Ipswich River Watershed Association

1997 Low Flow / No Flow Study

The IRWA Staff Gauge in the Reading Town Forest, 9-12-97

51 S. Main Street - PO Box 576
Ipswich, MA 01938
978.356.8939 978.356.8958 (f)

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Throughout the summer and fall of 1997, the Ipswich River experienced a severe low-flow, no-flow episode. In order to determine the relationship between the low flow situation and drinking water withdrawal areas a total of ten sites were monitored by the Ipswich River Watershed Association's Stream Team and Monitoring Coordinator between August 12th and November 7th of 1997. Sites were also monitored on April 7th, 1998. Sampling sites were located upstream of, within, and downstream of water withdrawal locations in both Wilmington and Reading. In addition, four control sites were monitored: one in Reading, one in Wilmington, and two in Boxford. Sites were monitored one to two times per week for: Dissolved Oxygen, Air and Water Temperature, Depth, Velocity, and Flow. A picture log of all sites was also maintained.

WILMINGTON

The most startling example of the effects of water withdrawals on the surface waters of the Ipswich River basin occurred in Wilmington on the tributary streams. Sawmill Brook flowed under Chestnut Street upstream of the Wilmington wells throughout the summer. As Sawmill flows downstream, it merges with Maple Meadow Brook and passes through the Wilmington Chestnut Street / Butters Row Wellfields. Maple Meadow Brook as it crossed through the Old Middlesex Canal Bridge in the Town Park near the wellfields was dry at every sampling date, except for April 7, 1998. Downstream on Maple Meadow at the Route 38 Bridge, the surface water of Maple Meadow Brook flowed backwards (upstream) at every sampling date, again excepting the April 7th, 1998 date. Thus there was flowing water at a location upstream of the well withdrawals, no water in the vicinity of the withdrawals, and reverse flow at a location downstream of the withdrawals. In the graph on the next page you will find a flow versus time and rainfall graph for these three sites. Rainfall data was obtained from the Reading Waste Water Treatment Plant.

As can be seen from the graph, there was a noticeable increase in flow after rainfall. After both the August 21st and September 12th storms, the rate of flow increased at Chestnut Street. At Route 38, there was increased reverse flow in response to the rainfall on these two dates. There was no response to rainfall at the Wilmington Town Park site, located within the wellfields.

When the flow data acquired on the April 7th, 1998 monitoring date is analyzed:

Site	Flow (cfs)
Sawmill Brook at Chestnut Street	7.913
Maple Meadow Brook at Wilmington Town Park	7.018
Maple Meadow Brook at Route 38	7

one can see that there is a strong correlation between the flows at the sites before, within, and after the wellfields. In fact, the flow values obtained were almost identical as one moved down the stream. This springtime flow provides a strong counter-example to the reverse flow phenomenon seen during the summer and fall months.

Another point of interest within the data collected in Wilmington is that Dissolved Oxygen was lower than the Class B Water Quality Standard of 5.0 mg/L at a significant number of the summer / fall sampling dates. A summation of the Dissolved Oxygen data is listed below:

SITE	Range of Summer / Fall DO Values (mg/L)	April 7th, 1998	Number of Samples below Class B Waterbody Standard
Sawmill Brook at Chestnut Street	2.16 - 7.14 Average: 4.048	10.7	11 samples of 14 below standard
Maple Meadow Brook at Wilmington Town Park	No water to sample.	9.05	No water to sample.
Maple Meadow Brook at Route 38	2.11 - 6.82 Average: 4.025	8.05	9 samples of 12 below standard
Mill Creek at Adams Street (Control Site)	4.04 - 7.98 Average: 5.653	9.24	5 samples of 13 below standard

As can be seen, Dissolved Oxygen was very low at both the Route 38 and Chestnut Street sites. The average DO level at the control stream was over 1.5 mg/L higher than either Chestnut Street or Route 38. In April, however, DO was healthy at all locations. The lower depth and corresponding higher temperatures of water that result from a water withdrawal area work to lower the oxygen content of the streams, and prevent the maintenance of healthy fish and wildlife habitat.

READING

Reading provides another example of an area severely affected by the low-flow, no-flow situation in the Ipswich River. Upstream of the wellfields, at Route 93, there was ponded, but not flowing, water throughout the monitoring season. At the wellfields, in the Reading Town Forest, there exists a very large cut out section of the river where the main channel is approximately 300 feet wide as a result of soil excavation by a sand & gravel operation earlier this century. That area was completely dry most of the summer, although some days there was a small amount of water in the deeper main channel sections. Downstream of the wellfields at Mill Street in Reading, there was ponded, not flowing water throughout the summer. The fact that Mill Street went from ponded and not flowing in the summer / fall, to a swiftly flowing stream of 407.64 cfs of flow in April is a strong indicator of the effects of water withdrawals on surface water in the Ipswich.

On the next page you will find a graph that shows the variation of the widths of the river at Route 93, before the wellfields, and at the Reading Town Forest, in the wellfields, versus rainfall and time. As can be seen, the width of the Rte. 93 site was fairly constant, and showed slight rises after rainfall. In the town forest, however, the only time water was there was right after a rainfall. Downstream of the wellfields width was not a measurable quantity because there was no water under the bridge at all, and thus it is not included within this graph. The fact that there was always water present at Rte. 93, as

opposed to in the Town Forest where the wellfields are, shows that there is significant surface water effects from the Reading Wellfields on the Ipswich River.

As in Wilmington, Dissolved Oxygen samples were often below the Class B waterbody standards within the Reading sites. The table below details DO results:

SITE	Range of Summer / Fall DO Values (mg/L)	April 7th, 1998	Number of Samples below Class B Waterbody Standard
Ipswich River at Route 93	2.14 - 4.44 Average: 3.203	6.5	11 of 11 samples below standard
Ipswich River at Reading Town Forest	2.61 - 6.03 Average: 4.51	6.38	2 of 5 samples below standard
Ipswich River at Mill Street	0.52 - 4.05 Average: 2.459	9.21	13 of 13 samples below standard
Bear Meadow Brook at Haverhill Str. (Control)	3.46 - 5.0 Average: 4.22	6.84	2 of 3 samples below standard

As can be seen, DO levels were extremely low in the summer / fall months in all of the Reading sites. Ironically, DO levels were highest where there usually was no water (in Bear Meadow Brook and in the Reading Town Forest). This can be explained with the understanding that when there was water in those sites, it was because it had previously rained, and DO levels were high due to the agitation involved in rainfall.

CONTROL SITES

A total of three tributaries with no known water withdrawals in their basins were monitored to provide control data. In Reading, Bear Meadow Brook was monitored. In Wilmington, Mill Creek was monitored. And outside of those towns, Boston Brook was monitored at two sites in N. Andover and Middleton. The next few paragraphs will summarize the information gathered from the monitoring of these sites in comparison to the water withdrawal sites.

Mill Creek in Wilmington had water in it at each monitoring date throughout the summer and fall. The flow varied from 0.0 to 1.037 cfs during that time. The creek always looked about the same, and depending on rainfall flowed less or more. When revisited in April of 1998, Mill Creek still looked about the same. It was approximately a foot deeper, but its velocity was 0.59 fps, well within the range of velocities seen in the summer / fall period. In summary, Mill Creek seems a canonical example of a "normal" stream: it goes down in the summer and back up in the spring. This stream is a far cry from the dramatic difference seen in the Route 38 (reverse flow to downstream flow) and Town Park (no water to flowing stream) sites from the summer / fall period to the spring period, and shows a stream without water withdrawal effects behaving in the expected normal manner in Wilmington.

Bear Meadow Brook in Reading never flowed at any of the monitoring dates. It, in fact, only had water in it on three monitoring dates in the summer and fall, and then again on April 7, 1998. Even in April it was flowing only an unmeasurable slight flow. Given the lack of water at most times, and lack of flow at all times, this creek seems extremely sensitive to rainfall, and to serve as primarily stormwater storage in the area we

monitored. Bear Meadow Brook most closely resembled the Reading Town Forest site in its responses over time. At Route 93, there was ponded, non-flowing water in both summer / fall and in April. In Reading Town Forest there was no water in summer / fall and ponded water in April. Downstream of the wellfields at Mill Street there was no or little non-flowing water during the summer / fall and quickly flowing water in April. The dramatic difference between the Mill Street site in the summer / fall and April is the strongest proof of the effects of the Reading wellfields on the Ipswich River.

Boston Brook in North Andover and Middleton was monitored at two sites, one on Sharpner's Pond Road and one at the Essex County Greenbelt Association's Footbridge near N. Liberty Street. The Sharpner's Pond Road site looked very similar in the summer / fall and in April. It did not flow at all in the summer / fall, and only flowed very slightly (0.76 fps velocity for 30.81 cfs of flow) in April. In April the brook was about 1 foot higher than it was on average in the summer / fall. Like Mill Creek in Wilmington, it seemed a canonical example of a normal stream. In contrast, however, downstream of this site, at the footbridge, there was no water all in the summer / fall, until November 7th, 1997. On November 7th there was a rushing brook that looked much the same when revisited in April. The reasons for this sudden reappearance of brook need to be further investigated.

The control streams monitored for this project show the diversity of streams within the watershed. Both Mill Brook and Boston Brook in North Andover act as a normal, non water withdrawal influenced stream would be expected to act over the seasonal changes within a year. Bear Meadow Brook, on the other hand, acts not so much as a brook at this location, but more as a stormwater retention area. Boston Brook at the footbridge acts in a way that needs to be further investigated. None of these streams, however, show the dramatic changes seen in the two sites downstream of the wellfields in Reading and Wilmington: changing from no water to rushing stream, and changing from reverse flow to flowing downstream stream, respectively.

CONCLUSION

As can be seen in the above data report, there was a significant effect on surface water in the Ipswich River and its tributaries due to water withdrawals in Reading and Wilmington in the summer / fall of 1997. Reductions in flow, unhealthy levels of dissolved oxygen, and reductions of habitat due to dry stream beds were all direct results of water withdrawals. The study design of comparing sites upstream of, in the vicinity of, and downstream of the withdrawal sites shows the relative effect of water withdrawals on the river and its tributaries, independent of drought conditions. Water conservation strategies, and alternative supplies and other changes in water management should be investigated and implemented in order to ameliorate the surface water effects of water withdrawals in the Reading and Wilmington area.

APPENDIX A: PARAMETERS & METHODOLOGY

All parameters were sampled by the Monitoring Coordinator using the methods detailed in the IRWA's Monitoring Manual (copy available on request). Briefly, equipment and methodologies used are outlined below:

Air Temperature: was measured using Enviro-safe® Celsius Thermometers. Results were rounded to the nearest half degree.

Water Temperature and Dissolved Oxygen: was measured using a YSI 55 dissolved oxygen meter. Membranes were changed on a regular basis. Readings were allowed to stabilize for 3 -5 minutes. Water Temperature was also measured on a thermometer to provide comparison at certain sampling times. No noticeable differences were noted.

Depth: was measured using a rope marked off at six inch intervals with a weight attached to the bottom.

Velocity: was measured using orange peels or twigs and a stopwatch. The average of three runs was used as the velocity.

Flow: was calculated by multiplying cross-sectional area by velocity. See site summaries for details on how cross-sectional area was determined at each site.

APPENDIX B: SITE SUMMARIES

A total of ten sites were monitored throughout the sampling season. Below you will find descriptions of: why the location was chosen, where the site is, and any notes about sampling methodologies in that location.

Chestnut Street Bridge crossing of Sawmill Brook, Wilmington

Selected because it is located upstream of the well withdrawals in the Chestnut Street / Butter's Row Wilmington Wellfields, the Chestnut Street site was monitored on the upstream side of the roadway bridge. The stream is culverted through two 36" RCP pipes as it flows under the roadway. Flow was calculated by measuring velocity and depth in the field in the left pipe (looking U/S). Using geometric equations, the cross sectional area of the pipe was calculated, and multiplied by velocity to determine flow. The final answer was then doubled in order to account for both of the 36" pipes.

Old Middlesex Canal Bridge crossing of Maple Meadow Brook in the Wilmington Town Park, Wilmington

This site was selected because of its proximity to the wellfields in the Wilmington Town Park. Sampling was done on the upstream side of the remains of the Old Middlesex Canal, near a small staff gauge. There was no flow here throughout the monitoring period, except for April 7, 1998 when flow was measured from a small constructed footbridge on the U/S side of the canal crossing. One issue of note in the Wilmington sites is that prior to the Old Middlesex Canal crossing, Sawmill Brook flows into Maple Meadow Brook. The portion of Maple Meadow Brook before the confluence with Sawmill Brook was not monitored due to both time and access constraints, so it is unknown whether there was also flow in Maple Meadow Brook before the wellfields where it was dry. If there was water in Maple Meadow Brook before the confluence with Sawmill Brook, then the Wilmington Butter's Row / Chestnut Street wellfields would be drying up even more flow than we present here.

Route 38 crossing over Maple Meadow Brook, Wilmington

This site was selected because of its location immediately downstream of the Town Park and wellfields, and was monitored on the natural downstream side of the Route 38 bridge.
During the monitoring period, when the flow here was running in the upstream direction, flow was measured in a small rivulet between the ponded area downstream of the bridge and the bridge itself. This small rivulet ran upstream at all of the monitoring dates except for April 7, 1998, when the river was flowing in the downstream direction.

Adams Street Bridge crossing over Mill Brook, Wilmington

This site was the control site for Wilmington. As far as we know, there are no water withdrawals along Mill Brook. Monitored on the downstream side of the Adams street crossing.

Route 93 crossing of the Ipswich River, Reading

Chosen because of its directly upstream of the Reading Town Forest Wellfields location, Route 93 was sampled directly at the downstream side of the Route 93 culvert. Although there was never any documented flow here, including in April, the width of the river was measured at each monitoring date to provide comparison of the amount of surface water retained.

Staff Gauge, Reading Town Forest, Reading

Chosen because of its location within the Reading Water Treatment Plant and the Reading wellfields forest land, the Reading Town Forest site was monitored at the location of the IRWA Staff Gauge installed by the Reading Stream Team. Here, the river bed has been cut out by an old sand and gravel company and the "main channel" is virtually non-existent, replaced by an approximately 500 foot wide ponded area. Although there was never any flow here, including in April of 1998, when there was water ponded in this area, the width of the ponded water in the channel area the Gauge is within was measured to provide comparison of the amount of surface water retained. Also, depth (based on the staff gauge) was reported as a comparison parameter.

Mill Street Crossing of the Ipswich River, Reading

This site was chosen because it is downstream of the Reading Wellfields, and it is one of IRWA's RiverWatch monitoring sites. Although there was never any flow in this location, except for on the April 7, 1998 monitoring date, the depth of the river at the upstream side of the bridge was measured for comparison. On a few occasions when the depth of the river at the bridge was 0 and there was ponded water upstream of the bridge, samples were taken from the pond upstream of the bridge, and the width of that pond was

recorded. Flow was calculated on April 7, 1998 by measuring velocity and depth in the field. Cross sectional area was determined using a cross section provided by the RiverWatch monitoring volunteers.

Haverhill Street Crossing of Bear Meadow Brook, Reading

Bear Meadow Brook was Reading's control site. Samples were taken from the downstream side of the Haverhill street bridge. Although there was only flow in this location on April 7, 1998, depth was measured at each monitoring date in order to provide comparison data.

Sharpner's Pond Road crossing of Boston Brook, Middleton

Boston Brook was monitored as another possible control stream in the watershed. Sharpner's Pond Road is upstream of the Essex Greenbelt Bridge location and samples were taken from the upstream side of the bridge. Although there was no flow under the bridge until the April 7th 1998 monitoring date, depth was recorded as a comparison parameter.

Essex County Greenbelt Footbridge crossing (off N. Liberty Street) of Boston Brook, Middleton

Downstream of the Sharpner's Pond Road crossing, this site was dry except for the November 7, 1997 and April 7, 1998 monitoring dates. Samples were taken from the upstream side of the footbridge. This was to act as another control site within the watershed.

Appendix C: Data