such as nitrogen and phosphorus are ubiquitous elements in surface waters and are essential to the growth and survival of aquatic plants, algae and microbes. Nutrients occur in a variety of chemical forms in both particulate and dissolved phases. Nutrients also occur in biotic forms such as algae, which can be re-released into the aquatic environment upon decay. The availability of nutrients for uptake by aquatic organisms depends on the chemical form and the organism. Only the dissolved forms of nutrients are directly available for algae, such as ammonia, nitrate, nitrite and orthophosphate. Particulate forms of nutrients can become indirectly available as the material degrades and decomposes in the aquatic environment (including sediments).

In excess, nutrients can lead to increased production of algae and aquatic plants in freshwater systems. Reductions in dissolved oxygen caused by algal respiration and decay, unsightly algal blooms, reduced water transparency, and the production of toxins by certain algae species can all occur to varying degrees. Depending on the severity, nutrient enrichment, also known as eutrophication, can detrimentally impact aquatic life. Eutrophication may also impact drinking water supplies by increasing disinfection by-product precursors (organic carbon) and in extreme cases can lead to threats to human health by harmful algal toxins. Excessive levels of nitrate in drinking water supplies may also pose human health threats. Swimming and other recreational activities may be impaired or precluded due to reduced water clarity associated with algal growth, which can affect the attractiveness of the water body and prompt safety concerns.

Potential major sources that deliver nitrogen and phosphorus to streams and reservoirs within the Springfield-Greene County region include wastewater treatment plants and collection systems, failing on-site wastewater systems, urban runoff, stream erosion, and agriculture runoff.

Due to the complexities and various potential impacts of nutrients, the Expert Panel decided to break nutrients into three different indicator categories, depending on the community priority:

- Total Phosphorus (TP) – TP is considered the primary nutrient responsible for eutrophication related issues in Springfield area waterbodies. Based on its potential to generate unsightly algal blooms, reduced transparency, and algal toxins, phosphorus was selected as an indicator for waterbody aesthetics, primary and secondary contact recreation and drinking water.
- TP and Dissolved Oxygen (DO) – Low levels of dissolved oxygen can adversely impact aquatic life and is closely linked to eutrophication issues associated with excess nutrients such as

phosphorus. Because they are so closely linked, TP and DO are grouped as an indicator for aquatic life impacts.

- Total Nitrogen (TN) – TN, along with TP, can be a co-limiting nutrient for primary production in streams, rivers, and lakes. Although TP is typically the more limiting nutrient, TN can be a factor in driving harmful algal blooms and undesirable algal species.

***Linked Community Priorities*:** Aquatic Life Impacts (TP and DO), Waterbody Aesthetics (TP), Primary and Secondary Contact Recreation (TP), Clean Drinking Water (TP and TN).

5.11. Trash

Trash, litter and other types of solid waste from human activities can impair the recreational value and aesthetics of a waterbody and may impact aquatic life. The most common types of litter in streams include plastic cups, plastic bags and wrapping materials, fast-food wrappers, plastic bottles, and other plastic containers. Trash can also include large objects (e.g., appliances, barrels, mattresses), floatables, and other types of debris of human origin. Sources of trash can include direct dumping and littering into waterbodies and discharges into stormwater.

***Linked Community Priorities*:** Waterbody Aesthetics, Primary and Secondary Contact Recreation

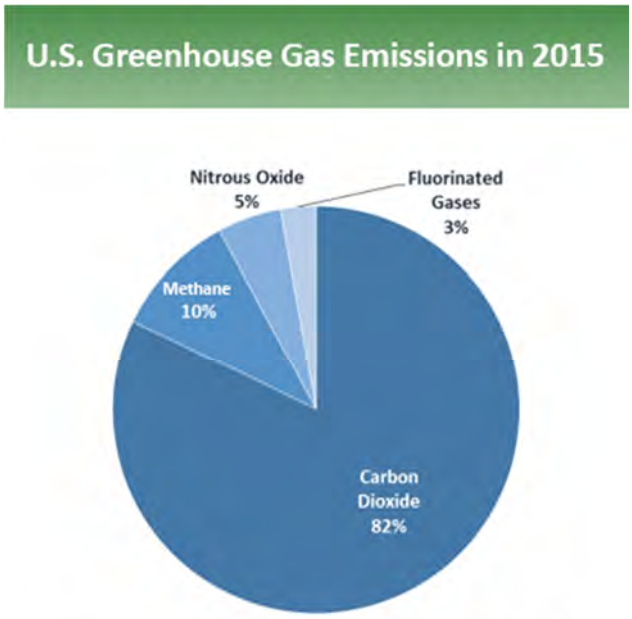
5.12. Greenhouse Gases

Greenhouse gases are broadly defined as those gases that trap heat in the atmosphere by absorbing and emitting solar radiation. Naturally occurring levels of greenhouse gases play an important role in keeping the Earth's atmosphere warm and able to sustain life. However, greenhouse gases have increased since the industrial revolution and scientists are concerned that a buildup of these gases could cause climate impacts in the coming decades. The four principal greenhouse gases are carbon dioxide, methane, nitrous oxide and fluorinated gases.

Carbon Dioxide (CO_2)

CO_2 is a major greenhouse gas emitted through the burning of fossil fuels (oil, natural gas, and coal), solid waste, and trees and wood products. While CO_2 is naturally present in the atmosphere as part of the Earth's carbon cycle, levels have been rising steadily since the start of the industrial revolution (NRC 2010). Human activities have resulted in increasing emissions of CO_2 to the atmosphere and are influencing the ability of natural sinks, like forests, to remove CO_2 from the atmosphere. USEPA's annual *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2014* estimates that electricity and transportation represent the primary sources of CO_2 emissions in the United States at 37% and 31%, respectively (USEPA 2016b).

***Linked Community Priorities*:** Climate Change, Agricultural Impacts



U.S. Environmental Protection Agency (2017). *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2015.*

Methane (CH_4)

Methane is the primary component of natural gas, but comes from many sources, both natural and manmade. It

is emitted during the production and transport of coal, natural gas, and oil. Emissions also originate from livestock and the decay of organic matter. Methane is more effective at absorbing heat than CO_2 but does not linger as long in the atmosphere.

***Linked Community Priorities*:** Climate Change

Nitrous Oxide (N_2O)

Nitrous oxide is a natural part of the Earth's nitrogen cycle, but increasing levels have been attributed to human activities. It is considered the third leading contributor to climate change behind CO_2 and methane. Like methane, nitrous oxide is more effective at trapping heat than CO_2. The major anthropogenic sources of nitrous oxide emissions are agriculture, fossil fuel combustion and industrial processes.

Linked Community Priorities: Climate Change

Fluorinated Gases

Fluorinated gases are the most potent and persistent of the greenhouse gases, but only account for about three percent of the greenhouse gas emissions in the United States. Fluorinated gases are man-made gases that are emitted from a variety of industrial processes. The four types of fluorinated gases are hydrofluorocarbons, perfluorocarbons, sulfur hexafluoride and nitrogen trifluoride.

***Linked Community Priorities*:** Climate Change

5.13. Ozone (O3) and Precursors

Ozone is a gas composed of thee atoms of oxygen (O3), which occurs both in the upper atmosphere and at ground level. Ozone in the upper atmosphere occurs naturally and beneficially provides a protective barrier from the sun's harmful ultraviolet rays. Ground level ozone, however, can trigger a variety of health problems such as aggravation of asthma and permanent lung damage. It can also damage sensitive vegetation and reduce crop yield. Ground level ozone is created by chemical reactions between nitrogen oxides (NOx) and volatile organic compounds (VOC) in the presence of sunlight. NOx is the generic term for nitric oxide (NO) and nitrogen dioxide (NO_2) and other nitrogen oxides, which are a family of poisonous, highly reactive gases. VOCs are organic compounds that are emitted from certain solids and liquids. The primary sources of NOx and VOCs include industrial facilities and electric utilities, motor vehicle exhaust, gasoline vapors, and chemical solvents.

***Linked Community Priorities*:** Ability to Attract and Retain Local Businesses (O3 precursors - NOx, VOCs), Health Impacts from Air Pollution (O3), Agricultural Impacts (O3))

5.14. Atmospheric Particulate Matter and Precursors

Atmospheric particulate matter (PM), also known as particle pollution, is one of six principal pollutants identified by USEPA as "criteria" air pollutants. PM represents a complex mixture of extremely small particles and liquid droplets that occur over a wide range of sizes. Particles may be emitted directly or by transformations of gaseous precursor emissions such as sulfur oxides (SOx), NOx, and VOCs. Sources of primary particles include agricultural operations, industrial processes, combustion of wood and fossil fuels, demolition activities, unpaved roads and construction. Precursor gases responsible for "secondary" particles can originate from distant sources. Examples include sulfates formed from sulfur dioxide emissions from power plants and industrial facilities and nitrates formed from nitrogen oxides released from power plants, mobile sources, and other combination sources.

Particle pollution is generally categorized into one of two size categories, known as PM_{10} and $PM_{2.5}$. $PM_{2.5}$, or fine particles smaller than 2.5 micrometers in diameter, can remain airborne for long periods traveling hundreds of miles. PM_{10}, or coarse particles smaller than 10 micrometers in diameter, are typically deposited on the ground downwind of emission sources and have a smaller spatial impact than $PM_{2.5}$. $PM_{2.5}$ not only impacts a larger area, but consists of secondary particles to a much greater extent than PM_{10}. If inhaled, particulate matter can cause serious health effects potentially affecting the heart and lungs. It can also cause eye, nose and throat irritation, and can serve as a carrier for toxic metals.

***Linked Community Priorities*:** Ability to Attract and Retain Local Businesses ($PM_{2.5}$ precursors), Health Impacts from Air Pollution ($PM_{2.5}$)

5.15. Hazardous Air Pollutants (HAPs)

USEPA defines HAPs as toxic air pollutants that may cause cancer or other serious health effects, such as reproductive effects or birth defects, or adverse environmental and ecological effects. Additionally, some toxic air pollutants such as mercury can be deposited onto soils or surface waters, where they can be incorporated into the food supply. There are currently 187 HAPs that USEPA is required to regulate, examples of which include benzene, perchlorethlyene, and methylene. Most HAPs originate from mobile sources such as vehicles, stationary sources such as factories and power plants, and indoor sources associated with building materials and cleaning activities.

***Linked Community Priorities*:** Health Impacts from Air Pollution, Agricultural Impacts (HAP Metals)

6. Indicator Weights

The Expert Panels were tasked with assigning weights to each of the indicators to account for relative impacts on community priorities. Weights were assigned on a scale of 0 to 1 such that the sum of the indicator weights corresponding to a community priority equaled 1. Indicator weights were assigned based on considerations provided below.

- *Watershed Scale* (water and land only) –The significance of this factor is a function of the number and importance of the community priority watersheds impacted by the indicator. It is considered of major significance if the indicator impacts all community priority watersheds. Conversely, it is considered of minor significance if it only impacts one watershed of minor importance with respect to the community priority.
- *Severity of Impact* – The significance of this factor is gaged by the severity of the impact. It is considered of major significance if the indicator severely impacts the community priority. If the impacts are only minimal, it is considered of only minor importance.
- *Likelihood of Impact* – The significance of this factor is based on the likelihood of impacts to the community priority. It is considered of major significance if there are known significant impacts from the indicator to the community priority. If impacts are highly suspected, it is considered of moderate significance. If impacts are only marginally suspected, it is considered of minor significance.
- *Frequency of Impact* – The significance of this factor is based on the frequency of impacts. It is considered of major importance if the indicator chronically impacts the community priority. Frequent acute impacts are considered moderate and infrequent acute impacts are considered minor.
- *Ability to Control* – The significance of this factor is based on the ability of the community to control the indicator. It is considered of major significance if actions by agencies or partners to control the indicator may greatly improve the community priority condition. If actions may result

in significant improvements, it is considered moderate. If actions may only result in marginal improvements it is considered minor.

Indicator weights are summarized in Table 2. Rationale for final indicator weightings is provided in the minutes from the Expert Panel workshops (Appendices C and D).

Table 2. Indicator Weights.

	Community Priority	Indicator	Weight
Water and Land	Aquatic Life Impacts	Physical Habitat	0.2
		Flow Regime	0.2
		Contaminated Sediment	0.2
		Water Column Toxicants	0.2
		Clean Sediment & Turbidity	0.1
		TP & DO	0.1
	Waterbody Aesthetics	Trash	0.3
		Physical Habitat	0.2
		TP	0.2
		Flow Regime	0.1
		Clean Sediment & Turbidity	0.2
	Primary and Secondary Contact Recreation	Pathogens	0.5
		TP	0.1
		Flow Regime	0.2
		Trash	0.2
	Clean Drinking Water	Pathogens	0.4
		TP	0.3
		TN	0.1
		Toxic Organics	0.1
		Turbidity	0.1
	Fish Consumption Advisories	Mercury	0.5
		Toxic Organics	0.5
Air	Climate Change	CO_2	0.76
		CH_4	0.16
		N_2O	0.06
		Fluorinated Gas	0.02
	Ability to Retain and Attract Businesses	O3 Precursors (NOx, VOC)	0.7
		$PM_{2.5}$ Precursors	0.3
	Health Impacts from Air Pollution	HAPs	0.3
		$PM_{2.5}$	0.5
		O3	0.2
	Agricultural Impacts	O3	0.9
		HAPs (Metals)	0.1

7. Ratings

After identifying and weighting indicators, the Expert Panels were tasked with rating the link between each indicator and pollution source. Ratings were made on a scale of 0 to 3 and represent the relative impact a source has on a particular indicator, with 3 being the most impactful and 0 having no impact. As guidance, workshop participants were instructed to collectively consider the following factors when scoring pollution sources.

- *Watershed Scale* (water and land only) – The significance of this factor is a function of the number and importance of the community priority watersheds impacted by the indicator. It is considered of major significance if the pollution source impacts all community priority watersheds. Conversely, it is considered of minor significance if the source only impacts one watershed of minor importance with respect to the community priority.

- *Relative Contribution* – The significance of this factor is based on the contribution of the pollution source to the pollutant species relative to other sources. If the relative contribution from the source is high, then it is considered of major significance. If the relative contribution from the source is low, then it considered of minor significance.
- *Hydrologic Condition* (water and land only) – This factor refers to the range of hydrologic conditions under which impacts occur. If the pollution source impacts the community priority under a wide range of hydrologic conditions, it is considered of major significance. If impacts are primarily during dry weather conditions only, then it is considered of moderate significance. If impacts are primarily during wet weather conditions only, then it is considered of minor importance.
- *Risk of Pollutant* - The risk posed by the pollutants associated with the pollution source determines the significance of this factor. The source is considered of major significance if the pollutants associated with it pose a high risk to the community priority. If the pollutants only poses a low risk, then the source is considered of minor significance.

Final ratings from the Expert Panel workshop are presented in Table 3. Rationale for ratings are provided in the minutes from the Expert Panel workshops (Appendices C and D).

Table 3. Pollutant Source Ratings.

			RATINGS (0-3)															
			Air				Land			Water								
	Community Priorities	Indicator	Stationary	Power Generation	Mobile	Residential Burning	Legacy Contaminated Sites	Significant Contaminated Sites	Improper Disposal & Dumping	Urban Runoff	Industrial Runoff	Agricultural Runoff	Land Disturbance Runoff	Stream Bank Erosion	Sanitary Sewer Exfiltration	Sanitary Sewer Overflows	Failing On-Site Wastewater Systems	Permitted Wastewater Discharges
Water and Land	Aquatic life impacts	Physical Habitat							1	3	1	2	1	2				
		Flow Regime								3	1	2	1					
		Contaminated Sediment					3	3	0.5	2	2							
		Water Column Toxicants					2	2	1	2	3	1			2	1		0.5
		Clean Sediment & Turbidity								1	0.5	1.5	1	3				
		TP & DO								1.5	0.5	2	1	3	3	0.5	1	3
	Waterbody aesthetics	Trash							3	3	1		1			1		
		Physical Habitat								3	1	2	1	2				
		TP								1.5	0.5	2	1	3	3	0.5	1	3
		Flow Regime								3	1	2	1					
		Clean Sediment & Turbidity								1	0.5	1.5	1	3				
	Primary and secondary contact recreation	Pathogens							0.5	1	0.5	3			3	1.5	1	0.5
		TP								1.5	0.5	2	1	3	3	0.5	1	3
		Flow Regime								3	1	2	1					
		Trash							3	3	1		1			1		
	Clean drinking water	Pathogens								0.5		3			3		1	0.5
		TP								1		3		3	2		1	1
		TN								1		3		2	2		1	1
		Toxic Organics					1	3	1	1		1			2		0.5	0.5
		Turbidity								1		2	1.5	3				
	Fish consumption advisories	Mercury							2	2	1				2			0.5
		Toxic Organics					3	1	1	2	1				1	0.5		0.5
Air	Climate Change	CO_2	1	3	2													
		CH_4	1.5	0.5														
		N_2O		0.5	0.5													
		Fluorinated Gas	1		1													
	Ability to attract and retain local businesses	O3 Precursors (NOx, VOC)	3	0.5	3	0.5												
		PM2.5	3	2	2	1												
	Health impacts from air pollution	HAP	2	1	2	3												
		$PM_{2.5}$	2	2	1	3												
		O3	3	0.5	3	0.5												
	Agricultural Impacts	O3	3	0.5	3	0.5												
		HAP Metals	2	3	1	0.5												

8. Results

The objective of the MCDA is to prioritize the most significant sources of pollution in the Springfield-Greene County region. To determine significance, each of the 16 pollution sources were scored and ranked based on the sum-product of the community priority weight, indicator weight, and rating (Table 4, Figure 3). Possible scores for any individual pollution source range from 0 to 3. Final scores ranged from 0.19 for significant contaminated sites to 1.03 for agricultural runoff. Pollution sources were categorized as high, medium, or low priority based on scores as discussed below. However, such categories are only intended to convey a relative priority and do not necessarily reflect importance.

High Priority Sources

1. **Agricultural Runoff (Score = 1.03)** – Agricultural runoff impacts clean drinking water (0.49) more than any other community priority. The agricultural runoff indicator that most heavily impacts this and all community priorities is pathogens.

2. **Urban Runoff (Score = 0.97)** – Urban runoff impacts primary and secondary contact recreation (0.28) more than any other community priority. The urban runoff indicators that most heavily impact this priority are flow regime and trash. Impacts from both these indicators are equal with respect to primary and secondary contact recreation. The indicator that most heavily impacts all community priorities is trash.

3. **Stationary – Air (Score = 0.93)** – Stationary sources impact health impacts from air (0.29) more than any other community priority. The stationary indicator that most heavily impacts this community priority is $PM_{2.5}$. The indicator that most heavily impacts all community priorities is ozone and ozone precursors.

4. **Sanitary Sewer Exfiltration (Score = 0.90)** – Sanitary sewer exfiltration impacts clean drinking water (0.40) more than any other community priority. The sanitary sewer exfiltration indicator that most heavily impacts this and all community priorities is pathogens.

5. **Mobile – Air (Score = 0.89)** – Mobile air sources impact agricultural impacts (0.25) more than any other community priority. The mobile air sources indicators that most heavily impact this priority are HAPs and ozone. Impacts from both these indicators are equal with respect to agricultural impacts. The indicator that most heavily impacts all community priorities is ozone and ozone precursors.

Medium Priority Sources

6. **Power Generating Facilities – Air (Score = 0.60)** – Power generating facilities impact climate change (0.26) more than any other community priority. The power generating facility indicator that most heavily impacts this and all community priorities is CO_2.

7. **Stream Bank Erosion (Score = 0.51)** – Stream bank erosion impacts clean drinking water (0.25) more than any other community priority. The stream bank erosion indicator that most heavily impacts this and all community priorities is total phosphorus.

8. **Residential Burning – Air (Score = 0.43)** – Residential burning impacts health impacts from air (0.33) more than any other community priority. The residential burning indicator that most heavily impacts this and all community priorities is $PM_{2.5}$.

9. **Industrial Runoff (Score = 0.39)** – Industrial runoff impacts aquatic life (0.15) more than any other community priority. The industrial runoff indicator that most heavily impacts this and all community priorities is water column toxicants.

10. **Improper Disposal & Dumping (Score = 0.38)** – Improper disposal and dumping impacts primary and secondary contact recreation (0.13) more than any other community priority. The improper disposal and dumping indicator that most heavily impacts this and all community priorities is trash.

11. **Permitted Wastewater Discharges (Score = 0.32)** – Permitted wastewater discharges impact clean drinking water (0.12) more than any other community priority. The permitted wastewater discharges indicator that most heavily impacts this and all community priorities is total phosphorus.

Low Priority Sources

12. **Failing On-Site Wastewater Systems (Score = 0.27)** – Failing on-site wastewater systems impact clean drinking water (0.15) more than any other community priority. The failing on-site wastewater system indicator that most heavily impacts this and all community priorities is pathogens.

13. **Legacy Contaminated Sites (Score = 0.24)** – Legacy contaminated sites impact fish consumption advisories (0.12) more than any other community priority. The legacy contaminated site indicator that most heavily impacts this and all community priorities is toxic organics.

14. **Land Disturbance Runoff (Score = 0.23)** – Land disturbance runoff impacts primary and secondary contact recreation (0.08) more than any other community priority. The land disturbance runoff indicators that most heavily impacts this priority are flow regime and trash. Impacts from both these indicators are equal with respect to primary and secondary contact recreation. The indicator that most heavily impacts all community priorities is flow regime.

15. **Sanitary Sewer Overflows (Score = 0.22)** – Sanitary sewer overflows impact primary and secondary contact recreation (0.15) more than any other community priority. The sanitary sewer overflow indicator that most heavily impacts this and all community priorities is pathogens.

16. **Significant Contaminated Sites (Score = 0.19)** – Significant contaminated sites impact aquatic life (0.10) more than any other indicator. The significant contaminated site indicator that most heavily impacts this priority is contaminated sediment. The indicator that most heavily impacts all community priorities is toxic organics.

Table 4. MCDA Scoring Table.

					RATINGS (0-3)																SCORES (W_P x W_I x Rating)																	
					Air				Land			Water									Air				Land			Water										
	Community Priorities	Priority Weight (Wp)	Indicator	Indicator Weight (Wi)	Stationary	Power Generation	Mobile	Residential Burning	Legacy Contaminated Sites	Significant Contaminated Sites	Improper Disposal & Dumping	Urban Runoff	Industrial Runoff	Agricultural Runoff	Land Disturbance Runoff	Stream Bank Erosion	Sanitary Sewer Exfiltration	Sanitary Sewer Overflows	Failing On-Site Wastewater Systems	Permitted Wastewater Discharges	Stationary	Power Generation Facilities	Mobile	Residential Burning	Legacy Contaminated Sites	Significant Contaminated Sites	Improper Disposal & Dumping	Urban Runoff	Industrial Runoff	Agricultural Runoff	Land Disturbance Runoff	Stream Bank Erosion	Sanitary Sewer Exfiltration	Sanitary Sewer Overflows	Failing On-Site Wastewater Systems	Permitted Wastewater Discharges
Water and Land	Aquatic life impacts	0.10	Physical Habitat	0.2							1	3	1	2	1	2											0.020	0.060	0.020	0.040	0.020	0.040					
			Flow Regime	0.2								3	1	2	1												0.060	0.020	0.040	0.020						
			Contaminated Sediment	0.2					3	3	0.5	2	2												0.060	0.060	0.010	0.040	0.040								
			Water Column Toxicants	0.2					2	2	1	2	3	1			2	1		0.5					0.040	0.040	0.020	0.040	0.060	0.020			0.040	0.020		0.010
			Clean Sediment & Turbidity	0.1								1	0.5	1.5	1	3												0.010	0.005	0.015	0.010	0.030				
			TP & DO	0.1								1.5	0.5	2	1	3	3	0.5	1	3								0.015	0.005	0.020	0.010	0.030	0.030	0.005	0.010	0.030
																				Subtotal					*0.10*	*0.10*	*0.05*	*0.23*	*0.15*	*0.14*	*0.06*	*0.10*	*0.07*	*0.03*	*0.01*	*0.04*
	Waterbody aesthetics	0.07	Trash	0.3							3	3	1		1			1									0.063	0.063	0.021		0.021				0.021		
			Physical Habitat	0.2								3	1	2	1	2												0.042	0.014	0.028	0.014	0.028				
			TP	0.2								1.5	0.5	2	1	3	3	0.5	1	3								0.021	0.007	0.028	0.014	0.042	0.042	0.007	0.014	0.042
			Flow Regime	0.1								3	1	2	1													0.021	0.007	0.014	0.007					
			Clean Sediment & Turbidity	0.2								1	0.5	1.5	1	3												0.014	0.007	0.021	0.014	0.042				
																				Subtotal							*0.06*	*0.16*	*0.06*	*0.09*	*0.07*	*0.11*	*0.04*	*0.03*	*0.01*	*0.04*
	Primary and secondary contact recreation	0.15	Pathogens	0.5							0.5	1	0.5	3			3	1.5	1	0.5							0.038	0.075	0.038	0.225			0.225	0.113	0.075	0.038
			TP	0.1								1.5	0.5	2	1	3	3	0.5	1	3								0.023	0.008	0.030	0.015	0.045	0.045	0.008	0.015	0.045
			Flow Regime	0.2								3	1	2	1													0.090	0.030	0.060	0.030					
			Trash	0.2							3	3	1		1			1									0.090	0.090	0.030		0.030			0.030		
																				Subtotal							*0.13*	*0.28*	*0.11*	*0.32*	*0.08*	*0.05*	*0.27*	*0.15*	*0.09*	*0.08*
	Clean drinking water	0.18	Pathogens	0.4								0.5		3			3		1	0.5								0.036		0.216			0.216		0.072	0.036
			TP	0.3								1		3		3	2		1	1								0.054		0.162		0.162	0.108		0.054	0.054
			TN	0.1								1		3		2	2		1	1								0.018		0.054		0.036	0.036		0.018	0.018
			Toxic Organics	0.1					1	3	1	1		1			2		0.5	0.5					0.018	0.054	0.018	0.018		0.018			0.036		0.009	0.009
			Turbidity	0.1								1		2	1.5	3												0.018		0.036	0.027	0.054				
																				Subtotal					*0.02*	*0.05*	*0.02*	*0.14*		*0.49*	*0.03*	*0.25*	*0.40*		*0.15*	*0.12*
	Fish consumption advisories	0.08	Mercury	0.5							2	2	1				2			0.5							0.080	0.080	0.040				0.080			0.020
			Toxic Organics	0.5					3	1	1	2	1				1	0.5		0.5					0.120	0.040	0.040	0.080	0.040				0.040	0.020		0.020
																				Subtotal					*0.12*	*0.04*	*0.12*	*0.16*	*0.08*				*0.12*	*0.02*		*0.04*
Air	Climate Change	0.11	CO_2	0.76	1	3	2														0.084	0.251	0.167														
			CH_4	0.16	1.5	0.5															0.026	0.009															
			N_2O	0.06		0.5	0.5															0.003	0.003														
			Fluorinated Gas	0.02	1		1														0.002		0.002														
																				Subtotal	*0.11*	*0.26*	*0.17*														
	Ability to attract and retain local businesses	0.09	O3 Precursors (NOx, VOC)	0.7	3	0.5	3	0.5													0.189	0.032	0.189	0.032													
			PM2.5	0.3	3	2	2	1													0.081	0.054	0.054	0.027													
																				Subtotal	*0.27*	*0.09*	*0.24*	*0.06*													
	Health impacts from air pollution	0.13	HAP	0.3	2	1	2	3													0.078	0.039	0.078	0.117													
			$PM_{2.5}$	0.5	2	2	1	3													0.130	0.130	0.065	0.195													
			O3	0.2	3	0.5	3	0.5													0.078	0.013	0.078	0.013													
																				Subtotal	*0.29*	*0.18*	*0.22*	*0.33*													
	Agricultural Impacts	0.09	O3	0.9	3	0.5	3	0.5													0.243	0.041	0.243	0.041													
			HAP Metals	0.1	2	3	1	0.5													0.018	0.027	0.009	0.005													
																				Subtotal	*0.26*	*0.07*	*0.25*	*0.05*													
																				Total	**0.93**	**0.60**	**0.89**	**0.43**	**0.24**	**0.19**	**0.38**	**0.97**	**0.39**	**1.03**	**0.23**	**0.51**	**0.90**	**0.22**	**0.27**	**0.32**

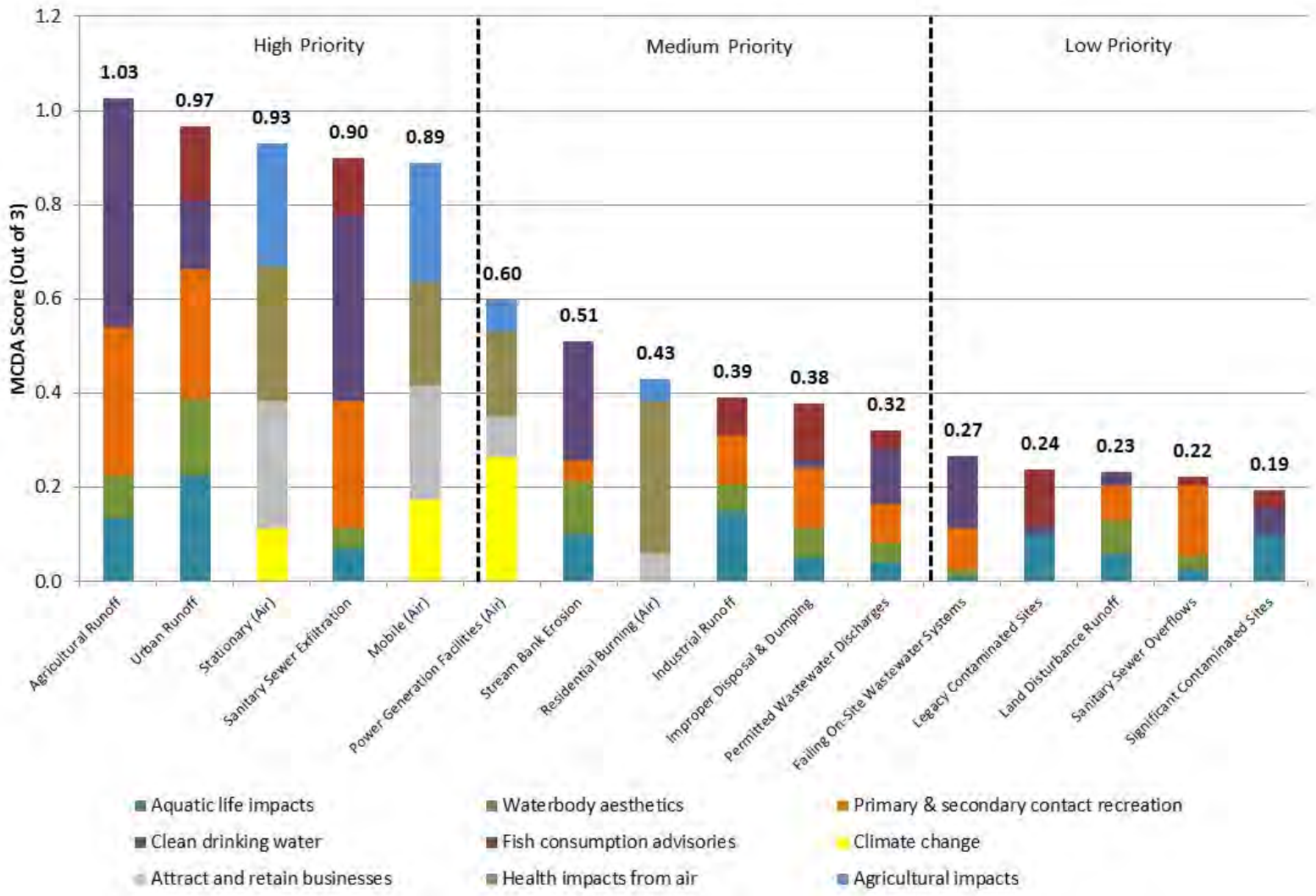


Figure 3. MCDA Scores by Community Priority.

9. Uncertainty Analysis

Uncertainty refers to a lack of data or an incomplete understanding of a decision. Uncertainty is inherent to the MCDA process. The purpose of this section is to assess uncertainty in the final MCDA scores to better understand its implications and limitations. The evaluation was conducted with a Monte Carlo simulation by randomly adjusting pollution source ratings based on a triangular distribution.

A triangular distribution is a method of describing uncertainty in variables based on a three-point estimate. The three-point estimate consists of a minimum value, maximum value, and the most likely value or mode. The three points form a continuous probability distribution shaped like a triangle, where the area under the curve is 1. The triangular distribution is typically used when there is little underlying data and is well suited for judgmental data estimates. In this case, the mode was represented by the MCDA ratings assigned during the Expert Panel workshops. The minimum and maximum were based on confidence levels ascribed to the ratings by City staff that participated in the Expert Panel workshops.

City staff assigned confidence levels ranging from 1 to 3 to all pollution source ratings. A confidence level of 1 represented a low level of confidence and a confidence level of 3 represented a high level confidence. These levels were based on the City's understanding of local pollution sources and environmental impacts coupled with the rationale used by the Expert Panel to set impact ratings. Using these confidence levels, minimum and maximum ratings adjusted anywhere from plus or minus 1/3 (high confidence) to 1 (low confidence). However, in no case were ratings set above 3 or below 0.

Having defined the minimum, maximum and mode, random x values that follow a triangular distribution were generated as part of a Monte Carlo simulation. Using this approach, boxplots were developed to provide a graphic depiction of the estimated range of uncertainty associated with the MCDA scores. The level of overlap between the interquartile range, as represented by the difference between the 25th and 75th percentile, was used as general guidance to visually assess whether differences exist between the MCDA scores. Where the median value of any one box overlapped with the interquartile range of another, the assumption was held that no difference in scores could be claimed.

9.1. Estimated Range of Pollution Source Scores

Boxplots of MCDA scores by pollution source demonstrate some uncertainty, but do not significantly alter findings presented in the Results section. This analysis suggests pollution sources categorized in the Results Section as either high, medium, or low priority are different from pollution sources in other categories. These differences appear likely as no interquartile range from one group intersects with that in another (Figure 4).

While the high, medium, and low priority categories of pollutant sources appear different from each other, differences within these categories are less clear. Within the high priority category, agriculture appears to rank highest followed by urban runoff and stationary sources. However, there does not appear to be any clear difference in scores between the mobile and sanitary sewer exfiltration sources of air and water pollution, respectively. Within the medium priority category, all sources appear to have different scores with the exception of industrial runoff and improper disposal & dumping. Within the low priority category, there is little to no distinction in scores between land disturbance runoff, legacy contaminated sites, and sanitary sewer overflows.

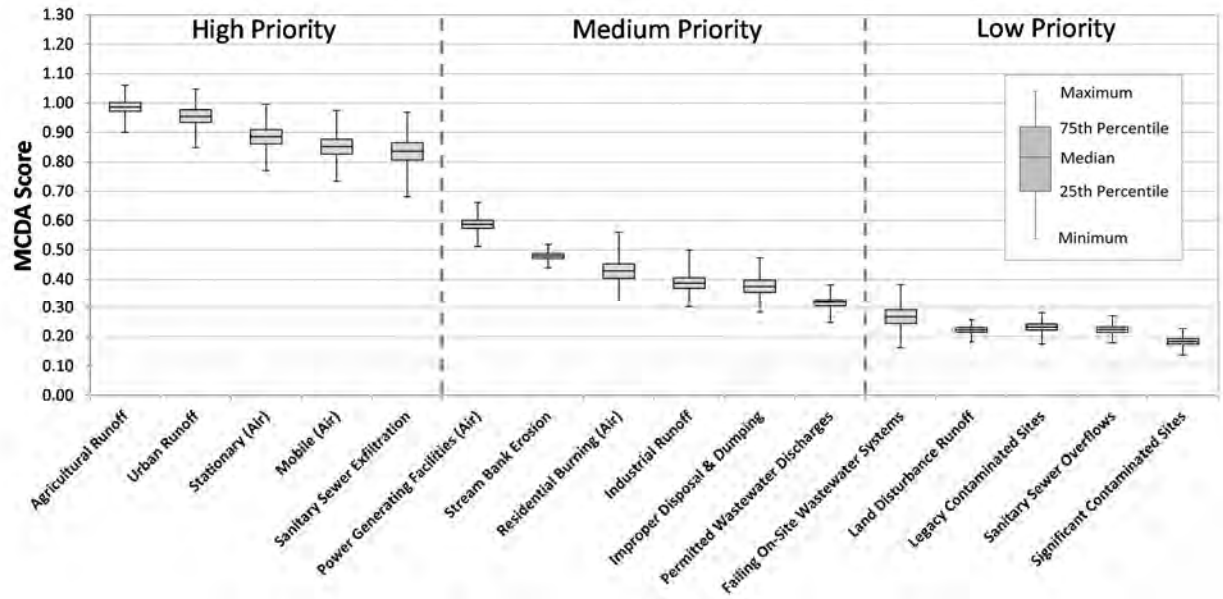


Figure 4. Estimated Range of Uncertainty for MCDA Pollution Source Scores. (Based on randomly generated values that follow a triangular distribution.)

9.2. Estimated Range of Pollution Indicator Impacts

MCDA scores were aggregated at the pollution indicator level to allow for a relative comparison of their impacts to all community priorities. The comparisons were made based on boxplots developed from a Monte Carlo simulation using the triangular distribution described above. Based on an approximate visual grouping, the most impactful indicators include pathogens, phosphorus and ozone (Figure 7). MCDA scores for all three of these indicators fall above and outside the range of all other indicators. Of these three indicators, pathogens has the highest score, followed by phosphorus and ozone. There does not appear to be any difference in scores between phosphorus and ozone due to the overlapping boxplots.

After pathogens, phosphorus and ozone, the six most impactful indicators in descending order of score are $PM_{2.5}$, toxic organics, CO_2, trash, flow regime, and HAPs. Indicators within this group appear to have statistically different scores based on the separation between the interquartile ranges. There is little separation in scores for the four subsequent indicators, which include physical habitat, mercury, sediment & turbidity, and water column toxics. On the low end, the five least impactful indicators in descending order of score include contaminated sediment, total nitrogen, CH_4, N_2O, and fluorinated gases.

In general, indicators with higher levels of impact had a wider distribution of scores suggestive of greater uncertainty (Figure 5). However, this pattern can largely be explained by the indicator weight, which corresponds with the magnitude and span of the scores. As the weight of an indicator increases, so does its score and the span of its boxplot. Therefore, a boxplot that spans a wider range of MCDA scores does not necessarily reflect any less confidence or understanding of the data than one that spans a tighter range. However, a high scoring indicator with a wide spanning boxplot does underscore the need for better characterization and understanding of that indicator. Based on findings presented in Figure 7, efforts to reduce uncertainty should be focused on pathogens, total phosphorus and ozone.

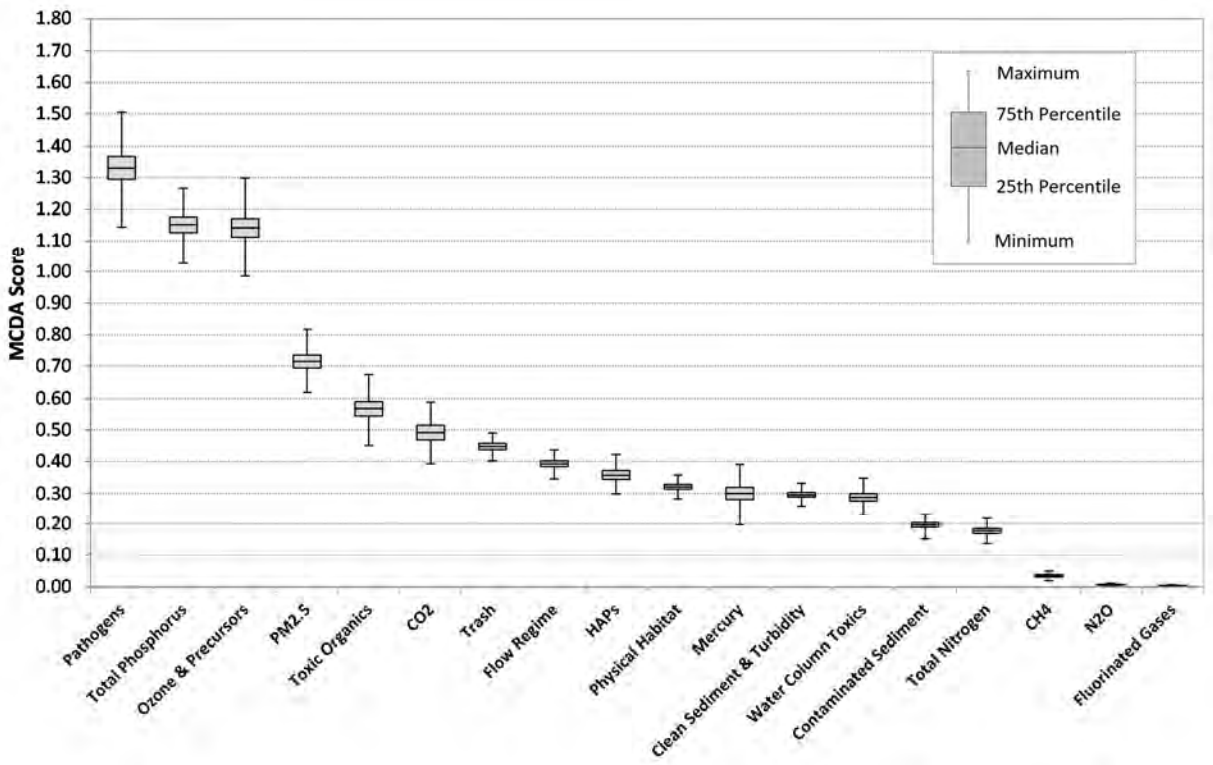


Figure 5. Estimated Range of Uncertainty for MCDA Pollution Indicator Scores. (Based on randomly generated values that follow a triangular distribution.)

10. Data Gaps

The MCDA is a data driven process that relies on the judgment of technical experts and those most knowledgeable of local pollution issues. However, it is inherent to the MCDA process that some decisions are made without a complete understanding of an issue. Where information was identified as lacking during the Expert Panel workshops, it was noted as a data gap. The intent of identifying data gaps was to help refine the MCDA process during future iterations. Data gaps identified during the workshops are summarized below.

1. **Nitrate and Bacteria Well Data** – Private wells are a significant source of drinking water outside Springfield City limits, but relatively little is known about well water quality. The Springfield-Greene County Health Department offers private well testing at the request of homeowners for a fee, but this information was not explicitly compiled as part of the MCDA process. However, as part of a limited review, Greene County determined there is relatively little nitrate data available for private wells. In 2016, just 56 of 3,700 wells with water testing were evaluated for nitrate. One of the 56 samples exceeded the nitrate limit of 10 mg/L at 17 mg/L, but further testing would be needed to track these results back to a source or determine if this outlier may have been due to laboratory error. Additional evaluation of the Health Department well data is also needed to assess whether there are drinking water issues associated with pathogens. Information on water table elevation is also important as it may correlate with pollutant concentrations. Given the importance of private wells as a drinking water source, this is considered a high priority data gap.

2. **Toxic Organic Impacts on Drinking Water Supplies** – Fulbright Spring represents an important source of drinking water for the City of Springfield and there is currently no evidence to suggest it is contaminated by toxic organics. However, the potential for contaminated legacy sites to impact Fulbright Spring at some point in the future remains unclear. Several legacy sites might be hydrologically connected to the Fulbright Spring, but further study is needed to characterize such connections. This is considered a high priority data gap.

3. **Monitoring for Exfiltration** – Flow studies suggest that the City of Springfield is losing a significant volume of sewage to exfiltration, which occurs from open joints and other sewer leaks. This suggests that exfiltration may represent a significant source of pathogens and nutrients to area streams and groundwater. However, additional monitoring is needed to better characterize the location and extent of exfiltration. Due to the potential severity of the source, this is considered a high priority data gap.

4. **Cryptosporidium and Giardia Data** – Cryptosporidium and Giardia are parasitic protozoans associated with water that cause intestinal illnesses and are relatively difficult to disinfect. Transmission of these parasites occurs when water has been contaminated with fecal matter of an animal or human that is infected with the parasite. City Utilities of Springfield (CU) has been collecting Cryptosporidium and Giardia data near the intake for the Blackman Water Treatment Plant. However, the Cryptosporidium and Giardia data compiled for purposes of the MCDA were relatively limited. CU should continue to collect additional Cryptosporidium and Giardia data to provide for a more thorough analysis. Given the potential risks associated with these pathogens, this is considered a high priority data gap.

5. **Continuous Dissolved Oxygen Data** – Characterizing dissolved oxygen (DO) is essential to understanding the health of a waterbody. The diurnal pattern of DO concentration, which increases during daylight hours in response to photosynthesis and decreases at night when photosynthesis ceases, is controlled by nutrients and algal growth. Excessive levels of nutrients and algal growth can result in large DO swings, which can be detrimental to aquatic life if DO levels go too low. Because DO fluctuates throughout the day, continuous DO data are necessary to fully characterize its patterns. DO data compiled for the MCDA are largely discrete providing little information about whether or not DO issues exist. Therefore, the lack of continuous DO data is considered a medium priority data gap.

6. **Farm Fertilizer Application Rates** – Farm fertilizer runoff potentially represents a significant source of nutrient loading in a watershed; however, little information is currently known about application rates and implementation of agricultural BMPs in the MCDA study area. The USGS SPARROW model suggests that nutrient loading from farm fertilizer is high relative to other nutrient sources including livestock manure, but this is unlikely as there is little row crop farming in the study area. Additional research is needed to determine how much fertilizer is applied to agricultural sites in the MCDA study area and whether this represents a significant source of nutrients. Additionally, information about whether this fertilizer is applied in accordance with agricultural BMPs is also important. For example, fertilizer applied at agronomically appropriate rates using appropriate methods would have less significant water quality implications than inappropriately applied fertilizer. Given the relative importance of nutrients to the health of aquatic life, this is considered a medium priority.

7. **Pathogens from Industrial Sites** – Existing data suggests that runoff from industrial sites is contributing to elevated bacteria levels in Springfield area streams. However, bacteria runoff from industrial sites is typically associated with animal droppings, which vary in terms of risk to human health. Bacteria originating from birds likely represents a lower level of risk with respect to human health than bacteria originating from rats and rodents. Additional study is needed to determine what pathogens are coming off of industrial sites and what level of risk they present for human health. This is considered a low priority data gap.

8. **Aquatic Life Pathogens** – The Expert Panel decided that aquatic life pathogens should be evaluated separately in terms of impacts on human health from fish consumption and impacts on aquatic life. However, it is currently unclear how to evaluate pathogens associated with these impacts. Therefore, it was determined that consultation with the Missouri Department of Conservation (MDC) and a literature search is necessary to better understand pathogen impacts on human health from fish consumption and on the health of aquatic life. The additional research is needed determine what types of pathogens impact fish health or create risks from fish consumption. It is also currently unclear where such pathogens come from and whether or not they represent a genuine threat. The lack of information on aquatic life pathogens is considered a low priority data gap.

9. **Nitrogen's Role in Algal Blooms** – Questions were raised during the Expert Panel workshop about nitrogen's role in controlling algal blooms in drinking water sources. One of the primary concerns about excessive nutrients is the risk of creating an algal bloom, which can result in fish kills and release of algal toxins. However, the relationship between nutrient levels and algal blooms is complex. Questions were raised during the Expert Panel workshop about nitrogen's role in controlling algal blooms in drinking water sources. Previous studies suggest local waterbodies are likely phosphorus limited, meaning nitrogen does not likely control algal productivity that may lead to blooms. Further study is needed to help characterize nitrogen's role, but this is considered a low priority data gap, based on existing studies showing phosphorus as the limiting nutrient.

10. **Links between Air and Water** – Air pollution sources can impact both air and water quality. For example, mercury and other hazardous air emissions may eventually settle to the ground as dust or be captured in rain and snow. However, contaminants from air pollutants found in waterbodies are typically of distant origin. The impacts of local air sources on local waterbodies, although likely insignificant, are not known. Therefore, links between air pollution sources and water quality were not developed for this MCDA. Understanding such links between air pollution sources and water quality would require further study. These linkages are considered a low priority data gap.

11. Summary

Phase III of the IP for City, County and CU consists of four key elements: 1) capturing the community priorities, 2) identifying and prioritizing the most significant sources of pollution, 3) identifying and prioritizing the most effective solutions, and 4) assessing the community's financial capability. Community priorities were previously captured through a series of Task Force meetings and a community survey. The purpose of this report was to address the second element by quantitatively linking those community priorities to various pollution sources.

Four tasks deemed essential to this IP include database development, MCDA development, data gap analysis, and data collection and analysis. Each task builds upon the previous such that the database informs the MCDA, which in turn informs the data gap analysis resulting in additional data collection. This process is intended to be iterative and periodically refined as new or additional information becomes available (Figure 6).

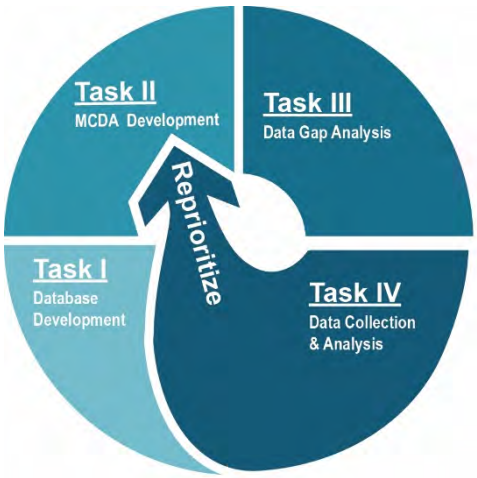


Figure 6. MCDA Task Diagram

Under Task I, a comprehensive database was developed to compile environmental data from a multitude of different sources for the seven different Task Force watersheds. These watersheds included the Sac River, Little Sac River, Pomme de Terre, Fellows & McDaniel Lake, Wilsons Creek, Middle James River, and Upper James River. This information was used to help characterize environmental conditions associated with a number of different pollution indicators.

As part of Task II, the HDR Team finalized development of an MCDA over the course of two separate Expert Panel workshops. These workshops combined the expertise of national experts in elements of water and air with those most knowledgeable of local pollution sources. Through consensus based decision-making, the structure of the MCDA was finalized and weights and ratings were assigned. From this effort, scores were calculated for each of 16 different pollution sources representing air, land and water. Based on the final scores, sources were ranked as high, medium or low priority as follows (scores are noted in parentheses):

<u>High Priority Sources</u>

- Agricultural Runoff (1.03)
- Urban Runoff (0.97)
- Stationary – Air (0.93)
- Sanitary Sewer Exfiltration (0.90)
- Mobile – Air (0.89)

<u>Medium Priority Sources</u>

- Power Generating Facilities - Air (0.60)
- Stream Bank Erosion (0.51)
- Residential Burning - Air (0.43)
- Industrial Dumping (0.39)
- Improper Disposal & Dumping (0.38)
- Permitted Wastewater Discharges (0.32)

Low Priority Sources

- Failing On-Site Wastewater Systems (0.27)
- Legacy Contaminated Sites (0.24)
- Land Disturbance Runoff (0.23)
- Sanitary Sewer Overflows (0.22)
- Significant Contaminated Sites (0.19)

These results represent the first iteration of the MCDA and may be refined as data gaps are addressed. Some of the more significant data gaps identified during the Expert Panel workshops include lack of knowledge concerning nitrates and bacteria in private drinking water wells, toxic organic impacts on drinking water supplies, the extent of exfiltration, and data on Cryptosporidium and Giardia upstream of drinking water intakes. These data gaps are considered significant because they are linked to clean drinking water, which was identified as the number one community priority.

The results of this MCDA analysis are intended to help identify solutions that address the most pressing environmental problems that matter most to the community. By prioritizing pollution sources, the MCDA helps inform the next step of the IP, which is the SROI approach. Although data gaps exist, results of an uncertainty analysis suggest the general order of the pollution source rankings is valid. Therefore, additional data may only have minimal impacts on the existing results. However, results could significantly change during future iterations if it determined that community priorities have shifted.

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