Lake Quinsigamond Watershed Association
PO Box 4243, Boston Turnpike | Shrewsbury, MA 01545

MassDEP – Watershed Planning Program
8 New Bond St.
Worcester MA 01606
Attention: Robert Smith
RE: Water Quality Monitoring – Lake Quinsigamond, Bacteria Samples

Dear Mr. Smith:

Enclosed are the data deliverables for the 2021 and 2022 sampling project performed in accordance with the approved 2022-2024 Water Quality Monitoring Program QAPP for "Bacterial Monitoring of Tributaries to Lake Quinsigamond".

Data deliverables include, and not limited to, sampling methodology, sampling locations with summary and site assessments, laboratory results, field observation results, quality control and quality assurance methods/results, summary reports, and supporting supplemental records.

If you have any questions or need additional information, please feel free to contact me.

Sincerely,

Gia Coleman
Project Coordinator
gia.coleman2020@gmail.com

ecc: Suzanne Flint, MassDEP-QA Manager
Mike Liberty, LQWA, Project Manager
Peter Collins, LQC
Jacquelyn Burmeister, City of Worcester Lakes and Ponds

Lake Quinsigamond Watershed Association
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Lake Quinsigamond Bacteria Monitoring Program 2020-2022

"Bacterial Monitoring in Tributaries to Lake Quinsigamond"

Partners ~
Lake Quinsigamond Watershed Association
Lake Quinsigamond Commission
City of Worcester DPW, Lakes and Ponds Program

Updated by ~
Jung Hyo Batino,
November 2022

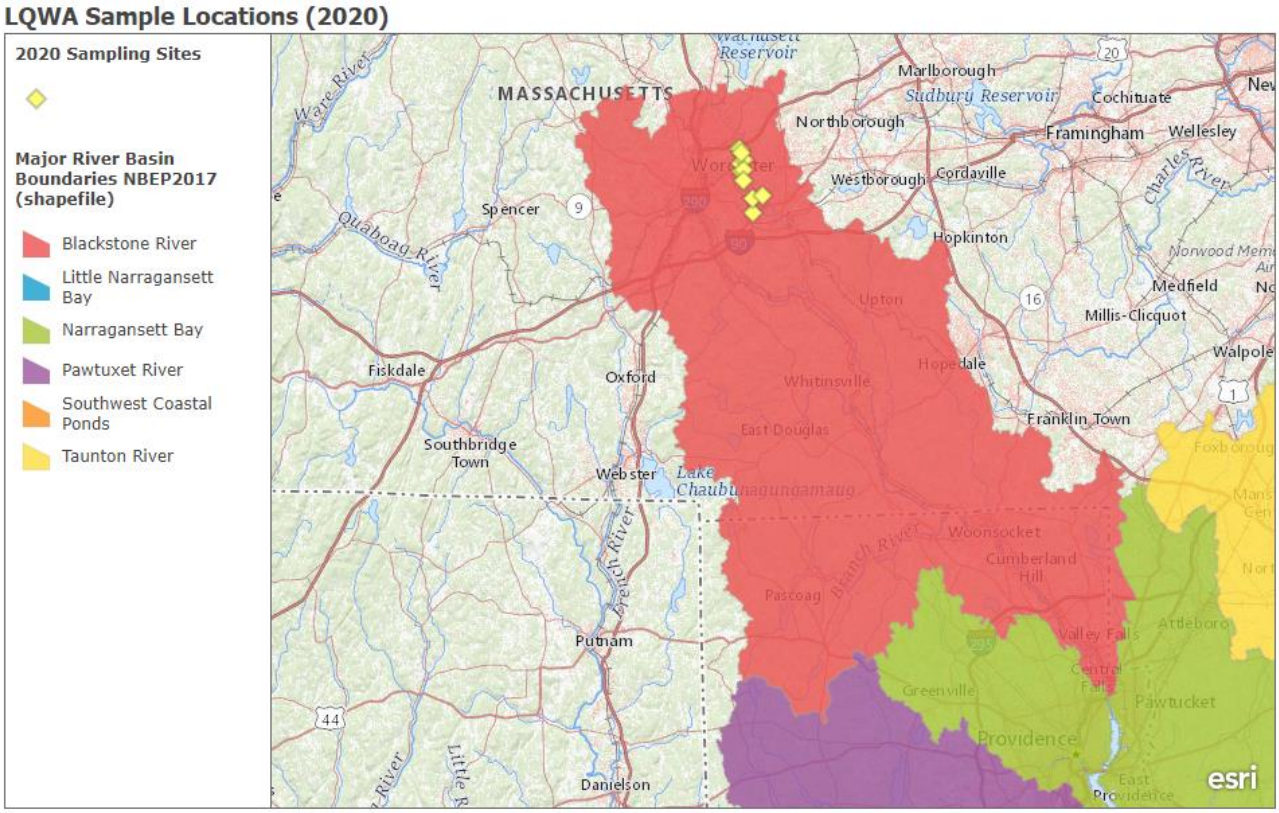
CONTENTS

1. INTRODUCTION

The Lake Quinsigamond Watershed Association (LQWA) is an all-volunteer organization founded in 1984. The LQWA is committed to enhancing the quality of life in and around Lake Quinsigamond, Flint Pond, and Shirley Pond, for its natural and human residents. This project was jointly funded by the Lake Quinsigamond Commission (LQC), the LQWA, the City of Worcester Department of Public Works, Lakes and Ponds Program and MassDEP's Water Quality Monitoring Grants.

Stormwater runoff to the lake and its tributaries is a significant source of bacteria pollution. The bacteria data is provided to MassDEP for the purpose of water quality assessment in Lake Quinsigamond and in several tributaries to the lake. The data is also provided to the Town of Shrewsbury and the City of Worcester to raise awareness of the problem of bacteria entering the lake and then to urge them to take appropriate corrective actions.

The Lake Quinsigamond Watershed Association (LQWA) conducted bacteria monitoring from roughly May to October in 2021 and 2022. Samples were collected at ten locations around Lake Quinsigamond roughly two weeks apart. Data collection activities were conducted in accordance with the 2022-2024 Water Quality Monitoring Program QAPP for "Bacterial Monitoring of Tributaries to Lake Quinsigamond".



10 sample locations

Esri Canada, Esri, HERE, Garmin, USGS, NGA, EPA, USDA, NPS | source: National Hydrography Dataset - USGS | USGS The National Map: National Boundaries Dataset, 3DEP Elevation Program, Geographic Names Information System, National Hydrography Dataset, National Land Cover Database, National Structures Dataset, and National Transportation Dataset; USGS Global Ecosystems; U.S. Census Bureau TIGER/Line data; USFS Road Data; Natural Earth Data; U.S. Department of State Humanitarian Information Unit; and NOAA National Centers for Environmental Information, U.S. Coastal Relief Model. Data refreshed May, 2020.

Figure 1: LQWA Sample Study Area within the Blackstone River Basin

2. METHODS USED

Sample collection (field) methodology was performed in accordance with LQWA's project-specific *Standard Operating Procedure #2020-02: Sample Collection Techniques for Bacterial Samples in Surface Waters*, which references the following best practice methods[1]: *Field Safety SOP# CN 000.2 (2009), Lake Sampling SOP# CN 151.0 (2010), Sample Collection Techniques for Surface Water Quality Monitoring SOP# CN 1.21 (2009), Field Equipment Decontamination to Prevent the Spread of Invasive Aquatic Organisms SOP# CN 59.5 (2015).*

Sample collection was performed by using a sampling pole for all collections apart from the blank sample. For both the 2021 and 2022 sampling seasons, all collections were completed for all the sample locations.

Samples (lab methods) were analyzed for E. Coli by Alpha Analytical using Standards Method 121,9223B-Colilert-QT with 33 analyses (121-Standard Methods for the Examination of Water and Wastewater. APHA-AWWA-WEF).

[1] MassDEP Watershed Planning Program

3. STUDY AREA

The study area is divided between the north and south basin. Six locations in the north and four locations in the south, totaling 10 sample locations.

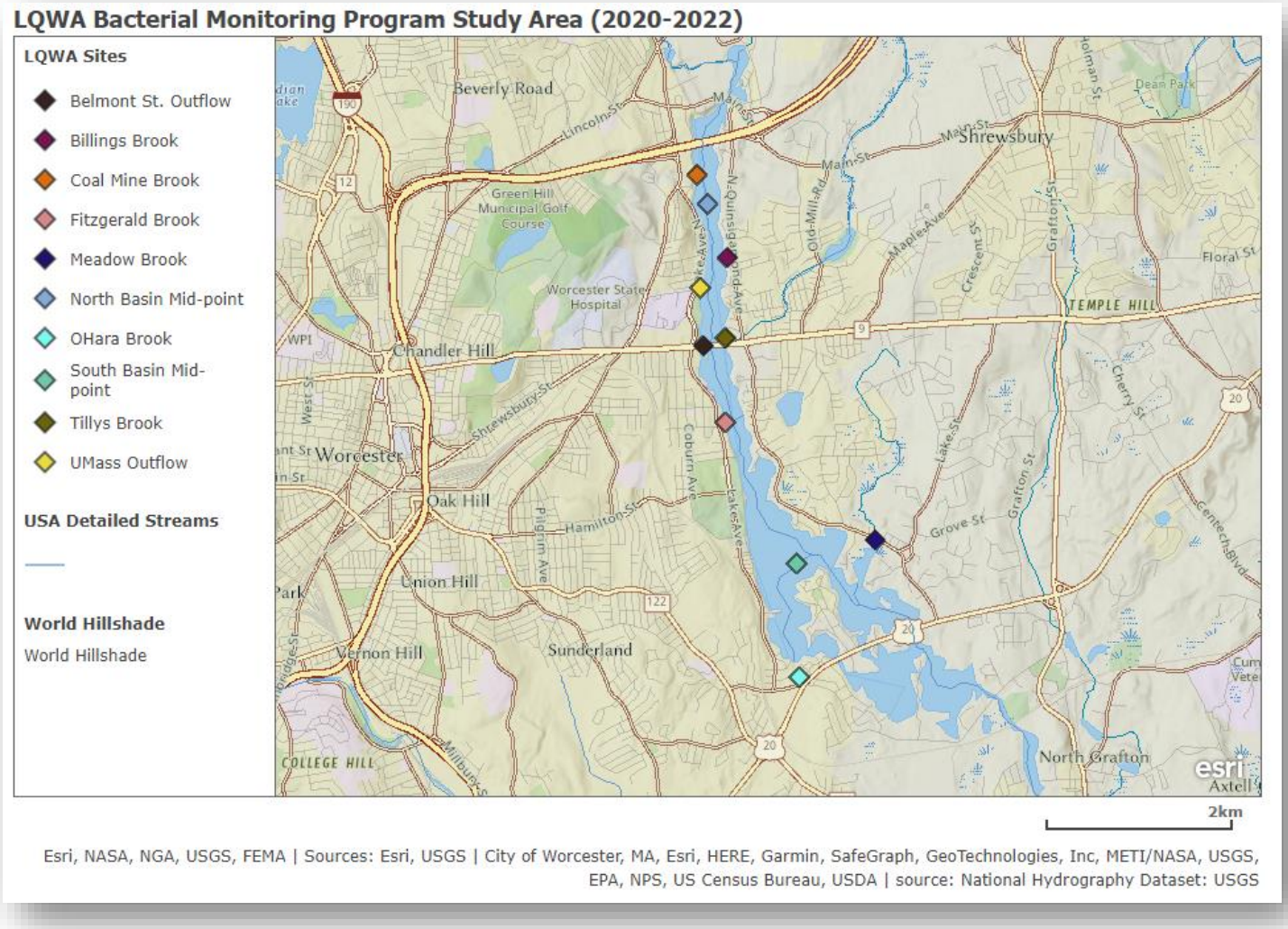


Figure 2: Sample Locations within the Study Area

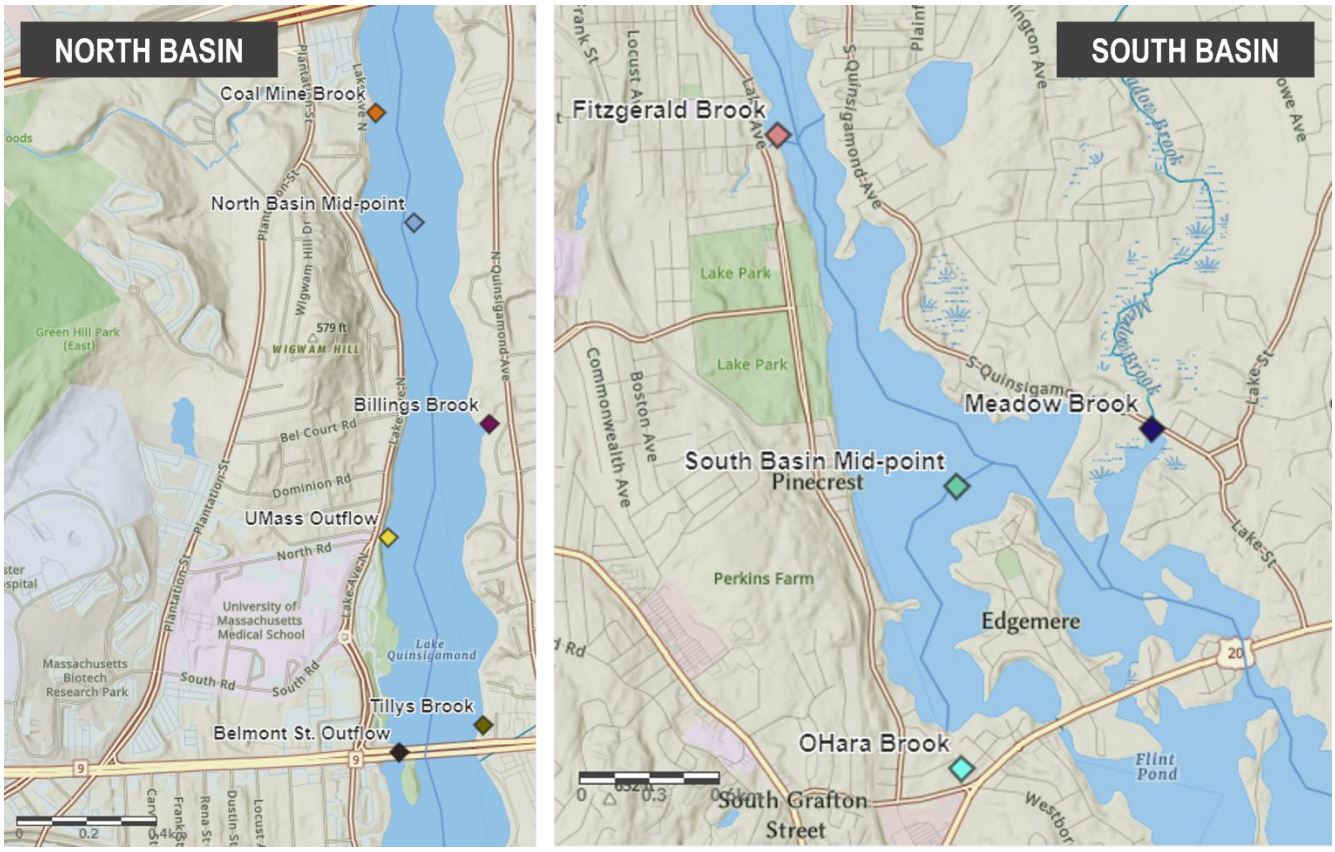


Figure 3: North and South Basin Sample Location Names

Table 1: Sample Location Metadata

Site ID	Site Name/Desc.	Town	Lat	Long
01_NB	Belmont St. Outfall	Worcester	42.274306	-71.757672
03_NB	UMass Outfall	Worcester	42.279667	-71.75778
04_NB2	Coal Mine Brook (2)	Worcester	*42.290794*	*-71.760113*
05_NB	Billings Brook	Shrewsbury	42.283183	-71.753767
06_NB	Tilly's Brook	Shrewsbury	42.274925	-71.754471
07_NB	North Basin Mid-point	Midpoint	42.28783	-71.756864
08_SB	O'Hara Book	Worcester	42.242419	-71.744942
10_SB	Fitzgerald Brook	Worcester	42.266325	-71.755047
12_SB	South Basin Mid-point	Midpoint	42.253264	-71.745226
13_SB	Meadow Brook	Shrewsbury	42.255481	-71.734985

4. RESULTS

Bacterial Sampling-Water Data

Table 2: 2021 - 2022 Bacteria results

2021 -2022 WATER QUALITY BACTERIA MONITORING RESULTS											
Sampling Day		*#1*	*#2*	*#3*	*#4*	*#5*	*#6*	*#7*	*#8*	*#9*	*#10*
SITE ID	**SITE NAME**	**5/25/2021**	**6/9/2021**	**6/22/2021**	**7/6/2021**	**7/20/2021**	**8/3/2021**	**8/18/2021**	**8/31/2021**	**9/13/2021**	**10/5/2021**
01_NB	*BELMONT STREET OUTFALL*	143.01	15.96	1732.89	10582	12396	1203.33	387.32	49.54	3893	4638
03_NB	*UMASS OUTFALL*	11	6.26	27.85	39.13	34.51	14.64	15.79	9.79	40.77	122.29
04_NB	*COAL MINE BROOK*	166.95	248.09	21720	214.26	920.84	127.4	435.17	365.4	980.39	816.41
05_NB	*BILLINGS BROOK*	28.47	48.74	325.54	85.74	2178	8.6	16.13	1869	191.79	613.14
06_NB	*TILLY'S BROOK*	325.54	2419.57	101.44	46.38	58.33	53.71	37.34	42.57	30.89	184.18
07_NB	*NORTHBASIN MID_POINT*	9.6	4.13	14.64	11	47.98	9.69	2.02	6.32	12.23	101.22
08_SB	*OHARA BROOK*	4105.8	27.85	41.35	435.17	172.71	1203.33	2419.57	1986.29	613.14	517.21
10_SB	*FITZGERALD BROOK*	58.06	64.47	307.59	579.43	3192	115.28	488.44	275.51	1046.24	1732.89
12_SB	*SOUTH BASIN MID-POINT*	7.38	1	6.32	13.5	29.76	3.06	11	11	22.81	7.31
13_SB	*MEADOW BROOK*	137.61	235.93	117.76	122.29	206.35	118.74	33.55	90.86	150.01	332.48

SITE ID	**SITE NAME**	**6/20/2022**	**7/11/2022**	**7/26/2022**	**8/9/2022**	**8/24/2022**	**9/9/2022**	**9/23/2022**	**10/7/2022**
01_NB	*BELMONT STREET OUTFALL*	261.25	261.25	137.61	137.35	579.43	149.72	2419.57	18,600.00
03_NB	*UMASS OUTFALL*	8.52	14.35	18.69	90.49	98.67	45.68	51.22	41.03
04_NB	*COAL MINE BROOK*	517.21	260.25	387.32	770.1	1,046.24	285.1	2419.57	726.99
05_NB	*BILLINGS BROOK*	2813	1986.29	866.44	365.4	13344	178.53	2785	47.98
06_NB	*TILLY'S BROOK*	137.61	20.11	27.85	36.41	1,299.65	98.67	461.11	1732.89
07_NB	*NORTHBASIN MID_POINT*	13.36	2.01	8.52	53.81	45.59	13.36	58.33	15.79
08_SB	*OHARA BROOK*	137.61	488.44	866.44	1,986.29	298.66	344.8	1553.12	240.03
10_SB	*FITZGERALD BROOK*	325.54	866.44	1,299.65	142.09	1,299.65	137.35	1732.89	62.44
12_SB	*SOUTH BASIN MID-POINT*	9.6	15.47	18.69	17.31	11.99	4.13	5.12	54.48
13_SB	*MEADOW BROOK*	193.49	88.23	83.61	193.49	101.93	201.42	517.21	150.01

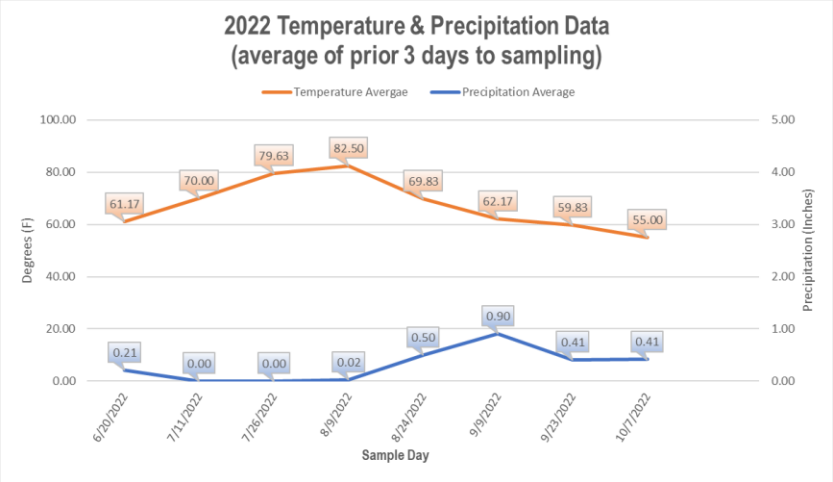


Figure 4: 2022 Precipitation and Air Temperature on Sampling Days

5. DATA QUALITY OBJECTIVES

After quality data reconciliation, performed by Gia Coleman and Barbara Kickham throughout the sampling seasons, the final data deliverables met Data Quality Objectives (DQO's) / Intended Uses of Data criteria outlined in the approved QAPP for all days, with the exception of sample day #8 in 2022 (October 7, 2022).

Accuracy & Precision (field), Completeness

Table 3: 2021 - 2022 Data Quality Objective Data; Accuracy, Precision, Completeness

Sampling Day	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10
2021	**5/25/2021**	**6/9/2021**	**6/22/2021**	**7/6/2021**	**7/20/2021**	**8/3/2021**	**8/18/2021**	**8/31/2021**	**9/13/2021**	**10/5/2021**
Precision; Field (duplicate)										
Site ID	**05_NB**	**08_SB**	**07_NB**	**10_SB**	**01_NB**	**13_SB**	**04_NB**	**03_NB**	**12_SB**	**06_NB**
Sample	28.47	27.85	14.64	579.43	12396.00	118.74	435.17	9.79	22.81	184.18
Duplicate	20.86	61.55	24.05	579.43	13008.00	118.74	344.80	21.09	13.36	141.37
%RPD	*9.74*	*21.30*	*16.93*	*0.00*	*0.51*	*0.00*	*3.91*	*28.80*	*18.71*	*5.20*
DQO Status	MET	MET	MET	MET	MET	MET	MET	MET	MET	MET
Accuracy; Field (blank)										
Site ID	**03_NB**	**10_SB**	**13_SB**	**04_NB**	**12_SB**	**07_NB**	**05_NB**	**01_NB**	**08_SB**	**06_NB**
Result	*<1*	*<1*	*<1*	*<1*	*<1*	*<1*	*<1*	*<1*	*<1*	*<1*
DQO Status	*MET*	*MET*	*MET*	*MET*	*MET*	*MET*	*MET*	*MET*	*MET*	*MET*
Completeness	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
DQO Status	*MET*	*MET*	*MET*	*MET*	*MET*	*MET*	*MET*	*MET*	*MET*	*MET*
2022	**6/20/2022**	**7/11/2022**	**7/26/2022**	**8/9/2022**	**8/24/2022**	**9/9/2022**	**9/23/2022**	**10/7/2022**		
Precision; Field (duplicate)										
Site ID	**01-NB**	**08-SB**	**10_SB**	**10_SB**	**04_NB**	**03_NB**	**03_NB**	**06_NB**		
Sample	261.25	488.44	1,299.65	142.09	1046.24	45.68	51.22	1,732.89		
Duplicate	206.35	325.54	1,732.89	107.58	1046.24	34.51	54.61	21,872.00		
%RPD	4	7	4	6	0	8	2	29		
DQO Status	MET	MET	MET	MET	MET	MET	MET	*NOT MET*		
Accuracy; Field (blank)										
Site ID	05-NB	06-NB	08_SB	08_SB	04_NB	13_SB	04_NB	07_NB		
Result	<1	<1	<1	<1	<1	<1	<1	<1		
DQO Status	MET	MET	MET	MET	MET	MET	MET	MET		
Completeness	100%	100%	100%	100%	100%	100%	100%	100%		
DQO Status	*MET*	*MET*	*MET*	*MET*	*MET*	*MET*	*MET*	*MET*		

Precision (lab)

Table 4: Data Quality Objective Data; Lab Precision (Alpha Analytical) 2022

Method Blank Analysis (Batch Control) Result				
Lab Analysis Date	**Alpha Sample ID**	**Batch Samples**	**Lab Analysis Time**	**Result**
5/25/2021	WG1503591-1	sample(s): 01-09	15:20	<1
5/25/2021	WG1503592-1	sample(s): 10-12	15:20	<1
6/9/2021	WG1509887-1	sample(s): 01-09	15:40	<1
6/9/2021	WG1509900-1	sample(s): 10-12	16:00	<1
6/22/2021	WG1515623-1	sample(s): 01-10	18:02	<1
6/22/2021	WG1515624-1	sample(s): 11-12	18:02	<1
7/6/2021	WG1520909-1	sample(s): 01-10	17:15	<1
7/6/2021	WG1520910-1	sample(s): 11-12	17:15	<1
7/20/2021	WG1525946-1	sample(s): 01-09	15:38	<1
7/20/2021	WG1525990-1	sample(s): 10-12	15:38	<1
8/3/2021	WG1531076-1	sample(s): 01-10	14:22	<1
8/3/2021	WG1531114-1	sample(s): 11-12	15:47	<1
8/18/2021	WG1536562-1	sample(s): 01-10	15:26	<1
8/18/2021	WG1536564-1	sample(s): 11-12	15:13	<1
8/31/2021	WG1541328-1	sample(s): 07-12	14:27	<1
8/31/2021	WG1541330-1	sample(s): 01-06	15:07	<1
9/13/2021	WG1545855-1	sample(s): 01-10	17:48	<1
9/13/2021	WG1545857-1	sample(s): 11-12	18:03	<1
10/5/2021	WG1554836-1	sample(s): 01-09	16:40	<1
10/5/2021	WG1554838-1	sample(s): 10-12	17:21	<1
6/20/2022	WG1652991-1	sample(s): 01-09	14:46	<1
6/20/2022	WG1652992-1	sample(s): 10-12	14:46	<1
7/11/2022	WG1661340-1	sample(s): 01-08	14:31	<1
7/11/2022	WG1661461-1	sample(s): 09-12	14:31	<1
7/26/2022	WG1667622-1	sample(s): 01-10	14:42	<1
7/26/2022	WG1667630-1	sample(s): 11-12	15:08	<1
8/9/2022	WG1673116-1	sample(s): 01-08	16:16	<1
8/9/2022	WG1673183-1	sample(s): 09-12	19:29	<1
8/24/2022	WG1679279-1	sample(s): 01-10	17:22	<1
8/24/2022	WG1679284-1	sample(s): 11-12	17:42	<1
9/9/2022	WG1685602-1	sample(s): 01-10	16:10	<1
9/9/2022	WG1685619-1	sample(s): 11-12	17:01	<1
9/23/2022	WG1691376-1	sample(s): 01-10	15:24	<1
9/23/2022	WG1691379-1	sample(s): 11-12	15:24	<1
10/7/2022	WG1696914-1	sample(s): 01-10	15:46	<1
10/7/2022	WG1696915-1	sample(s): 11-12	15:46	<1

Representativeness, Use of Best Practice SOP, and Documentation Methods

The sample locations were selected based on geographical/spatial proximity to stormwater outflows, direction of tributaries, distance from mixing activities (animal, human, or weather), turbidity, and history of bacteria. Post- and pre-sampling location investigation identified vulnerability and applicable mitigation needs. Potential mitigation needs for this project's purpose include preliminary surveying/investigation of, and not limited to; changes in biological conditions caused by animal or weather disturbance events (i.e. goose feces, gypsy moth carcass loading, and compounding defoliation induced waterbody condition(s) variances), and bacterial influx from anthropogenic outflows). Weather data will be acquired from NOAA's National Weather Service for Worcester's Regional Airport (ORH) webpage at https://w1.weather.gov/data/obhistory/KORH.html.

In addition to the sample design in the approved QAPP and SAP, in-depth site assessments were completed at each location. The assessments are based on tributary characteristics, field observations, tertiary evidence of land-use (i.e., storm water systems proximity, recreational use, etc.). Site assessments include imagery and video.

Site assessments available upon request.

5. QUALITY ASSURANCE, QUALITY CONTROL, AND DATA VALIDATION

In accordance with the approved QAPP, Data Validation & Usability was met successfully for the purposes of quality data acquisition and usability outlined in the Data Quality Objectives.

Field quality control audits, monthly check-ins, and data reporting were conducted continuously between Barbara Kickham **(Quality Control Officer)**, and Gia Coleman **(Project Coordinator, Quality Control Officer)**. Data entry of field notes and laboratory results were entered daily then reconciled with Gia Coleman **(Project Coordinator, Quality Control Officer)**. Revisions were completed by Gia Coleman and checked again by Barbara Kickham. For quality data deliverable specifications, see results.

Table 5: 2021 and 2022 Analyte Field QC

2. Analyte Field QC (use template or provide in other format)			Field Duplicate				Field Blanks		Performance Evaluation		Other	
Date	**Parameter**	**StationID**	**Sample ID**	**Field Result**	**Dup Sample ID**	**Dup Result**	**Sample ID**	**Field Blank Result**	**True Value**	**Result**	**Comments**	**QC**
5/25/2021	E.coli (MPN)	05_NB	L2127624-05	28.47	L2127624-06	20.86	L2127624-03	<1	N/A	N/A		GMC
6/9/2021	E.coli (MPN)	08_SB	L2130934-08	27.85	L2130934-02	61.55	L2130934-09	<1	N/A	N/A		GMC
6/22/2021	E.coli (MPN)	07_NB	L2133750-07	14.64	L2133750-02	24.05	L2133750-09	<1	N/A	N/A		GMC
7/6/2021	E.coli (MPN)	10_SB	L2136200-10	579.43	L2136200-09	579.43	L2136200-02	<1	N/A	N/A		GMC
7/20/2021	E.coli (MPN)	01_NB	L2138704-01	12396	L2138704-09	13008	L2138704-12	<1	N/A	N/A		GMC
8/3/2021	E.coli (MPN)	13_SB	L2141353-11	118.74	L2141353-02	118.74	L2141353-09	<1	N/A	N/A		GMC
8/18/2021	E.coli (MPN)	04_NB	L2144306-04	435.17	L2144306-02	344.8	L2144306-09	<1	N/A	N/A		GMC
8/31/2021	E.coli (MPN)	03_NB	L2146644-03	9.79	L2146644-02	21.09	L2146644-09	<1	N/A	N/A		GMC
9/13/2021	E.coli (MPN)	12_SB	L2149100-12	22.81	L2149100-02	13.36	L2149100-09	<1	N/A	N/A		GMC
10/5/2021	E.coli (MPN)	06_NB	L2153948-06	184.18	L2153948-02	141.37	L2153948-09	<1	N/A	N/A		GMC
6/20/2022	E.coli (MPN)	01_NB	L2232611-03	261.25	L2127624-06	206.35	L2232611-06	<1	N/A	N/A		BK
7/11/2022	E.coli (MPN)	08-SB	L2236708-05	488.44	L2236708-06	325.54	L2236708-02	<1	N/A	N/A		BK
7/26/2022	E.coli (MPN)	10_SB	L2239743-06	1,299.65	L2239743-07	1,732.89	L2239743-05	<1	N/A	N/A		BK
8/9/2022	E.coli (MPN)	10_SB	L2242701-06	142.09	L2242701-07	107.58	L2242701-05	<1	N/A	N/A		BK
8/24/2022	E.coli (MPN)	04_NB	L2245886-06	1046.24	L2245886-07	1046.24	L2245886-08	<1	N/A	N/A		BK
9/9/2022	E.coli (MPN)	03_NB	L2249101-07	45.68	L2249101-08	34.51	L2249101-05	<1	N/A	N/A		BK
9/23/2022	E.coli (MPN)	03_NB	L2252603-07	51.22	L2252603-08	54.61	L2252603-04	<1	N/A	N/A		BK
10/7/2022	E.coli (MPN)	06_NB	L2255809-01	1732.89	L2255809-02	21,872	L2255809-08	<1	N/A	N/A		BK

6. SEQUENTIAL DATA

The bacteria program has generated quality data that represents qualitative trends in representation of water quality, and quantitative data over both spatial and temporal scales.

Qualitative Findings

- Residential complaints of odor and appearance (Belmont St. Outfall, Coal Mine Brook, Tilly's Brook);
- Lake Avenue Pumping Station SSO overflows; Stormwater discharge from shopping area proximal to Billing's Brook;
- Cyanobacteria suspected at Belmont and UMass tributaries, evidenced by green algal surface layer (October 2022);
- Trash buildup/metal grate blockage (Belmont Street Outfall);
- Beaver dam upstream Meadow Brook (reported by DPW Shrewsbury);
- Organic debris, human trash dumping, possible beaver dam downstream at Tilly's Brook;
- Recreational activities and trash at the tributary (Tilly's Brook, Coal Mine Brook);
- Construction of wastewater pumping station adjacent to O'Hara Brook; and
- Construction of park adjacent to Coal Mine Brook.

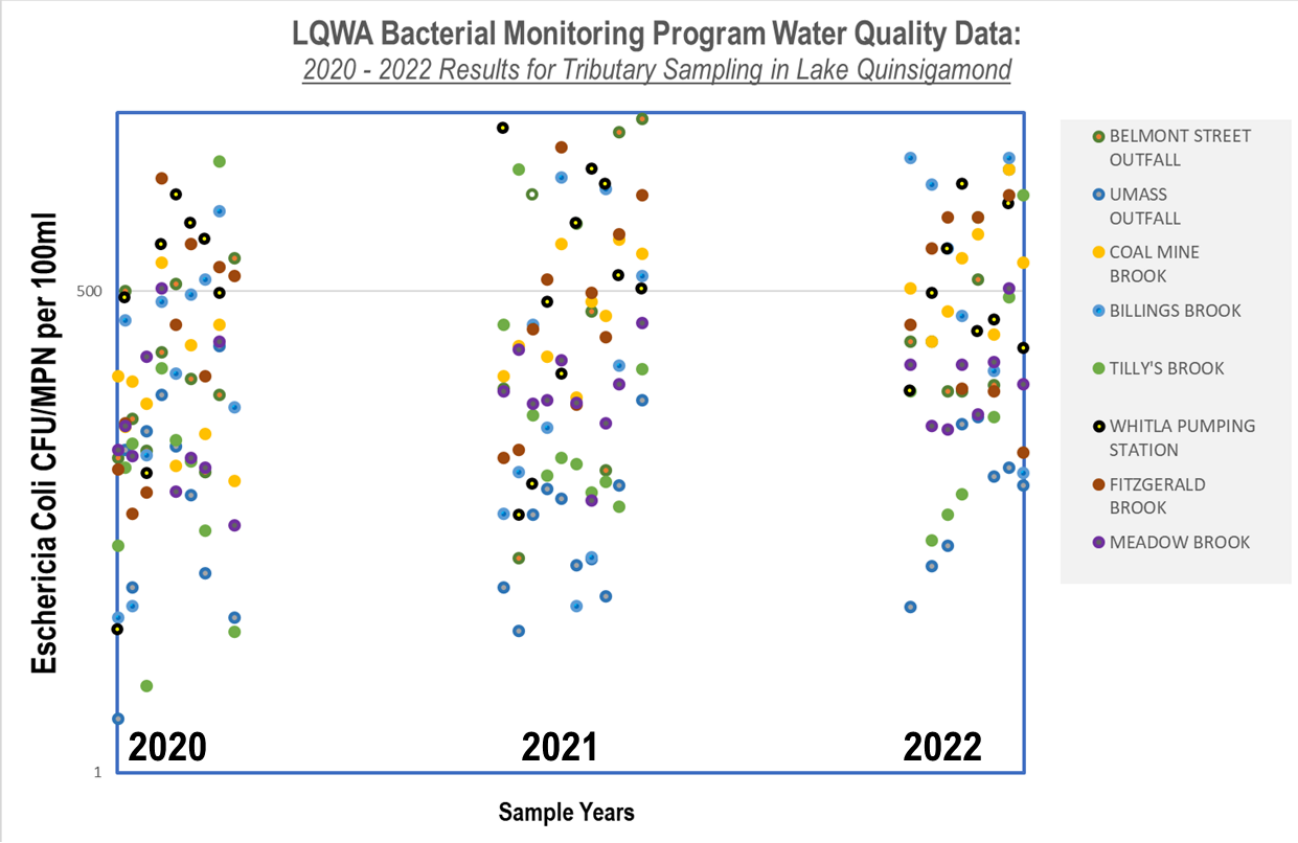


Figure 5: Scatterplot showing E. Coli cfu at each sample location over the course of 2020-2022

3-year data analysis generated a representation of tributaries that had consistent trends of bacteria exceedance[2].

Table 6: Geometric mean ranked highest in the sampling season

GEOMEAN 2020		GEOMEAN 2021		GEOMEAN 2022	
OHARA BROOK	*627.49*	BELMONT STREET OUTFALL	*858.03*	BILLINGS BROOK	*930.68*
FITZGERALD BROOK	*215.51*	COAL MINE BROOK	*557.07*	COAL MINE BROOK	*617.23*
BELMONT STREET OUTFALL	*167.83*	OHARA BROOK	*480.18*	BELMONT STREET OUTFALL	*516.14*
BILLINGS BROOK	*146.04*	FITZGERALD BROOK	*378.21*	OHARA BROOK	*508.08*
COAL MINE BROOK	*139.73*	BILLINGS BROOK	*138.36*	FITZGERALD BROOK	*422.01*

[2] In accordance with CMR4.05 Classes and Criteria (3) Inland Water Classes (a) Class A (4) Bacteria (b) bathing beaches.

All supplemental data is provided separately in a compressed file.

References

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