Ipswich River Watershed 2020 River Health Index

Ipswich River Watershed

The Ipswich River watershed is 155 square miles and includes all or part of 21 communities in northeastern Massachusetts. A watershed or river basin defines the area where rainfall and snow melt will flow to a stream or tributary. This river system supplies water to more than 330,000 people and thousands of businesses, providing all or part of the water supply for 14 communities. The Ipswich River also sustains fish and natural communities, and provides a scenic natural corridor with outstanding opportunities for the residents and eco-tourists to enjoy the great outdoors. The Ipswich River is Massachusetts' most popular paddling destination north of Boston. Understanding watershed systems through monitoring helps us make decisions that keep water clean and keep the Ipswich River and its environment healthy.

Organization Description

The Ipswich River Watershed Association (IRWA) is a non-profit organization incorporated in 1977. IRWA's mission is to protect the Ipswich River, now and for future generations. We work primarily in the 21 communities that are located in or draw water from the watershed. Our primary goals are:

- to ensure that the Ipswich River has enough clean water to provide for people's needs;
- to protect fish, wildlife and nature;
- to preserve the river's natural beauty and outstanding outdoor recreation; and
- to engage the public in protecting the environment

The Ipswich River Watershed Association also administers the Parker-Ipswich-Essex Rivers Restoration Partnership (PIE-Rivers), a coalition of governmental and non-governmental organizations. Consistent, coordinated sampling and management of the three PIE-Rivers systems will address similar pollution issues and improve the quality of water entering the Plum Island Sound and Great Marsh Area of Critical Environmental Concern (ACEC).

Watershed Description

The Ipswich River watershed is an Atlantic coastal plain basin, characterized by low relief, with an average grade of 3 feet per mile. The length of the river is a meandering 40 miles from the headwaters in Wilmington to the mouth of the River in Ipswich Bay. The watershed contains aquifers that are the location for municipal groundwater water supplies. There are also numerous private wells throughout the watershed communities. Major tributaries of the Ipswich River include Lubbers Brook and Maple Meadow Brook in Wilmington, Martins Brook in North Reading, Boston Brook in Middleton, Fish Brook and Howlett Brook in Topsfield and the Miles River in Hamilton and Ipswich. Extensive wetlands are present along the River and streams within the Ipswich River basin. These wetlands protect surrounding areas during flooding as well as positively affect the water quality of the River and streams.

The PIE-Rivers region also includes the Parker River watershed and Essex Bay portion of the North Coastal basin. The Parker River watershed is an 82 square mile coastal river watershed encompassing all or part of nine communities in northeastern Massachusetts. The Parker River begins at the confluence of two unnamed streams in West Boxford and flows approximately 21.3 miles through a rolling landscape to form its mouth at Plum Island Sound in Newbury and Rowley. Major Tributaries of the Parker River include: the Little River, Beaver Brook, Penn Brook, Wheeler Brook, Mill River, Ox Pasture Brook and the Egypt River.

The Essex Bay watershed is primarily in the town of Essex with a minor portion in West Gloucester. Major Tributaries include Alewife Brook which flows from Chebacco Lake, Soginese Creek, Ebben Creek and Walker Creek in West Gloucester.

Water Quality Challenges

Many parts of the watershed experience low flows in summer due to groundwater withdrawals. Water withdrawals deplete streamflow, impairing the rivers' ecology by causing a loss of critical habitat for aquatic life along with an increase in water temperature and a decrease in dissolved oxygen. Critical habitat for fish and other aquatic life occurs along the river bank and in shallow rocky riffle zones. When flows drop below the channel margins, these are the first areas to dry up, after which point the river can be reduced to a series of pools. Fish and other aquatic life become stressed under these conditions and must either move to more suitable areas if possible or perish. Certain species of fish that would normally be expected to be found in the Ipswich River under normal conditions are absent or isolated to certain sections of the river. Unlike fish, benthic, aquatic macroinvertebrates that depend on riffle habitats, cannot move so easily, making them ideal indicators of aquatic life health. Low flows, even for short periods of time can have long-term impacts on aquatic life and the state of the river.

Water temperature directly affects many aspects of water quality. Water temperatures rise in the summer, but low flows will raise temperatures even more. Increased water temperatures in the summer are brought on by low flows and climate change. Studies by the U.S. Geological Survey (USGS) and the Massachusetts Division of Fisheries and Wildlife have found that the Ipswich River's fisheries have been degraded by low-flow problems and the River has experienced a decrease in biodiversity due to the loss of river dependent fish species (Armstrong et al., 2001). The study identified critical aquatic habitats and recommended minimum flows necessary to preserve those habitats.

Monitoring the Ipswich River Watershed

Low flows continue to be a threat to the Ipswich River. In order to assess the health of the Ipswich River, the Ipswich River Watershed Association has maintained the RiverWatch Volunteer Water Quality Monitoring Program since 1997. Volunteers collect data monthly from

March-December on weather conditions, rain in the last 48 hours, water color, water odor, water temperature, dissolved oxygen, velocity, depth, specific conductivity and more recently, chloride. Streamflow and groundwater are also monitored by the United States Geological Survey (USGS) on the river at two gages in South Middleton and Ipswich and a groundwater gage in Wilmington. Three additional streamflow gages are monitored in cooperation with the Massachusetts Division of Ecological Restoration: The Ipswich River in North Reading, Martins Brook in North Reading and Fish Brook in Boxford. Data from these gages have not yet been incorporated into this index, however. A group of dedicated volunteers monitor a total of 35 sites monthly from March to December. Monitoring also includes annual sampling benthic macroinvertebrates (aquatic insect larvae) at 13 sites across the three watershed area. Macroinvertebrate data is also not currently included as part of this index.

The purpose of this report card is to provide as detailed an assessment of water quality for the Ipswich River and major tributaries as possible with available information. Scores are determined by comparing three indicators (water temperature, dissolved oxygen, flow and groundwater) to scientifically based ecological thresholds for aquatic life. These indicators are combined into a single score for sub-regions of the watershed (upper and lower). Sites outside of the watershed as well as tidally influenced sites (IP25, IP26, Egypt River, Alewife Brook, Chebacco Lake inlet and Walker Creek) are evaluated individually based only on dissolved oxygen and temperature data. This river health index is useful in making water quality monitoring results accessible to the public and municipal officials.

River Health Index

A River Health Index can evaluate long-term and recent data on water quality, water quantity, habitat, and human impacts in the Ipswich River watershed. The River Health Index is designed to compare measured conditions with optimal habitat conditions for native fish (based on published tolerances) at the sampling sites over the range of conditions during the year. Conditions accounted for include dissolved oxygen, water temperature, streamflow, groundwater level and percent impervious area.

The river health index score is adapted from the work of OARS (Organization for the Assabet, Sudbury and Concord Rivers). This method focuses on habitat conditions for native fish and is divided into subindices. Dissolved oxygen and temperature data are scored against published fish tolerances and Massachusetts surface water quality standards. (Oregon DEQ, 1995), Massachusetts Water Quality Standards (MassDEP, 2013), EPA recommended criteria (EPA, 1986) and EPA Ecoregion XIV subecoregion 59 data (EPA, 2000). Temperature data are evaluated against the warm water fishery standard, with the exception of Howlett Brook and Gravelly Brook, which are designated as cold-water fisheries and temperature data for these sites are scored against the cold-water fishery standard (Oregon DEQ 1995, McCullough, 1999, McCullough et. al., 2001), Massachusetts Water Quality Standards (MassDEP, 2013), and EPA recommended criteria (EPA 1986). The subindex for streamflow is based on minimum streamflow recommendations needed to support suitable habitat conditions for fish in the Ipswich River as determined by USGS. The groundwater subindex is determined based on a scale of the median, quartile, maximum and minimum of the long-term record.

The streamflow subindices for the upper and lower Ipswich River were developed using data from three measures of streamflow; Tennant, R2Cross, and Wetted Perimeter, and calculations of theoretical natural-flow 7Q10 and August median flows using USGS's StreamStats program. A Tennant method analysis, which sets recommended flows based on analysis of long-term flow records, was conducted on the combined long-term records of two USGS streamgaging stations in the Ipswich watershed (Armstrong, *et. al*, 2001). During summer low-flow periods, minimum streamflows are defined as 40, 30, and 10 percent of the mean annual discharge (QMA); these streamflows create "good," "fair," and "poor" habitat conditions, respectively, according to Tennant (1976). R2Cross and Wetted Perimeter are standard-setting methods based on site-specific physical and hydraulic data.

See Appendix A for the scoring criteria and regression equation used to calculate individual scores.

Each parameter is scored on a scale from 1 (worst) to 100 (best) (table 8). Subindex scores are combined into an overall "Stream Health" index by calculating the harmonic mean. Index scores are broken into five ranges and each range is given a grade and descriptor. Results for dissolved oxygen, temperature and streamflow are combined into two groups: upper and lower watershed, corresponding to the USGS South Middleton and Ipswich gages, respectively. The groundwater index is applied to all sites in the Ipswich River watershed. Sites that are tidal are considered separate, as are the sites in the Essex watershed as well as the Egypt River (figure 1). Upper and lower sections consist of 14 and 15 sites, respectively. There are two tidal sites, three sites in the Essex watershed. Composite scores are averaged by month for each region.

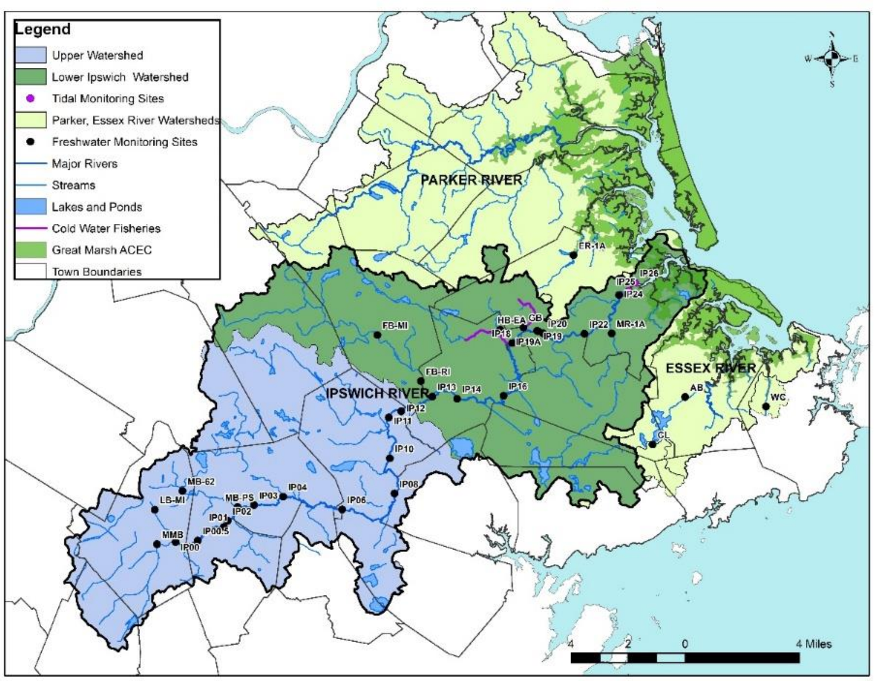

Figure 1. RiverWatch Water Quality Monitoring sites.

River Health Index Results

The following table shows monthly index scores for 2020 calculated from subindex scores for dissolved oxygen, temperature, streamflow and groundwater. Monitoring data are collected by volunteers through the monthly RiverWatch water quality monitoring program. Streamflow and groundwater data are calculated from USGS gages. Gaps in the data are largely due to incomplete monitoring during the Covid-19 pandemic.

2020 River Health Index					
Metrics	DO, Temp., Flow, Groundwater		DO, Temp. only		
Month	Upper Ipswich Watershed Sites	Lower Ipswich Watershed Sites	Tidal Sites	Egypt River Site	Essex Watershed Sites
January	86	90			88
February	88	93			
March	86				
May	73	75	69	70	76
June	24	18	37	41	50
July	32	38	18	32	35
August	0	0	55	23	62
September	0	0	64		50
October	51	64	84	65	66

What do these grades mean?

Index Score Ranges	Steam Health Index Graphic	Grade
80-100	**Excellent**	**A**
60-80	**Good**	**B**
40-60	**Fair**	**C**
20-40	**Poor**	**D**
1-20	**Very Poor**	**F**

A 80-100%: All water quality indicators meet desired levels. Quality of water in these locations tends to be very good, most often leading to preferred habitat conditions for aquatic life.

B 60- 80%: Most water quality indicators meet desired levels. Quality of water in these locations tends to be good, often leading to acceptable habitat conditions for aquatic life.

C 40–60%: There is a mix of good and poor levels of water quality indicators. Quality of water in these locations tends to be fair, leading to sufficient habitat conditions for aquatic life.

D 20–40%: Some or few water quality indicators meet desired levels. Quality of water in these locations tends to be poor, often leading to degraded habitat conditions for aquatic life.

F 0–20%: Very few or no water quality indicators meet desired levels. Quality of water in these locations tends to be very poor, most often leading to unacceptable habitat conditions for aquatic life.

Recommendations

Streamflow restoration will benefit habitat for native fish, including anadromous fish like river herring. Restoration in the Howlett Brook sub-watershed, including restocking herring to Hood Pond, repairing the fish ladder at the Howlett Dam, replacing the fish ladder at the Willowdale Dam will benefit the restoration of river herring to Hood Pond as well as increase the pace of restoration elsewhere in the region. Removal of the South Middleton Dam at Bostik will also restore anadromous fish habitat to the entire upper watershed.

Compliance with water withdrawal permits and registrations should continue to be monitored.

Monitoring of aquatic life use conditions should continue to be tracked through routine sampling for physical and biological indicators. Monitoring of chlorides should be continued to better understand the impact of road salt on water quality.

Monitor bacterial pathogen levels to assess the status of the primary and secondary contact recreation uses. Bacteria sampling should also bracket potential nonpoint sources including agricultural and other potential land use sources.

Monitor target fish communities periodically to assess the impacts of restoration efforts.

Prevent the spread of non-native, invasive aquatic plants through monitoring, education and outreach.

Hold stream cleanup events, distribute crossing signs and maintaining landings and navigation to encourage a sense of ownership and recreational opportunities on the river.

Ways You can Help

Water conservation on the part of individuals continues to be an important part of water management. While conserving water indoors is important, outdoor water use drives demand in the summer months, when the river most needs it.

Turn off your sprinklers. Grass only needs about 1” of water per week, which it will usually get from rainfall even during drier months. You can also switch to fescue grass, a native drought-tolerant variety that not only doesn’t need watering, but comes in varieties that rarely ever need mowing!

Install a rain barrel to collect run-off from your roof to be used in outdoor watering during dry conditions.

Recharge groundwater by replacing lawn with shrubs, trees and native perennials. They create shade, habitat for wildlife and are low maintenance!

Use permeable pavers/pavement for walkways, driveways and parking areas. Leaving even a half inch between paving stones creates space for water to be absorbed into the ground.

Install a dry well or rain garden to let rainwater more quickly enter the ground.

References

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(USGS) United States Geological Survey. South Middleton Flow Gauge Records. http://waterdata.usgs.gov/ma/nwis/uv?site_no=01101500

(USGS) United States Geological Survey. Wilmington Groundwater conditions. http://nwis.waterdata.usgs.gov/nwis/dv?referred_module=gw&site_no=423401071093801

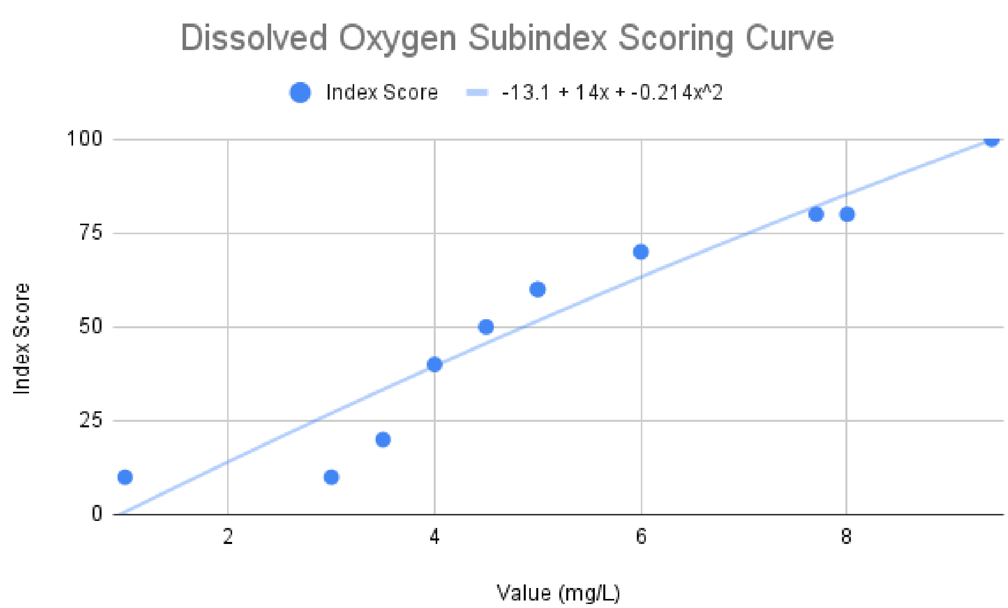
Appendix

A. Dissolved Oxygen Index

The dissolved oxygen index score is based on the following criteria:

Dissolved oxygen scoring curve for warm-water fisheries with DO < 100% saturation	Value (mg/L)	Index Score
acute mortality for crappie (Oregon DEQ 1994)	1	10
acute mortality (EPA 1986), critical oxygen tension for largemouth bass (Oregon DEQ 1994)	3	10
Severe impairment (EPA 1986)	3.5	20
Moderate impairment (EPA 1986)	4	40
swimming performance reduced in largemouth bass (Oregon DEQ 1994)	4.5	50
Slight impairment (EPA 1986)	5	60
Massachusetts Water Quality Standards for warm-water fisheries	5	60
No impairment (EPA 1986), reduced growth rates in bass (Oregon DEQ 1994)	6	70
25th percentile calculated from Ecoregion XIV subregion 59 data (June - Sept)	7.7	80
onset of O2-dependent metabolism in brown bullhead (Oregon DEQ 1994)	8	80
75th percentile calculated from Ecoregion XIV subregion 59 data (June - Sept)	9.4	100

The equation for calculating the dissolved oxygen concentration subindex is:
y= -13.1+14x+-0.214x^2 where x is the dissolved oxygen concentration value

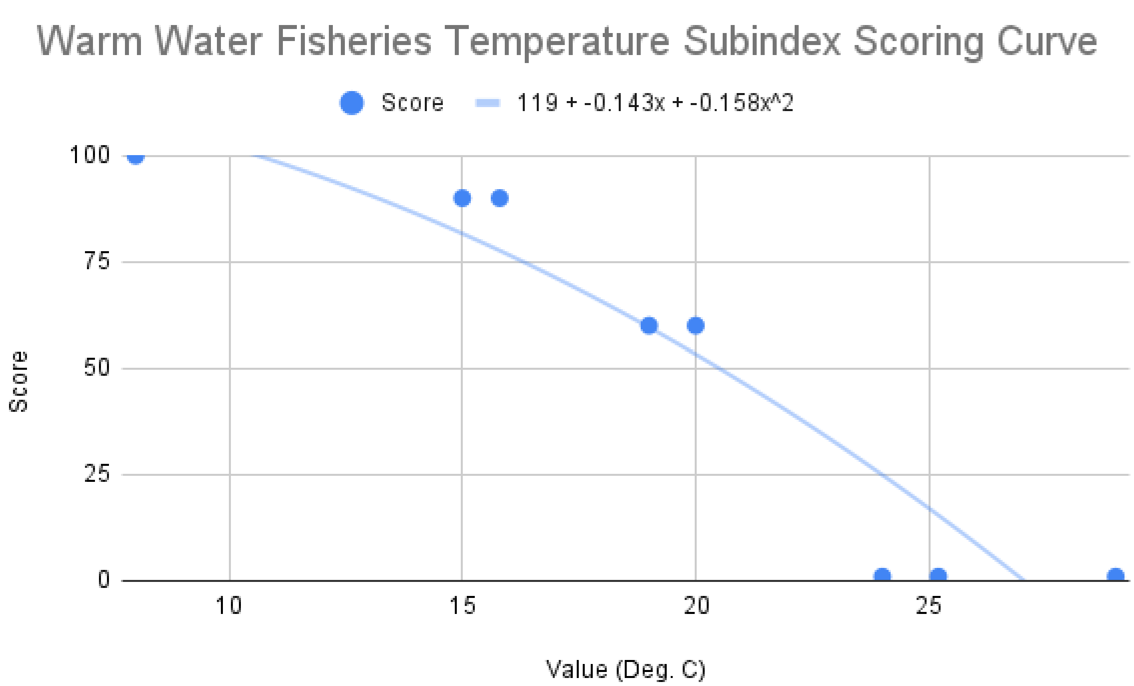


B. Temperature index score

a. The temperature subindex score is based on the following criteria for warm water fisheries

Temperature scoring curve for warm-water resources	Value (Deg. C)	Score
Mass WQS cold (Mass WQS 1993)	20	100
maximum for growth in black crappie (EPA 1986)	27	60
Mass WQS for warm water fisheries (Mass WQS 1993)	28.6	50
maximum for growth of largemouth bass (EPA 1986)	32	20
maximum for survival of largemouth bass (EPA 1986)	34	1

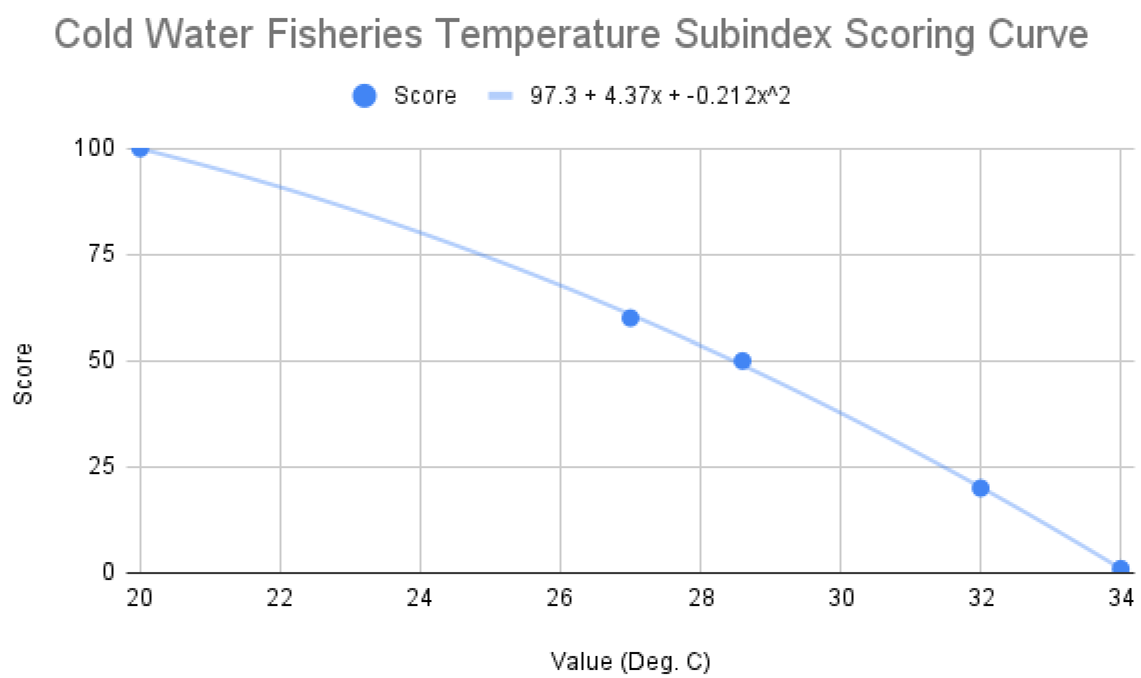
The equation for calculating the warm water fisheries temperature subindex is: 119+ -0.143x + -0.158x^2 where x is the temperature value



b. The temperature subindex score for cold-water fisheries. In the case of Howlett Brook and Gravelly Brook, the cold water fisheries criteria can be applied.

Description & Citation	Value (Deg. C)	Score
excellent condition (Hallock 2001)	8	100
average optimum for growth of brook trout (McCullough 2001)	15	90
average optimum for growth of rainbow trout (McCullough 2001)	15.8	90
maximum for growth of brook trout (EPA 1986)	19	60
Mass WQS cold water fisheries	20	60
maximum for survival of rainbow and brook trout (EPA 1986)	24	1
maximum for survival of brown trout (McCullough 1999)	25.2	1
maximum for growth of blacknose dace & yellow perch (EPA 1986)	29	1

The equation for calculating the cold water fishery subindex score is:
$y=97.3+4.37x+-0.212x^2$ where x is the temperature

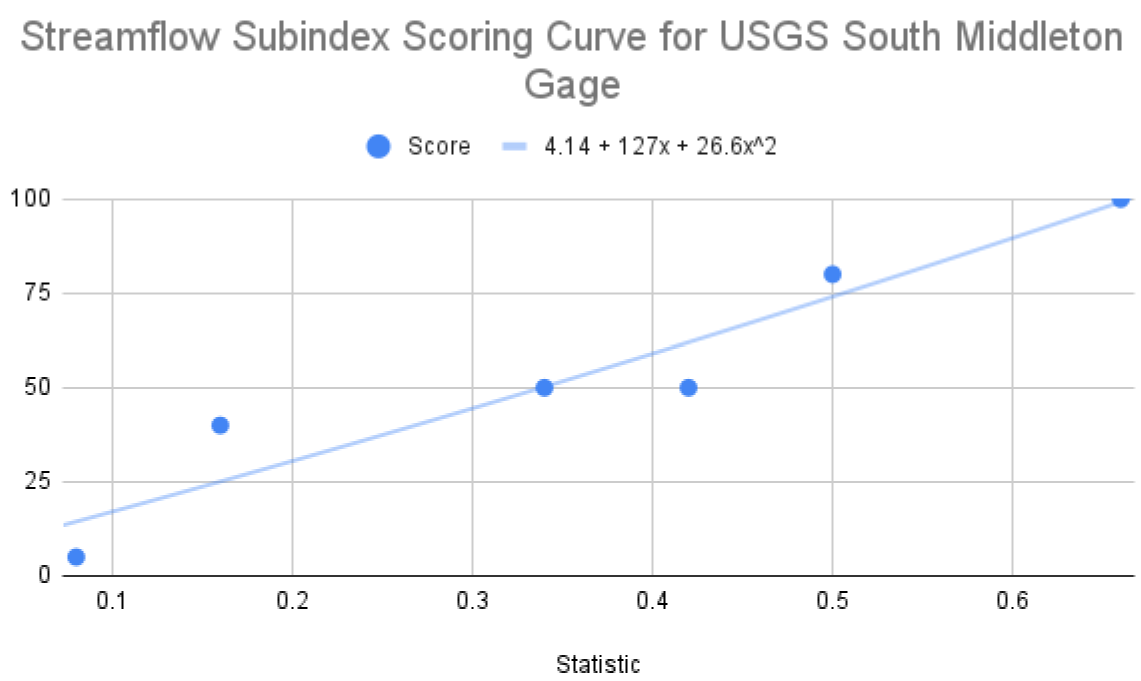


C. Streamflow subindex scoring method

a. The USGS South Middleton streamflow gage is applied to the subindex score for sites in the upper watershed

The equation for calculating the streamflow subindex score at USGS South Middleton gage is y= 4.14+127x+26.2x^2 where x = streamflow in cfsm.

Flow (cfsm) from USGS study	Flow cfs (cfsm*drainage area)	Statistic	Score
0.66	29.37	Tennant 40%	100
0.5	22.25	Tennant 30%	80
0.42	18.69	Wetted perimeter	50
0.34	15.13	August median flow	50
0.16	7.12	Tennant 10%	40
0.08	3.56	7Q10	5

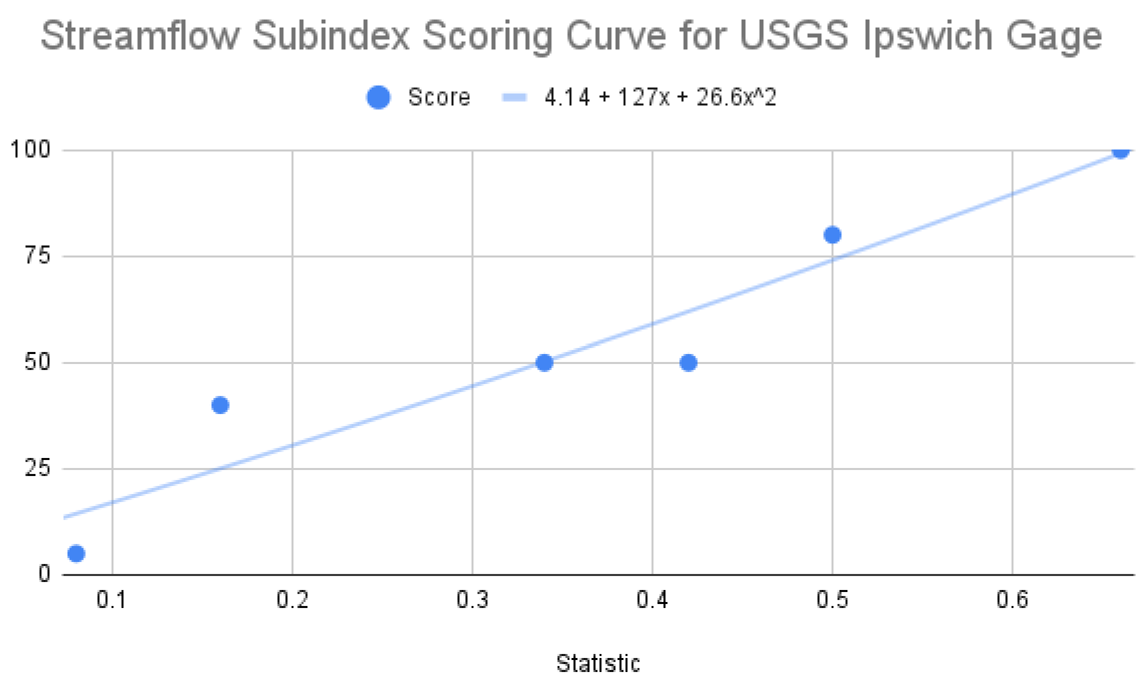


b. The USGS Ipswich gage is applied to the subindex score for lower watershed monitoring sites.

The equation for calculating the streamflow subindex score at the USGS Ipswich gage is:

y= 4.14+127x+26.2x^2 where x=streamflow in cfsm.

Flow (cfsm) from USGS study	Flow cfs (cfsm*drainage area)	Statistic	Score
0.66	82.5	Tennant 40%	100
0.5	62.5	Tennant 30%	80
0.42	52.5	Wetted perimeter	50
0.34	42.5	August median flow	50
0.16	20	Tennant 10%	40
0.08	10	7Q10	5

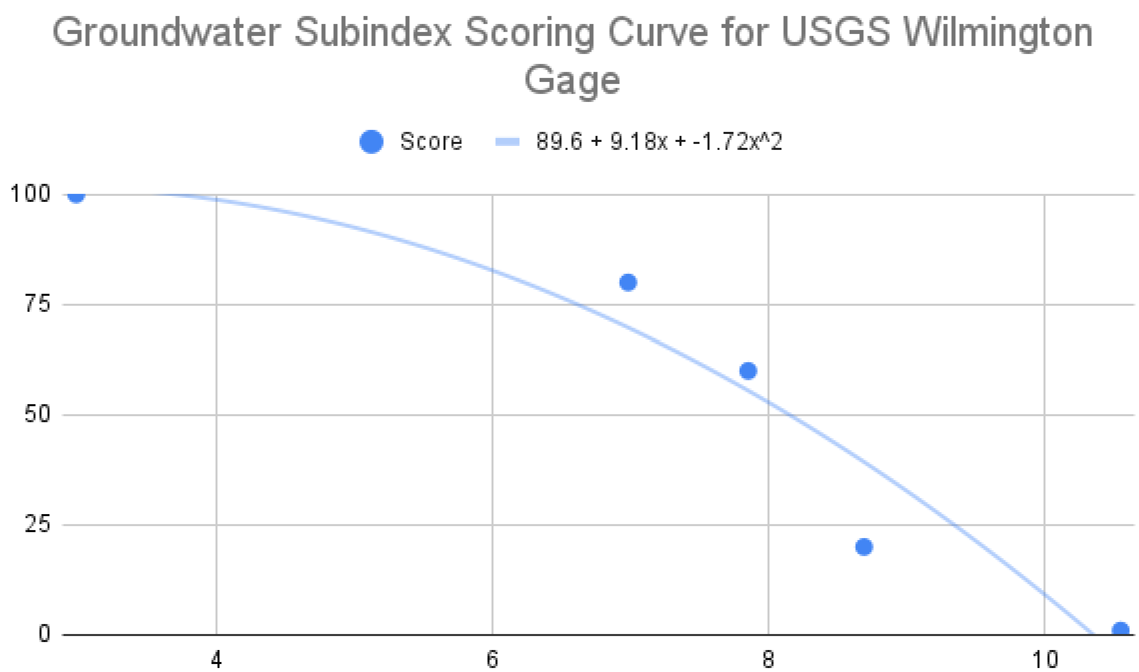


D. USGS Wilmington groundwater gage subindex scoring method.

The equation for calculating the groundwater subindex score at the USGS Wilmington gage is:

$y=89.6+9.18x+-1.72x^2$ where x=depth to groundwater

Scoring Criteria	Depth to groundwater	Score
Minimum of record	2.98	100
25^{th} Percentile	6.98	80
Median	7.85	60
75^{th} Percentile	8.69	20
Maximum of record	10.55	1



E. Total Impervious Area Subindex Scoring Method

a. This subindex is used relative to the following sub-watersheds in addition to the upper and lower Ipswich sub-watershed areas.

Sub-watershed Area	Percent Impervious Cover (TIA%)
Alewife Brook	5.1
Egypt River	9
Fish Brook	8
Gravelly Brook	3.6
Howlett Brook	7.4
Upper Ipswich	12.8
Lower Ipswich	10.9
Lubbers Brook	17.3
Martins Brook	14.9
Maple Meadow Brook	20.4
Miles River	9.9
Walker Creek	5.9

b. The equation for calculating the total impervious area subindex score is:

i. $y = -1x*100$ where x is the total impervious area for delineated subwatersheds