2013 Smelt Monitoring Report

Town Brook
Quincy Massachusetts

Submitted to

City of Quincy
Planning and Community Development Department

By:

URS Corporation
101 Federal Street, Suite 1000
Boston, MA 02110

Lucas Environmental, LLC
67 Coddington Street, Suite 204
Quincy, MA 02169

April 2014

Table of Contents

TOWN BROOK MONITORING NARRATIVE (2013)

1.0 INTRODUCTION

The Town Brook Enhancement project entails the realignment of 1,700 linear feet of primarily culverted river from Quincy Center to a new location. The new alignment consists of approximately 1,200 linear feet of stream channel of which approximately 264 linear feet will be open channel, proposed as smelt spawning habitat (See Figure 1 – Site Location Map). The 2013 monitoring program follows the Town Brook Enhancement Project Monitoring Plan with a focus on rainbow smelt (*Osmerus mordax*) in Town Brook. This report has been prepared to document the requirements described in the monitoring plan.

2.0 BACKGROUND

The Town Brook Enhancement Project Monitoring Plan ("Protocol") was prepared by URS in conjunction with Lucas Environmental, LLC in February 2013, revised April 2013, per the requirements of the Final Order of Conditions ("FOC") and Water Quality Certification ("WQC") for the Town Brook Enhancement Project (MassDEP File No. 59-1261). The purpose of the Protocol was to identify the monitoring program to be implemented for the 2013 through 2015 smelt spawning seasons within Town Brook. The monitoring program includes several components consisting of water quality sampling, flow measurements, smelt egg assessment, and wetland planting monitoring as outlined in the Protocol.

The FOC and WQC have several requirements for the monitoring program that the City of Quincy is required to implement upon completion of the diversion of Town Brook into the newly constructed channel. The new channel construction was completed and the Town Brook flows were diverted from the existing culvert into the new alignment on March 8, 2013. Discussions with the Division of Marine Fisheries (DMF) were initiated following the diversion to finalize the Protocol and begin the monitoring program. The Protocol was initiated during the week of March 25, 2013 based upon these discussions and verbal acceptance of the Protocol by the DMF, pending submittal and review of the Protocol and reporting requirements.

3.0 SPECIAL CONDITIONS

As noted in the WQC and FOC, the City of Quincy is required to implement specific monitoring programs within the Town Brook channel as described in the Protocol. The special conditions are outlined below in italics with the current status of each, documenting the City's compliance with each condition.

WQC #40/FOC #51

A permanent staff gage shall be installed at the inside of the stream bend to assist in monitoring sediment accumulation. A gage or benchmark shall be placed along the outside of the stream bend to assist in monitoring for scour. The staff gage(s) should be installed so as to be visible from street level.

Two staff gages were installed during the 2013 season.

WQC #41/FOC #52

The bordering vegetated wetland (BVW) island shall be monitored by the Environmental Monitor or qualified designee for success of plantings as well as for scour or deposition

of materials, including both sediments and debris. Failed plantings shall be replaced with similar species as approved by MassDEP. A monitoring report shall be submitted to MassDEP at the beginning and end of each growing season for three years and shall include recommendations for replacement, as required.

A wetland monitoring program is included in the Protocol and discussed in the report.

WQC #42/FOC #53

The applicant shall submit a proposal for a smelt monitoring study to DMF for review and approval. The study shall include three years of monitoring and shall incorporate 2-3 site visits per week between March 1st and May 31st of each monitoring year. The proposal shall include (1) documentation of the spatial and temporal distribution of smelt eggs, (2) sediment accumulation, water depth, and velocity shall be measure at each inspection at the daylighted spawning riffles, resting pools and at the stream bend, and (3) water quality (including dissolved oxygen and temperature) and effectiveness of the fish exclusion barrier shall be monitored.

A smelt monitoring program has been incorporated into the Protocol as documented in the following sections. The program consists of three components as discussed with DMF in the field in late March 2013. The program includes documentation of the spatial and temporal distribution of smelt eggs and the sediment accumulation, water quality, water depth, and velocity at specific locations. The 2013 monitoring season has been completed.

WQC #43/FOC #54

The applicant shall submit a channel monitoring plan in order to identify the development of any scour pools, perched conditions, invert drops or any other obstructions to fish passage, especially at the transition between the new section of channel and the exiting channel just south of Revere Road. If any obstructions to fish passage are observed, a remedial action plan shall be submitted to MassDEP and DMF within 30 days of the identification of the obstruction that will avoid or reduce impact to fish movement.

At this time, smelt have been observed in Town Brook and eggs identified in large numbers west of Mechanic Street. The City will prepare a monitoring plan at the request of the DMF if any issues are identified during the weekly monitoring for the measures outlined in WQC #43/FOC #54. No issues have been identified to date.

WQC #44/FOC #55

The applicant shall submit a remedial action proposal in the event that DMF concludes that the channel's design specifications are not met and, as a result, significant smelt egg or adult mortality results. This remedial action proposal shall be submitted to MassDEP and DMF for review and approval with the time set forth in the notice to the applicant that a remedial action plan is required.

The City will submit a remedial action plan if required by DMF due to channel design specifications not meeting the designed requirements or resulting in smelt egg or adult mortality. No such plan has been required to date.

WQC #45/FOC #56

The structural integrity and capacity of the banks, including the wall on Parcel 90, and channel of both the realigned portion of Town Brook and the downstream portion of the

brook within the project area, being integral to protection of flood control, storm damage prevention and protection of fisheries, shall be maintained. This shall include, but is not limited to, maintenance of the channel bottom to address sedimentation, preservation of the spawning substrate, and prevention of any conditions that may serve as an obstruction to fish passage as long as the fish continue to return to Town Brook. In addition, all vegetative plantings shall be maintained. This on-going condition shall be included in any Certificate of Compliance and shall not expire with the issuance of a Certificate of Compliance.

The City of Quincy will continue to maintain the Town Brook as required in the FOC and WQC and according to the protocol for the 2013 smelt spawning season.

WQC #46

The applicant shall have an on-going responsibility to operate and maintain the approved flow augmentation alternatives consistent with their design in order to ensure protection of the fish run and spawning habitat.

The Preliminary Design of Flow Restoration in Town Brook (March 2011) details the flow augmentation plan the City proposed and completed during 2013 as reviewed by MassDEP, DMF, the U.S. Army Corps of Engineers (USACE), and the Department of Conservation and Recreation (DCR).

FOC #57

Once achieved, flow augmentation shall be on-going to ensure protection of the fish run and spawning habitat. This on-going condition for protection of fisheries shall be included in any Certificate of Compliance and shall not expire with the issuance of a Certificate of Compliance.

The City will continue to operate and maintain the flow augmentation, under WQC #46.

4.0 WETLAND MONITORING PROGRAM

Monitoring of the replication area within the small island in the open section of Town Brook will be performed by a qualified individual to ensure successful plant establishment. The first inspection took place upon completion of the replication area during the 2013 growing season. The second inspection will take place at the end of the 2014 growing season. The monitoring reports will be prepared and submitted to MassDEP and will describe the work completed and vegetation within the designated area as well as any action to be taken to repair, restore, or replant the area if needed. After the inspections, the Contractor will replace all plants that have not become established and re-seed areas that have not reached the desired 75% percent cover of native vegetation.

If conditions develop that impede the success of the replication efforts, corrective action shall be taken. If the required corrective measures are minor in nature, including additional erosion controls, removal of undesirable invasive plants, or minor re grading/re-seeding, then the work shall be performed as required and MassDEP will be notified within 14 days.

WQC #41/FOC #52 require monitoring reports at the beginning and end of each growing season. Under the Protocol, two monitoring reports are recommended each year, the first report to be prepared and submitted after the spring portion of the growing season. The second report will be completed after the

growing season has ended. The reports will be prepared as noted above for three years beginning in 2013 and ending by December 2015.

Wetland plantings occurred in the fall of 2013, after the first monitoring season for smelt. Due to the season of planting, no vegetation was observed during the 2013 monitoring season. It is expected that vegetation will be present beginning in the spring of 2014. At that time, if corrective measures are necessary, as stated above, MassDEP will be notified.

Invasive Plant Control

The site will be monitored to ensure invasive species do not become established. In order to prevent the establishment of invasive species, such as honeysuckle, Japanese knotweed, purple loosestrife, Oriental bittersweet, or other invasive plant species, the following protocol is recommended. Any control method used should be repeated for several years to catch missed plants and those re-establishing from seed.

Hand digging and pulling is effective for small, young plants, especially those rooted in loose soil. The entire root must be removed to prevent re-sprouting. However, older plants are generally too big for pulling and are difficult to dig up and may be eradicated through a combination of clipping and herbicide application. Excessive soil disturbance should be avoided and native vegetation should remain in place to the greatest extent possible to avoid creating bare areas for future propagation and allow native vegetation to re-colonize sites. Plants should be removed prior to the onset of seeds. All plant parts will be bagged, removed and placed in proper containers for garbage pickup. Due to the small area of wetland creation, hand digging will be the most effective method to prevent the establishment of invasive species in addition to the proximity to water, therefore herbicide application is not recommended for this site.

5.0 SMELT MONITORING STUDY

Methodology

The Smelt Monitoring Study consists of three components: 1) documentation of the spatial and temporal distribution of smelt eggs, (2) sediment accumulation, water depth, and velocity measurements, and (3) water quality monitoring to comply with WQC Special Condition #42 and FOC Special Condition #53. URS and Lucas Environmental, LLC (LE) qualified staff conducted the work outlined for these components on behalf of the City of Quincy during the 2013 smelt spawning season.

Two meetings were conducted with URS, LE and Brad Chase (DMF) on March 20th and 26th in 2013to identify the transect locations for the monitoring program. Six transects (TR-1 through TR-6) were identified for measurements to be completed through the 2013 to 2015 smelt spawning seasons from March 1st through May 31st each year. Due to unusually cold weather earlier in 2013 coupled with the completion of the Town Brook diversion, the 2013 study began March 20th and continued through May 31st.

The six transects are described in Table 1 (and shown on Figures 2 and 3). Each transect has been marked in the field for identification purposes. Transects TR-1 to TR-3 are located in the newly constructed portions of the channel beginning at the upstream end. Transects TR-4 to TR-6 are located near the Miller Stile Road USGS monitoring station, beginning at the upstream end. The transect locations were discussed and approved in the field by DMF.

Table 1: Transect Locations		
Transect #	**Station Location**	**Description**
TR-1	Sta 23+00	Riffle located west of Mechanic Street
TR-2	Sta 21+75	Riffle located east of Mechanic Street near wetland island
TR-3	Sta 21+00	Riffle located in replaced section of defunct channel
TR-4	N/A	Riffle east of Miller Stile Road prior to USGS Gage
TR-5	N/A	Riffle located downstream of USGS Gage
TR-6	N/A	Riffle located downstream of bend in Town Brook

The monitoring program followed the requirements in the MassDMF Technical Report TR-42*: Quality Assurance Program Plan (QAPP) for Water Quality Measurements Conducted for Diadromous Fish Habitat Monitoring Version 1.0, 2008-2012*, prepared by Brad Chase, dated May 2010. The monitoring of smelt eggs, chemistry, and depths was conducted two times per week from March 29th to May 31st. Monitoring of chemistry and flows will continue on a monthly basis between June and February. URS conducted the water quality, water velocity, and water depth measurements. LE conducted the smelt egg monitoring and inspection of the upstream portions near Miller Stiles Road, Revere Road, and TR-1. One staff person from URS and one staff person from LE were typically in the stream per site visit to conduct the monitoring.

Water quality was sampled at three locations: TR-2, TR-3, and TR-4. Sampling included turbidity, dissolved oxygen, temperature, conductivity, and pH. A YSI Data Logger (Model #6820) was used for grab sampling at each transect noted. The YSI 6820 sonde collected real time water quality data and was used to record data at two to three minute intervals during sampling. Prior to collecting data, the instrument was calibrated for accuracy and placed in the channel water for 10 to 15 minutes to ensure that water quality parameters were stabilized.

Water velocity and water depths were measured at all six transects. Five measurements were taken at each transect in equal increments to provide a detailed cross section of the channel. A Global Water Flow Probe (Model #FP211) was used for these measurements. The Global Water Flow Probe is a highly accurate water velocity instrument used for measuring flows in the open channel. The flow computer incorporates true velocity averaging for the most accurate flow measurements. Instantaneous velocities were collected three times over approximately five minutes and average flows were recorded and logged. At each of the six transects the flow probe was used at five predetermined locations across the channel width. Readings were taken only when the protective propeller was completely submerged under water. If the propeller became fouled while measuring flows, it was cleaned until the prop turned freely then readings were taken again.

Smelt egg deposition was measured at all six transects. An area one meter upstream and one meter downstream of each transect was visually inspected during each visit for approximately five to ten minutes to document the absence or presence of smelt eggs on the substrate using the following scale to approximate the density per square foot:

Table 2: Egg Count Scale	
Scale	**Number of Eggs per square foot**
0	0
1	1-10
2	11-50
3	>50-100
4	>100-500
5	>500

Results: Smelt Egg Monitoring

Due to unusually cold weather conditions early in the 2013 smelt season, coupled with the completion of the Town Brook diversion, the 2013 study began March 26th (instead of March 1st) and continued through May 31st. Over the course of the 2013 survey each of the six transects contained deposited smelt eggs. Transects 1, 2, and 6 had the most smelt egg deposition and Transect 3 the least. Toward the start of the season, Transects 1 and 2 had the most numbers of eggs deposited ranging from 100-500 eggs (scale density 4) to 11-50 eggs (scale density 2), respectively. Transect 4, 5, 6 contain smaller amounts of eggs at a scale density 1 (1-10 eggs). Transect 3 did not contain any eggs until April 19th in which only a few were observed (scale density 1).

Due to the higher number of eggs observed in Transect 1 and 2 during the start of the study period it appears that several smelt spawned near or at Transects 1 and 2 at the end of March through the beginning of April. The numbers of observed eggs slowly diminished as the weeks went on (rainbow smelt incubation time is approximately 29 days). This decrease in number of eggs observed was believed to be a result of the eggs maturing, hatching, and the smelt swimming away.

Another increase in the amount of eggs observed occurred at the end of April in Transect 6 in which approximately 11-50 (scale density 2) and 50-100 eggs (scale density 3) were observed. Similar to Transects 1 and 2 the eggs observed in Transect 3 over the next month became larger and slowly decreased in number assuming the successful smelt mature and hatching. Transects 4 and 5 contained a scale density 1 early in the study then decreased to zero through early May. In early to mid-May, Transect 4 and 5 contained scale densities 1 or 2. Transect 3 had the least amount of eggs observed. Only on three site visits (April 19th, May 07th, and May 09th) were eggs observed within this transect with a scale density of 1.

Table 3: Smelt Egg Densities						
	Transect	Transect	Transect	Transect	Transect	Transect
Date	1	2	3	4	5	6
03/26/13						
03/29/13	1	1	0	1	1	1
04/03/13	2	2	0	1	1	1
04/05/13	4	2	0	1	0	1
04/08/13	4	1	0	0	0	1
04/11/13	4	1	0	0	0	1
04/17/13	4	0	0	0	0	1
04/19/13	4	0	1	0	0	1
04/22/13	2	0	0	0	0	2
04/24/13	3	1	0	0	2	2
04/29/13	2	2	0	0	0	3
05/03/13	2	2	0	0	0	3
05/07/13	2	2	1	1	1	3
05/09/13	1	1	1	2	2	3
05/15/13	0	0	0	1	1	2
05/17/13	0	0	0	1	1	1
05/22/13	0	0	0	0	1	1
05/24/13	0	0	0	0	0	1
05/28/13	0	0	0	0	0	0
05/31/13	0	0	0	0	0	0

Results: Water Quality Monitoring

Velocity

Water velocity is the rate of flow of the brook, measured in feet per second. Velocity was measured using a Global Water Flow Probe at all 6 transects during the sampling period. The measurements are taken at the same 5 locations along the transects during each date. During the sampling period, discharge ranged from a minimum of 0.73 feet/second, measured at transect 6, to a maximum of 6.90 feet/second, measured at transect 3. Transects 1, 2, 4, 5, and 6 all averaged between 2.03 and 2.40 feet/second during the sampling period. Transect 3 was the outlier, averaging 3.99 feet/second during the sampling period. Transect 3 generally has a higher flow rate because a large culvert feeds water into the stream above this transect.

Table 4: Velocity (feet/second)			
Transect	Min	Max	Average
1	0.80	3.53	2.14
2	1.30	3.97	2.37
3	2.23	6.90	3.99
4	1.13	3.57	2.40
5	1.50	3.50	2.33
6	0.73	2.90	2.03

Depth

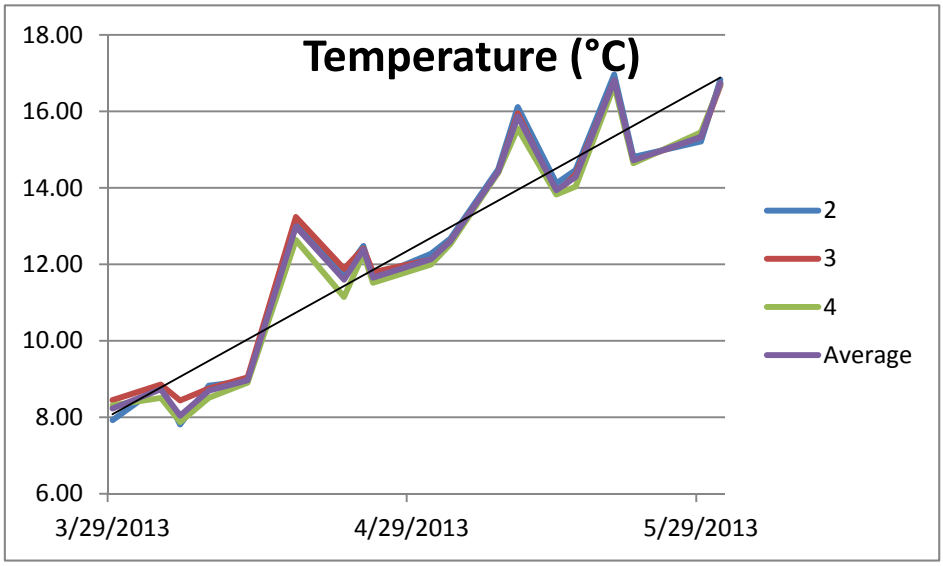
Water depth was measured using a Global Water Flow Probe at all 6 transects during the sampling period. During the sampling period, water depths ranged from a minimum of 0.20 feet, measured at transect 6, to a maximum of 2.50 feet, measured at transect 4. The brook depth averaged between 0.46 feet and 0.77 feet across all transects during the sampling season.

Table 5: Depth (feet)

Transect	Min	Max	Average
1	0.45	1.50	0.77
2	0.38	1.30	0.70
3	0.40	1.30	0.70
4	0.25	2.50	0.53
5	0.30	1.00	0.46
6	0.20	1.40	0.47

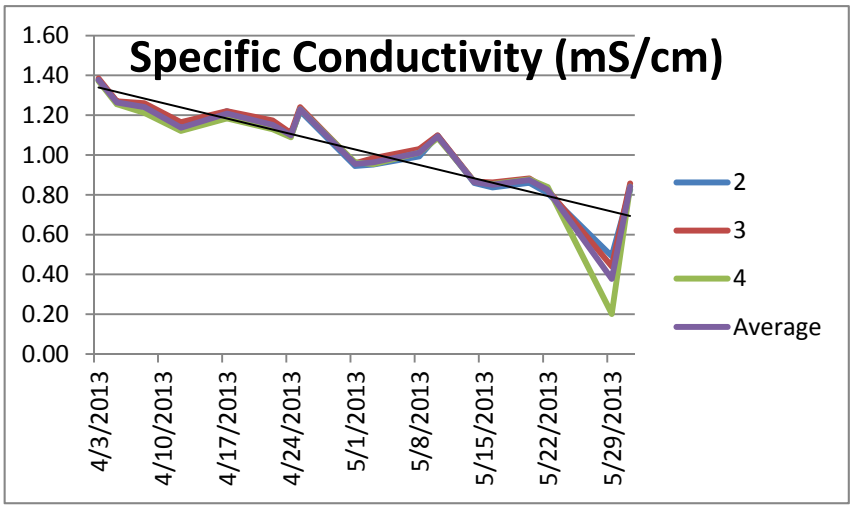
Temperature

Temperature data was collected at transects 2, 3, and 4 utilizing the YSI 6820 sonde. During the sampling period, water temperature steadily rose from an average of 8.04 degrees C to an average of 16.74 degrees C across all transects.



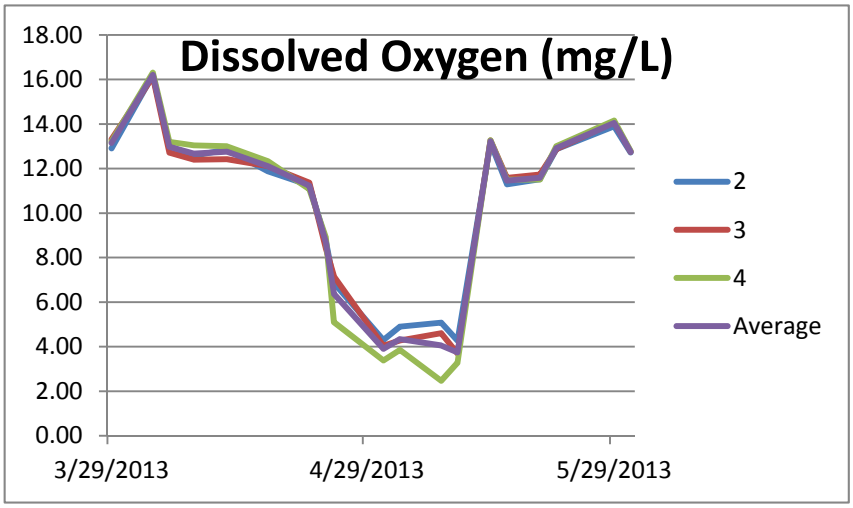
Specific Conductivity

Specific conductivity data was collected at transects 2, 3, and 4 utilizing the YSI 6820 sonde. Specific conductivity measures the water's ability to conduct an electrical current. Higher values indicate a larger amount of dissolved solids in the water, and can be an indication of pollution (though natural characteristics of the stream also influence specific conductivity). Fluctuations in the data can be indicative of changing conditions in the stream. During the sampling period, specific conductivity steadily decreased from 1.38 mS/cm to approximately 0.80 mS/cm. Town Brook experienced a specific conductivity low of 0.38 mS/cm averaged across all three transects on 5/29/13. No other sampling period registered an average lower than 0.82 mS/cm.



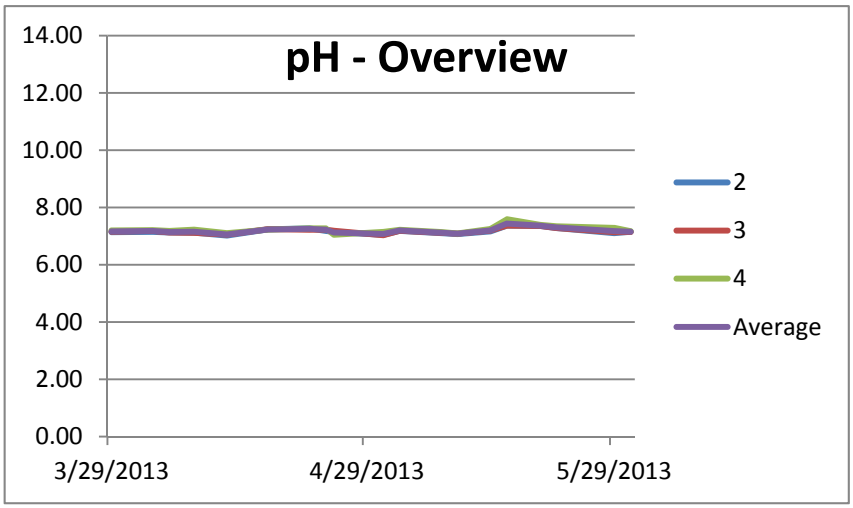
Dissolved Oxygen

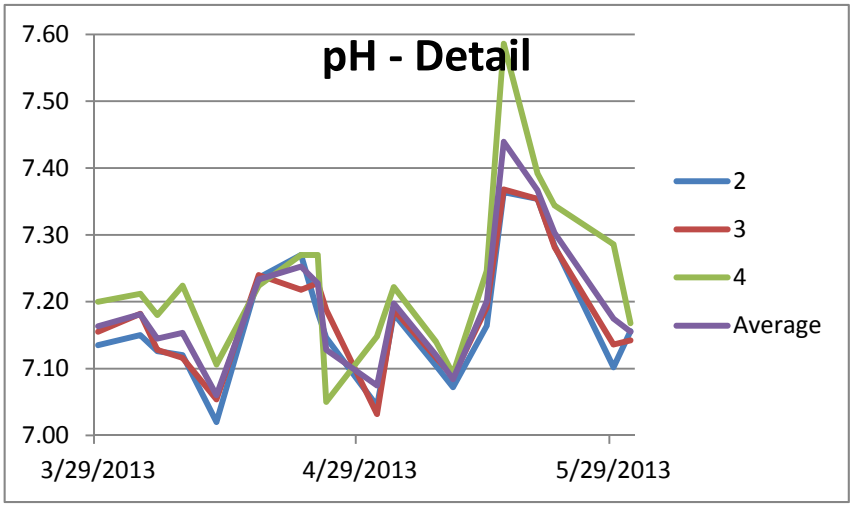
Dissolved oxygen (DO) data was collected at transects 2, 3, and 4 utilizing the YSI 6820 sonde. DO measurements provide an indication of a water body's ability to support aquatic life. Between the dates of 3/29/13 and 4/22/13, DO held steady between 11.23 mg/L and 13.15 mg/L, with a one period high of 16.21 mg/L. DO measurements decreased between 4/24/13 and 5/10/13 from 8.69 mg/L to 3.75mg/L. DO subsequently rebounded during the final six sampling dates ranging from 11.46 mg/L to 14.05 mg/L.



pH

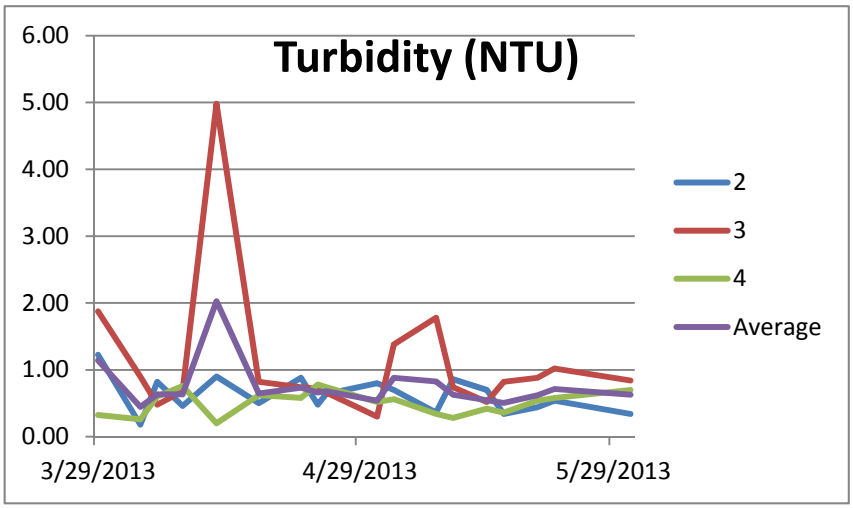
pH data was collected at transects 2, 3, and 4 utilizing the YSI 6820 sonde. pH is a measure of how acidic/basic the water is, with 7 being neutral. During the sampling period, pH ranged from a minimum of 7.0 to a maximum of 7.6. The data shows a small spike between 5/16/13 and 5/22/13, where pH values averaged between 7.30 and 7.44, however this is a relatively insignificant increase.





Turbidity

Turbidity data was collected at transects 2, 3, and 4 utilizing the YSI 6820 sonde. Turbidity is a measure of particulate matter suspended in the water, and is measured in nephelometric turbidity units (NTU). A nephelometer measures suspended particles utilizing a light beam and light detector. Turbidity can be caused by clay, silt, organic compounds, microorganisms, or inorganic matter. Turbidity remained consistently low during the sampling period, ranging from a minimum of 0.10 NTU to a maximum of 2.0 NTU. The data shows a small spike at transect 3 on 4/12/13; however as this is just one data point this could be the result of sediment stirred up by the sampler.



Conclusion

Due to the rise and fall of egg number deposition (which corresponds to the approximate smelt egg incubation time) and quantity of eggs observed within Transect 1, 2, 4, 5 and 6, it is assumed that most of the smelt eggs observed within these transects matured and hatched successfully. The eggs in Transect 3 did not have a long enough incubation time to become viable smelt adults and may have been predated, dislodged, or died. The survey indicates the presence of smelt adults utilizing Town Brook for spawning and spawning efforts appear to be successful.

The results of the water quality monitoring indicated that the conditions in the stream were favorable to smelt spawning in Town Brook. Depth and discharge fluctuated during the period based on snow melt and rain events, but measurements show there was sufficient depth and flow for spawning. With regards to the other measurements:

- temperature increased as expected during the time period;
- specific conductivity decreased slightly, but remained consistent during the period, with no large fluctuations;
- dissolved oxygen dropped for a three week period, which may have impacted smelt eggs, but rebounded during the sampling period;
- pH remained flat at a neutral measurement; and
- turbidity remained consistently low during the period.

The 2014 smelt monitoring season will begin on or around March 1st, depending on weather conditions. A coordination meeting will be scheduled with the Division of Marine Fisheries in February prior to the start of the monitoring season.

Appendix A: Graphics

URS

FIGURE 1
SITE LOCATION MAP

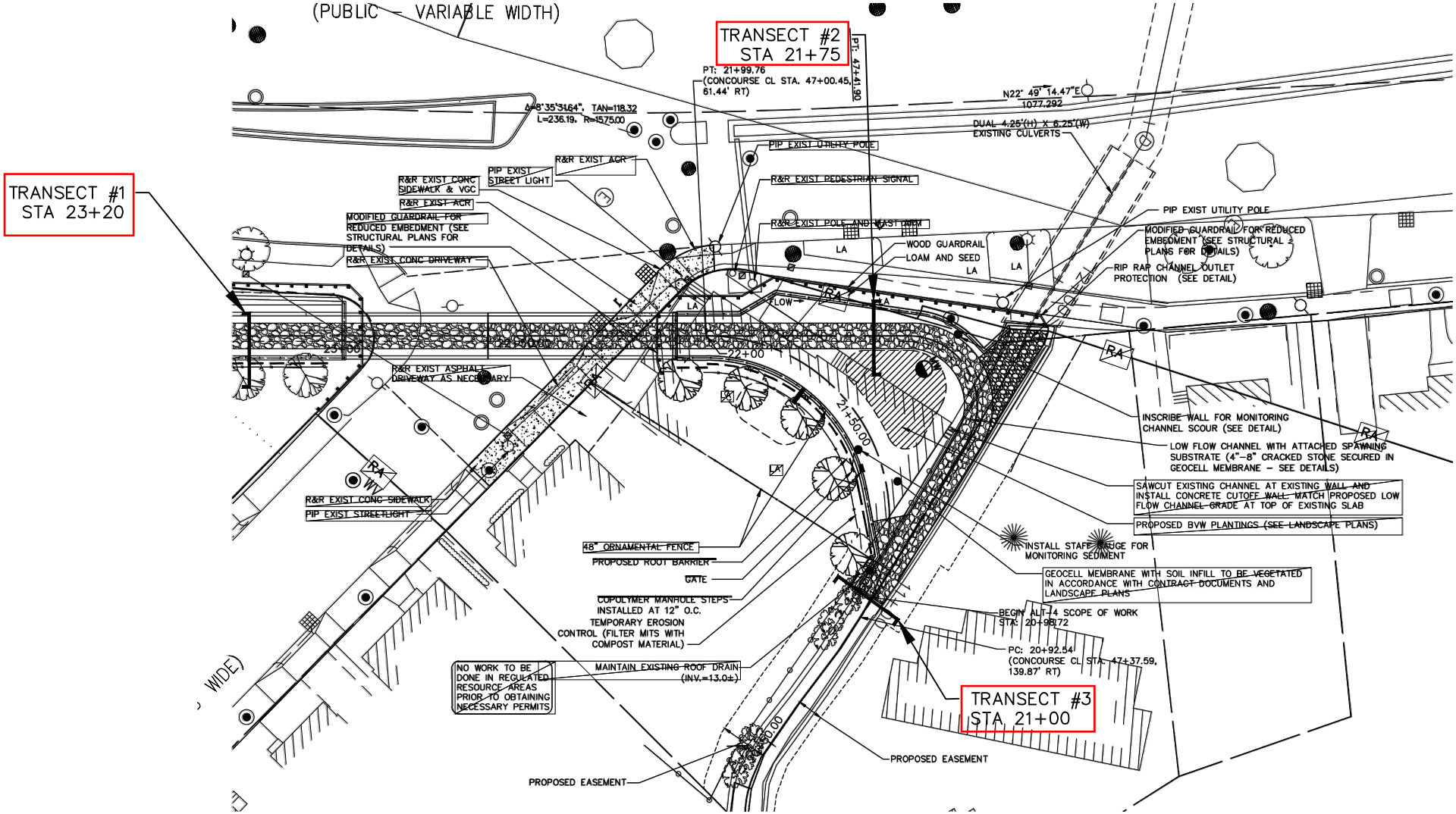


FIGURE 2
TRANSECT LOCATIONS #1, #2, #3

URS

FROM DRAWINGS PREPARED BY Stephenson Design Group

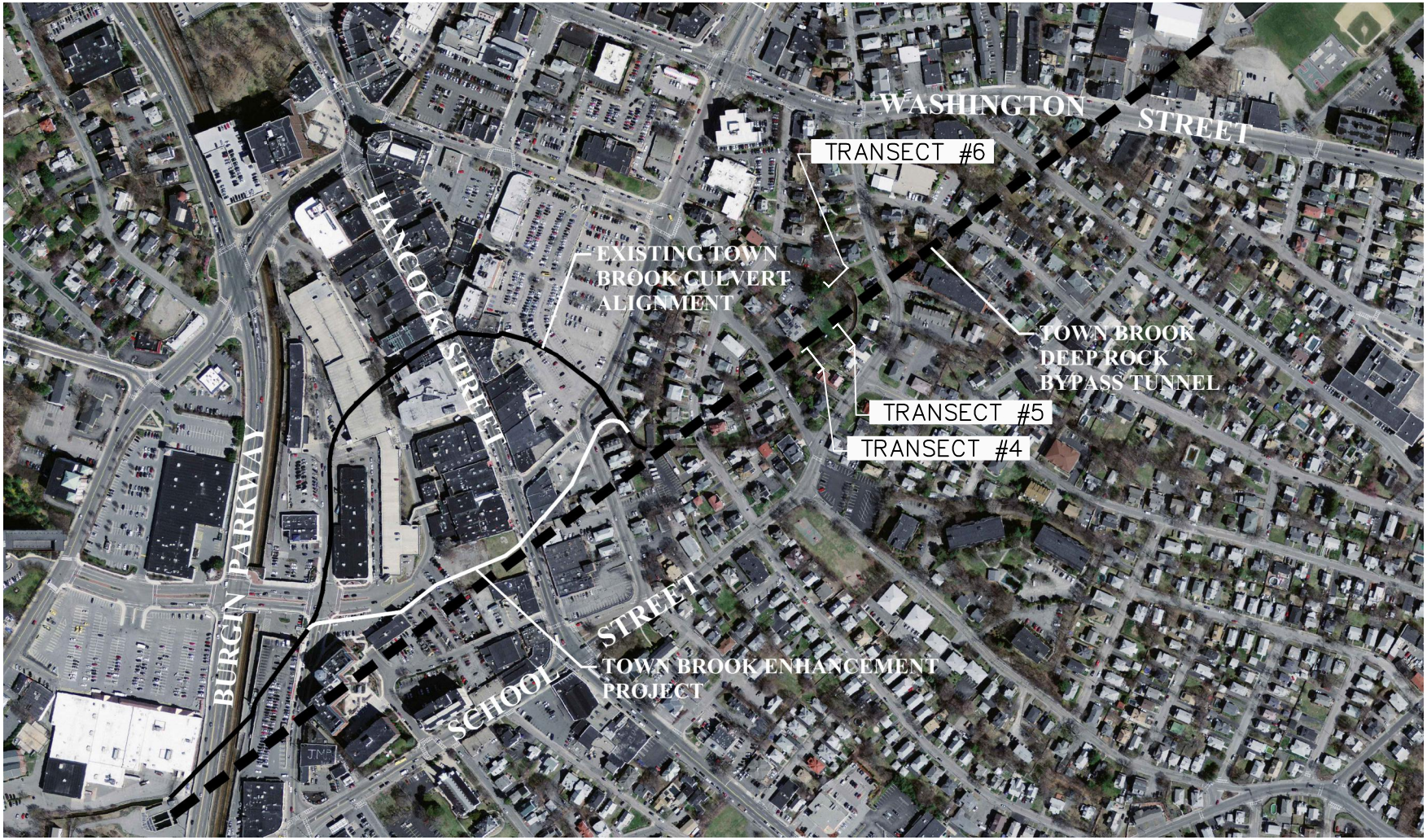
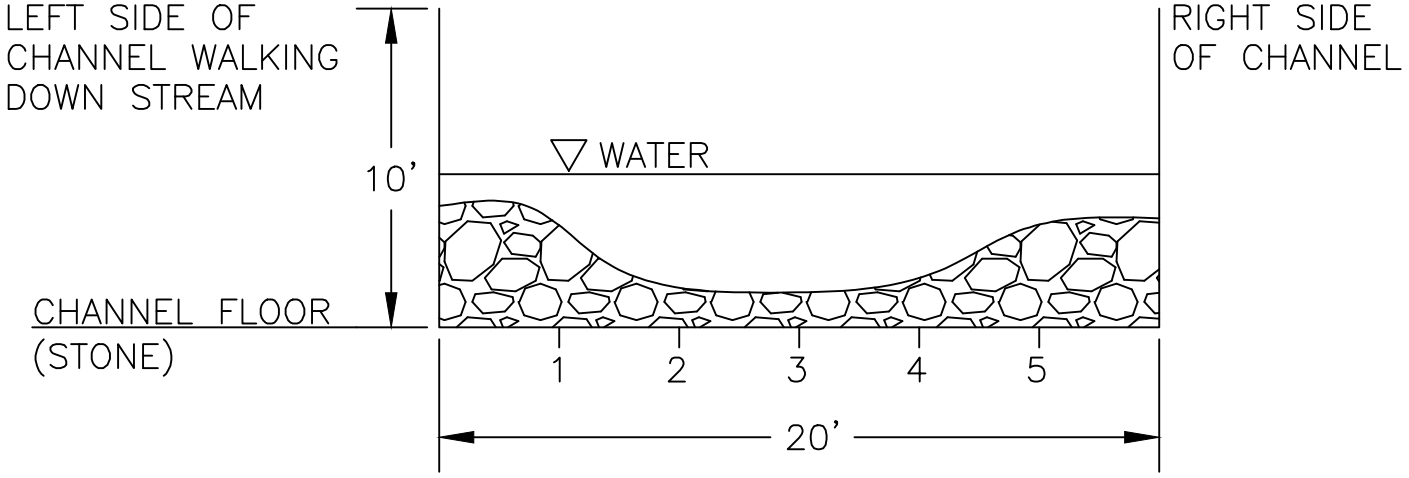


FIGURE 3
TRANSECT LOCATIONS #4, #5, #6

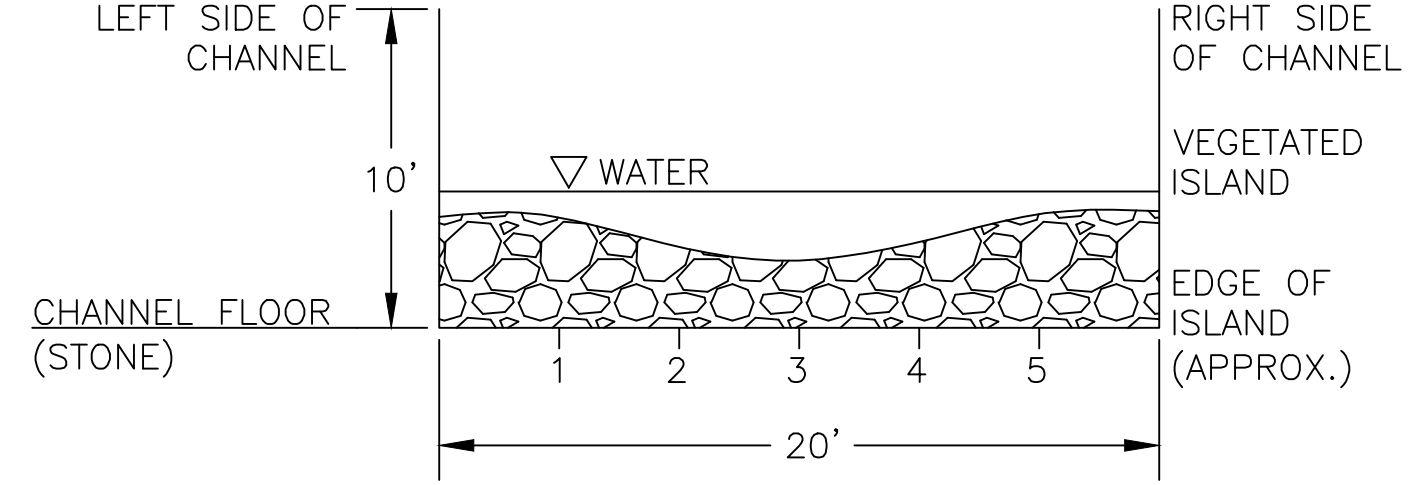
URS

NOTE: No. 1–5 INDICATE WATER VELOCITY LOCATIONS

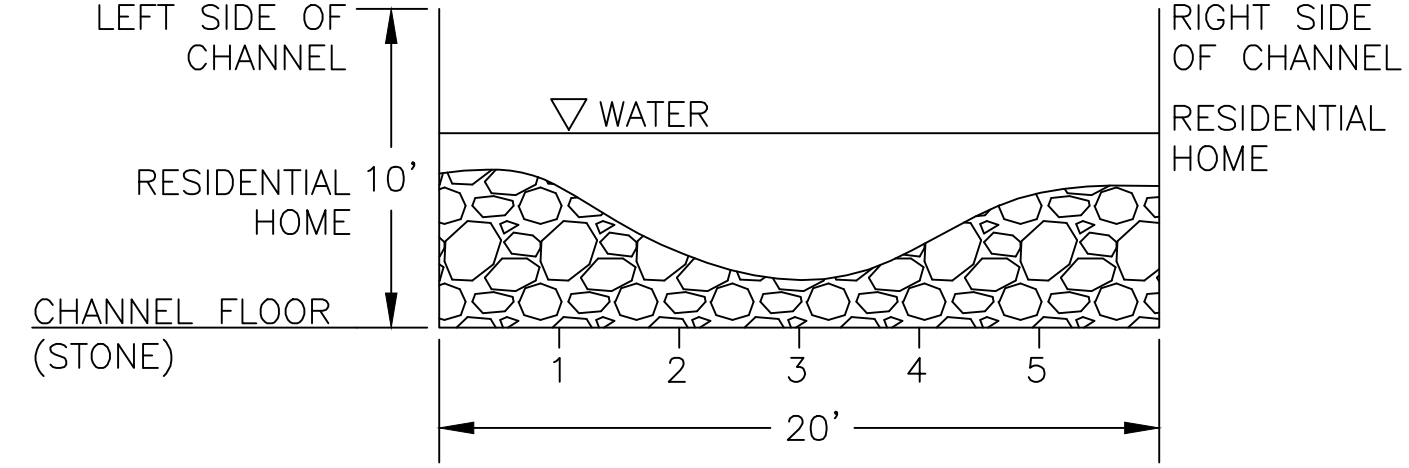
TRANSCET 1
STA 23+00



TRANSCET 2
STA 21+75



TRANSCET 3
STA 21+00



P:\JOBS-GED\CITY OF QUINCY - FST\TOWN BROOK\500 CADD-GIS-GRAPHICS\510 CADD\REPORT FIGURES.DWG FIG 1 12/09/13 3:06PM

URS Corporation
260 Franklin Street
Suite 300
Boston, MA 02110
Tel: 617.542.4244
Fax: 617.542.3301
www.urscorp.com

SCALE:	NTS
DATE:	12/9/2013
FILE NO:	--
DESIGN:	XXX
APPROVED:	XXX
DRAWN:	XXX

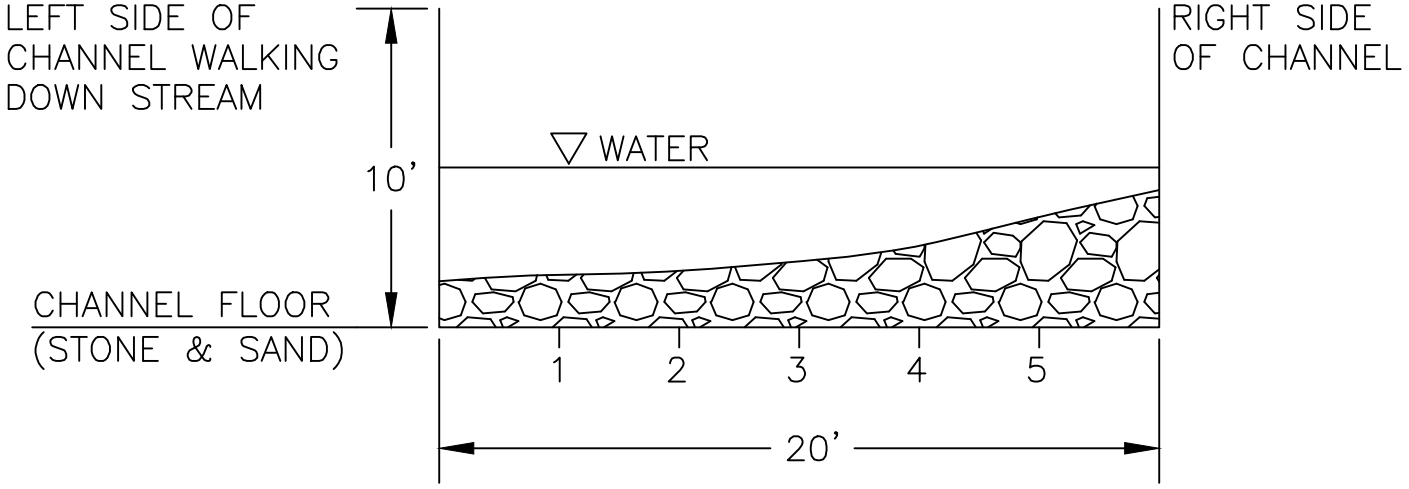
CLIENT: CITY OF QUINCY
PROJ: WATER QUALITY MONITORING
PROJECT NO: 10161265

TITLE: WATER QUALITY MONITORING CHANNEL CROSS SECTIONS

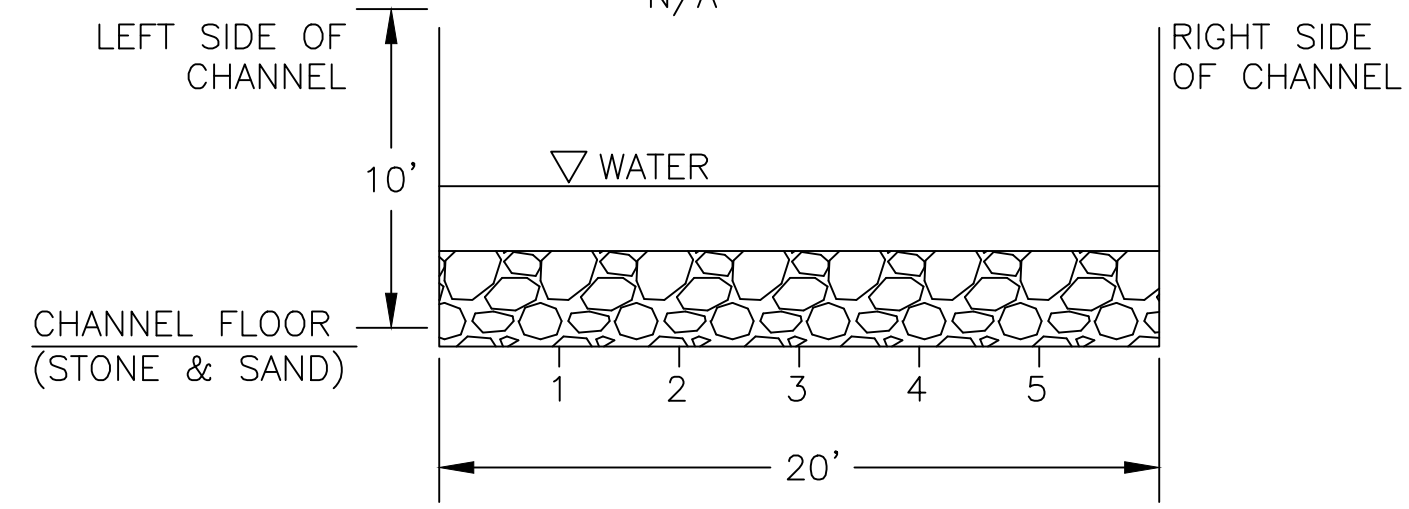
DRAWING NO.: FIG 4

NOTE: No. 1–5 INDICATE WATER VELOCITY LOCATIONS

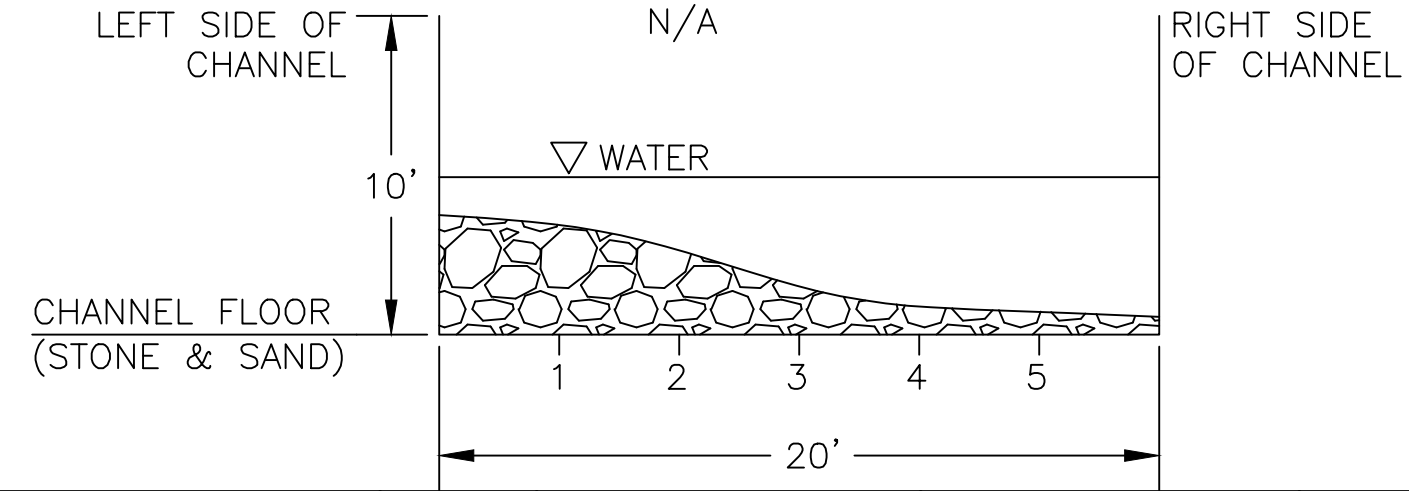
TRANSCET 4
N/A



TRANSCET 5
N/A



TRANSCET 6
N/A



P:\JOBS-GED\CITY OF QUINCY - FST\TOWN BROOK\500 CADD-GIS-GRAPHICS\510 CADD\REPORT FIGURES.DWG FIG 2 12/09/13 3:06PM

URS Corporation
260 Franklin Street
Suite 300
Boston, MA 02110
Tel: 617.542.4244
Fax: 617.542.3301
www.urscorp.com

SCALE:	NTS
DATE:	12/9/2013
FILE NO:	--
DESIGN:	XXX
APPROVED:	XXX
DRAWN:	XXX

CLIENT: CITY OF QUINCY

PROJ: WATER QUALITY MONITORING

PROJECT NO: 10161265

TITLE: WATER QUALITY MONITORING CHANNEL CROSS SECTIONS

DRAWING NO.: FIG 5

Appendix B: Photographic Documentation

Photograph 1: View of Transect #1, facing southwest.

Photograph 2: View of Transect #2, facing southwest.

Photograph 3: View of Transect #3, facing southeast.

Photograph 4: View of Transect #4, facing northeast.

Photograph 5: View of Transect #4, facing southwest.

Photograph 6: View of Transect #5, facing northeast.

Photograph 7: View of Transect #5, facing southwest.

Photograph 8: View of Transect #6, facing north. Photo by URS.

Photograph 9: View of the fish barrier at the old Town Brook culvert.

Photograph 10: View of the relocated culvert near the open channel portion of Town Brook.

Photograph 11: View of the rock substrate with live smelt eggs visible, observed in the new open channel sections of Town Brook.

Photograph 12: View of the rock substrate with live smelt eggs visible observed in the new open channel sections of Town Brook.

Appendix C: Raw Data

Town Brook Rainbow Smelt Monitoring:
Water Chemistry Measurements
Year: 2013
State: Massachusetts

Data Entered:
Data Reviewed:
Status:

Date	River	Time	Transect	Discharge (ft/s) (No. 1)	Discharge (ft/s) (No. 2)	Discharge (ft/s) (No. 3)	Discharge (ft/s) (No. 4)	Discharge (ft/s) (No. 5)	Discharge (m/s) (No. 1)	Discharge (m/s) (No. 2)	Discharge (m/s) (No. 3)	Discharge (m/s) (No. 4)	Discharge (m/s) (No. 5)	Water Temp. (C°) (No. 1)	Water Temp. (C°) (No. 2)	Water Temp. (C°) (No. 3)	Water Temp. (C°) (No. 4)	Water Temp. (C°) (No. 5)	Water Temp. (C°) Mean	Water Temp. (C° SD	Water Temp. RSD
3/29/2013	TB		1	0.8	1.3	2.7	2.3	1.7	0.24	0.40	0.82	0.70	0.52								
4/3/2013	TB		1	1.1	2.1	2.9	2.7	1.9	0.34	0.64	0.88	0.82	0.58								
4/5/2013	TB		1	1.7	1.9	2.5	2.3	1.9	0.52	0.58	0.76	0.70	0.58								
4/8/2013	TB		1	1.9	2.1	2.4	2.7	2.1	0.58	0.64	0.73	0.82	0.64								
4/12/2013	TB		1	1.83	2.1	2.57	2.37	1.9	0.56	0.64	0.78	0.72	0.58								
4/17/2013	TB		1	2.43	2.57	2.97	2.63	2.17	0.74	0.78	0.91	0.80	0.66								
4/22/2013	TB		1	1.37	2.17	2.57	2.37	1.97	0.42	0.66	0.78	0.72	0.60								
4/24/2013	TB		1	1.3	1.93	2.83	2.5	2.23	0.40	0.59	0.86	0.76	0.68								
4/25/2013	TB		1	1.9	2.5	2.63	2.43	1.83	0.58	0.76	0.80	0.74	0.56								
5/1/2013	TB		1	1.83	2.20	2.63	2.10	1.63	0.56	0.67	0.80	0.64	0.50								
5/3/2013	TB		1	2.03	2.23	2.37	1.83	1.43	0.62	0.68	0.72	0.56	0.44								
5/8/2013	TB		1	1.57	2.10	2.50	2.37	2.17	0.48	0.64	0.76	0.72	0.66								
5/10/2013	TB		1	1.57	1.97	2.70	2.57	2.23	0.48	0.60	0.82	0.78	0.68								
5/14/2013	TB		1	2.43	2.70	2.63	2.43	2.03	0.74	0.82	0.80	0.74	0.62								
5/16/2013	TB		1	1.30	2.17	2.43	2.23	1.13	0.40	0.66	0.74	0.68	0.35								
5/20/2013	TB		1	1.20	1.90	2.37	2.10	1.63	0.37	0.58	0.72	0.64	0.50								
5/22/2013	TB		1	1.70	1.90	2.57	2.43	2.17	0.52	0.58	0.78	0.74	0.66								
5/29/2013	TB		1	2.63	3.23	3.53	3.37	3.03	0.80	0.99	1.08	1.03	0.92								
5/31/2013	TB		1	1.07	1.30	1.63	1.43	1.10	0.33	0.40	0.50	0.44	0.34								
3/29/2013	TB		2	1.3	1.7	2.9	2.7	2.1	0.40	0.52	0.88	0.82	0.64	7.9	7.93	7.94	7.94		7.9275	0.01893	0.24%
4/3/2013	TB		2	1.7	1.9	3.1	2.5	1.9	0.52	0.58	0.94	0.76	0.58	8.82	8.83	8.83	8.84	8.85	8.834	0.011402	0.13%
4/5/2013	TB		2	2.1	2.5	2.9	2.7	2.1	0.64	0.76	0.88	0.82	0.64	7.79	7.79	7.8	7.83	7.86	7.814	0.030496	0.39%
4/8/2013	TB		2	1.9	2.3	2.5	2.1	1.9	0.58	0.70	0.76	0.64	0.58	8.8	8.82	8.84	8.84	8.85	8.83	0.02	0.23%
4/12/2013	TB		2	1.97	2.43	2.63	2.33	2.1	0.60	0.74	0.80	0.71	0.64	8.98	8.94	8.95	8.95	8.95	8.954	0.015166	0.17%
4/17/2013	TB		2	2	2.3	2.6	2.5	2.2	0.61	0.70	0.79	0.76	0.67	13.06	13.07	13.1	13.11	13.11	13.09	0.023452	0.18%
4/22/2013	TB		2	1.97	2.37	2.63	2.5	2.1	0.60	0.72	0.80	0.76	0.64	11.76	11.77	11.77	11.78	11.78	11.772	0.008367	0.07%
4/24/2013	TB		2	1.9	2.73	2.77	2.63	2.06	0.58	0.83	0.84	0.80	0.63	12.46	12.47	12.48	12.49	12.5	12.48	0.015811	0.13%
4/25/2013	TB		2	2.5	3.03	2.9	2.23	1.9	0.76	0.92	0.88	0.68	0.58	11.62	11.63	11.64	11.66	11.67	11.644	0.020736	0.18%
5/1/2013	TB		2	2.50	2.70	2.83	2.57	2.23	0.76	0.82	0.86	0.78	0.68	12.23	12.26	12.28	12.3	12.31	12.276	0.032094	0.26%
5/3/2013	TB		2	2.03	2.23	2.37	2.03	1.83	0.62	0.68	0.72	0.62	0.56	12.66	12.66	12.67	12.67	12.68	12.668	0.008367	0.07%
5/8/2013	TB		2	2.17	2.30	2.57	2.37	2.23	0.66	0.70	0.78	0.72	0.68	14.48	14.49	14.49	14.49	14.49	14.488	0.004472	0.03%
5/10/2013	TB		2	2.43	2.77	2.83	2.63	2.23	0.74	0.84	0.86	0.80	0.68	16.08	16.1	16.11	16.12	16.13	16.108	0.019235	0.12%
5/14/2013	TB		2	2.23	2.57	2.57	2.50	2.30	0.68	0.78	0.78	0.76	0.70	14.11	14.12	14.12	14.12	14.12	14.118	0.004472	0.03%
5/16/2013	TB		2	2.23	2.50	2.70	2.50	1.97	0.68	0.76	0.82	0.76	0.60	14.44	14.46	14.47	14.48	14.49	14.468	0.019235	0.13%
5/20/2013	TB		2	2.10	2.30	2.43	2.50	1.97	0.64	0.70	0.74	0.76	0.60	16.94	16.95	16.96	16.98	16.99	16.964	0.020736	0.12%
5/22/2013	TB		2	1.77	2.23	2.63	2.50	2.23	0.54	0.68	0.80	0.76	0.68	14.8	14.8	14.81	14.81	14.81	14.806	0.005477	0.04%
5/29/2013	TB		2	3.17	3.60	3.97	3.50	3.17	0.97	1.10	1.21	1.07	0.97	15.21	15.2	15.21	15.22	15.22	15.212	0.008367	0.06%
5/31/2013	TB		2	1.43	1.97	2.23	2.10	1.57	0.44	0.60	0.68	0.64	0.48	16.79	16.81	16.82	16.84	16.86	16.824	0.027019	0.16%
3/29/2013	TB		3	4.2	5.1	5.3	4.6	3.8	1.28	1.55	1.62	1.40	1.16	8.45	8.44	8.45	8.46		8.45	0.00816	0.10%
4/3/2013	TB		3	4.4	5.4	5.9	4.8	4.1	1.34	1.65	1.80	1.46	1.25	8.85	8.86	8.86	8.85	8.85	8.854	0.005477	0.06%
4/5/2013	TB		3	2.9	4.1	5.4	5	3.7	0.88	1.25	1.65	1.52	1.13	8.37	8.4	8.44	8.47	8.51	8.438	0.055408	0.66%
4/8/2013	TB		3	3.1	4.4	4.8	5	2.9	0.94	1.34	1.46	1.52	0.88	8.75	8.75	8.74	8.75	8.77	8.752	0.010954	0.13%
4/12/2013	TB		3	4.7	5.33	5.97	5.73	4.67	1.43	1.62	1.82	1.75	1.42	9.03	9.05	9.05	9.06	9.01	9.04	0.02	0.22%
4/17/2013	TB		3	2.9	4.27	4.9	4.46	3.37	0.88	1.30	1.49	1.36	1.03	13.23	13.24	13.23	13.24	13.24	13.236	0.005477	0.04%
4/22/2013	TB		3	3.53	4.27	4.67	4.17	3.5	1.08	1.30	1.42	1.27	1.07	11.87	11.88	11.88	11.89	11.89	11.882	0.008367	0.07%
4/24/2013	TB		3	3.73	4.2	4.67	4	3.57	1.14	1.28	1.42	1.22	1.09	12.4	12.41	12.41	12.42	12.43	12.414	0.011402	0.09%
4/25/2013	TB		3	3.3	3.96	4.43	4.16	3.36	1.01	1.21	1.35	1.27	1.02	11.76	11.79	11.8	11.81	11.82	11.796	0.023022	0.20%
5/1/2013	TB		3	3.03	3.73	4.33	4.13	2.93	0.92	1.14	1.32	1.26	0.89	12.11	12.12	12.13	12.13	12.14	12.126	0.011402	0.09%
5/3/2013	TB		3	2.90	4.27	4.27	3.67	3.10	0.88	1.30	1.30	1.12	0.94	12.59	12.6	12.6	12.61	12.61	12.602	0.008367	0.07%
5/8/2013	TB		3	3.30	3.73	4.23	3.97	3.10	1.01	1.14	1.29	1.21	0.94	14.4	14.41	14.41	14.41	14.41	14.408	0.004472	0.03%
5/10/2013	TB		3	3.73	4.47	4.70	4.23	3.67	1.14	1.36	1.43	1.29	1.12	15.92	15.94	15.95	15.96	15.96	15.946	0.016733	0.10%
5/14/2013	TB		3	3.03	3.40	3.77	3.37	2.90	0.92	1.04	1.15	1.03	0.88	13.85	13.86	13.87	13.87	13.87	13.864	0.008944	0.06%
5/16/2013	TB		3	2.83	3.37	3.80	3.57	3.03	0.86	1.03	1.16	1.09	0.92	14.33	14.34	14.35	14.36	14.37	14.35	0.015811	0.11%
5/20/2013	TB		3	2.63	3.17	3.67	3.37	2.57	0.80	0.97	1.12	1.03	0.78	16.78	16.79	16.8	16.81	16.82	16.8	0.015811	0.09%
5/22/2013	TB		3	2.63	3.17	3.57	3.23	2.77	0.80	0.97	1.09	0.99	0.84	14.69	14.7	14.7	14.71	14.71	14.702	0.008367	0.06%
5/29/2013	TB		3	5.90	6.37	6.90	6.50	5.73	1.80	1.94	2.10	1.98	1.75	15.33	15.33	15.34	15.34	15.34	15.336	0.005477	0.04%
5/31/2013	TB		3	2.37	2.77	3.37	2.97	2.23	0.72	0.84	1.03	0.90	0.68	16.68	16.69	16.68	16.68	16.67	16.68	0.007071	0.04%

Date	River	Time	Transect	Discharge (ft/s) (No. 1)	Discharge (ft/s) (No. 2)	Discharge (ft/s) (No. 3)	Discharge (ft/s) (No. 4)	Discharge (ft/s) (No. 5)	Discharge (m/s) (No. 1)	Discharge (m/s) (No. 2)	Discharge (m/s) (No. 3)	Discharge (m/s) (No. 4)	Discharge (m/s) (No. 5)	Water Temp. (C°) (No. 1)	Water Temp. (C°) (No. 2)	Water Temp. (C°) (No. 3)	Water Temp. (C°) (No. 4)	Water Temp. (C°) (No. 5)	Water Temp. (C°) Mean	Water Temp. (C° SD	Water Temp. RSD
3/29/2013	TB		4	2.5	2.7	3.1	2.3	2.1	0.76	0.82	0.94	0.70	0.64	8.33	8.32	8.31	8.3		8.315	0.01291	0.16%
4/3/2013	TB		4	2.5	2.9	3.4	2.5	2.3	0.76	0.88	1.04	0.76	0.70	8.47	8.49	8.49	8.53	8.55	8.506	0.032863	0.39%
4/5/2013	TB		4	2.7	2.9	3.1	2.5	1.9	0.82	0.88	0.94	0.76	0.58	7.9	7.89	7.88	7.86	7.85	7.876	0.020736	0.26%
4/8/2013	TB		4	2.3	2.5	2.5	2.1	1.7	0.70	0.76	0.76	0.64	0.52	8.5	8.51	8.51	8.52	8.52	8.512	0.008367	0.10%
4/12/2013	TB		4	2.23	2.37	2.57	2.13	2.1	0.68	0.72	0.78	0.65	0.64	8.9	8.91	8.9	8.9	8.91	8.904	0.005477	0.06%
4/17/2013	TB		4	2.43	2.57	2.37	2.1	2.1	0.74	0.78	0.72	0.64	0.64	12.58	12.61	12.63	12.66	12.68	12.632	0.039623	0.31%
4/22/2013	TB		4	2.63	2.57	2.43	2.17	1.7	0.80	0.78	0.74	0.66	0.52	11.14	11.14	11.15	11.15	11.15	11.146	0.005477	0.05%
4/24/2013	TB		4	2.57	2.77	2.9	2.63	2.37	0.78	0.84	0.88	0.80	0.72	12.25	12.27	12.28	12.28	12.29	12.274	0.015166	0.12%
4/25/2013	TB		4	2.16	2.36	2.7	2.7	2.63	0.66	0.72	0.82	0.82	0.80	11.49	11.5	11.52	11.54	11.55	11.52	0.025495	0.22%
5/1/2013	TB		4	1.13	1.43	2.30	2.23	2.63	0.35	0.44	0.70	0.68	0.80	11.98	11.99	12	12	12.01	11.996	0.011402	0.10%
5/3/2013	TB		4	1.70	2.03	2.33	2.43	2.63	0.52	0.62	0.71	0.74	0.80	12.51	12.52	12.52	12.53	12.53	12.522	0.008367	0.07%
5/8/2013	TB		4	2.17	2.37	2.43	2.30	2.03	0.66	0.72	0.74	0.70	0.62	14.39	14.4	14.4	14.4	14.41	14.4	0.007071	0.05%
5/10/2013	TB		4	2.70	2.43	2.43	2.23	1.97	0.82	0.74	0.74	0.68	0.60	15.54	15.55	15.55	15.56	15.57	15.554	0.011402	0.07%
5/14/2013	TB		4	2.43	2.63	2.50	2.23	2.03	0.74	0.80	0.76	0.68	0.62	13.8	13.82	13.83	13.83	13.84	13.824	0.015166	0.11%
5/16/2013	TB		4	2.43	2.37	2.30	2.03	1.83	0.74	0.72	0.70	0.62	0.56	14.01	14.03	14.04	14.04	14.05	14.034	0.015166	0.11%
5/20/2013	TB		4	2.10	2.37	2.50	2.83	1.97	0.64	0.72	0.76	0.86	0.60	16.65	16.67	16.68	16.7	16.71	16.682	0.023875	0.14%
5/22/2013	TB		4	2.63	2.43	2.50	2.03	1.83	0.80	0.74	0.76	0.62	0.56	14.63	14.64	14.65	14.65	14.65	14.644	0.008944	0.06%
5/29/2013	TB		4	2.97	3.37	3.57	3.23	3.10	0.90	1.03	1.09	0.99	0.94	15.45	15.45	15.45	15.45	15.44	15.448	0.004472	0.03%
5/31/2013	TB		4	2.43	2.30	2.57	2.10	1.57	0.74	0.70	0.78	0.64	0.48	16.66	16.67	16.71	16.74	16.77	16.71	0.046368	0.28%
3/29/2013	TB		5	1.9	2.1	2.7	2.3	2.1	0.58	0.64	0.82	0.70	0.64								
4/3/2013	TB		5	1.5	1.7	2.1	1.9	1.5	0.46	0.52	0.64	0.58	0.46								
4/5/2013	TB		5	2.7	2.7	2.9	3.1	2.1	0.82	0.82	0.88	0.94	0.64								
4/8/2013	TB		5	2.3	2.1	2.7	2.7	2.1	0.70	0.64	0.82	0.82	0.64								
4/12/2013	TB		5	2.03	2.23	2.43	2.5	2.23	0.62	0.68	0.74	0.76	0.68								
4/17/2013	TB		5	1.83	2.1	2.17	2.17	1.9	0.56	0.64	0.66	0.66	0.58								
4/22/2013	TB		5	2.43	2.57	2.5	2.3	1.9	0.74	0.78	0.76	0.70	0.58								
4/24/2013	TB		5	2.17	2.37	2.37	2.23	2.03	0.66	0.72	0.72	0.68	0.62								
4/25/2013	TB		5	2.23	2.36	2.5	2.36	2.23	0.68	0.72	0.76	0.72	0.68								
5/1/2013	TB		5	2.43	2.37	2.50	2.43	2.23	0.74	0.72	0.76	0.74	0.68								
5/3/2013	TB		5	2.17	2.50	2.43	2.43	2.10	0.66	0.76	0.74	0.74	0.64								
5/8/2013	TB		5	2.17	2.30	2.43	2.30	1.97	0.66	0.70	0.74	0.70	0.60								
5/10/2013	TB		5	2.37	2.57	2.70	2.30	2.03	0.72	0.78	0.82	0.70	0.62								
5/14/2013	TB		5	2.43	2.70	2.63	2.43	2.03	0.74	0.82	0.80	0.74	0.62								
5/16/2013	TB		5	2.23	2.43	2.43	2.30	2.03	0.68	0.74	0.74	0.70	0.62								
5/20/2013	TB		5	2.10	2.03	2.30	2.50	2.03	0.64	0.62	0.70	0.76	0.62								
5/22/2013	TB		5	1.90	2.23	2.37	2.30	1.97	0.58	0.68	0.72	0.70	0.60								
5/29/2013	TB		5	3.03	3.37	3.50	3.37	3.17	0.92	1.03	1.07	1.03	0.97								
5/31/2013	TB		5	2.03	2.23	2.43	2.37	2.23	0.62	0.68	0.74	0.72	0.68								
3/29/2013	TB		6	1.5	1.9	2.7	2.9	2.3	0.46	0.58	0.82	0.88	0.70								
4/3/2013	TB		6	1.5	2.3	2.5	2.5	1.9	0.46	0.70	0.76	0.76	0.58								
4/5/2013	TB		6	1.3	1.9	2.5	2.7	2.5	0.40	0.58	0.76	0.82	0.76								
4/8/2013	TB		6	1.5	1.9	2.3	2.5	2.7	0.46	0.58	0.70	0.76	0.82								
4/12/2013	TB		6	1.83	2.17	2.5	2.43	2.3	0.56	0.66	0.76	0.74	0.70								
4/17/2013	TB		6	1.43	1.63	2.03	1.77	1.43	0.44	0.50	0.62	0.54	0.44								
4/22/2013	TB		6	1.63	2.3	2.5	2.63	2.5	0.50	0.70	0.76	0.80	0.76								
4/24/2013	TB		6	1.43	1.63	2.17	1.97	1.37	0.44	0.50	0.66	0.60	0.42								
4/25/2013	TB		6	2.43	2.3	2.36	2.03	1.06	0.74	0.70	0.72	0.62	0.32								
5/1/2013	TB		6	2.67	2.50	2.23	1.63	1.23	0.81	0.76	0.68	0.50	0.38								
5/3/2013	TB		6	2.57	2.37	2.23	1.90	1.43	0.78	0.72	0.68	0.58	0.44								
5/8/2013	TB		6	1.00	1.50	2.03	1.97	1.63	0.30	0.46	0.62	0.60	0.50								
5/10/2013	TB		6	1.83	2.37	2.70	2.50	2.03	0.56	0.72	0.82	0.76	0.62								
5/14/2013	TB		6	0.90	1.57	2.10	2.17	2.10	0.27	0.48	0.64	0.66	0.64								
5/16/2013	TB		6	1.03	2.10	2.37	2.43	2.50	0.31	0.64	0.72	0.74	0.76								
5/20/2013	TB		6	1.07	1.43	2.23	2.50	2.43	0.33	0.44	0.68	0.76	0.74								
5/22/2013	TB		6	0.87	1.43	2.03	2.50	2.43	0.26	0.44	0.62	0.76	0.74								
5/29/2013	TB		6	2.23	2.57	2.90	2.70	2.50	0.68	0.78	0.88	0.82	0.76								
5/31/2013	TB		6	0.73	1.07	1.63	2.23	2.37	0.22	0.33	0.50	0.68	0.72								

Town Brook Rainbow Smelt Monitoring: **RSD** = Relative Standard Deviation = (SD/Mean)*100 Use RSD when 3 samples were collected

Water Chemistry Measurements **RPD** = Relative Percent Difference = $[(X_1 - X_2)/Mean]*100$ Use RPD when only 2 samples were collected

Year: 2013 **Status Options:** *Preliminary* | | | *Conditional* | *Censored* | *Final*

State: Massachusetts

Date	River	Time	Transect	Sp. Cond. (mS/cm) (No. 1)	Sp. Cond. (mS/cm) (No. 2)	Sp. Cond. (mS/cm) (No. 3)	Sp. Cond. (mS/cm) (No. 4)	Sp. Cond. (mS/cm) (No. 5)	Sp. Cond. (mS/cm) Mean	Sp. Cond. (mS/cm) SD	Sp. Cond. RSD	D.O. (mg/L) (No. 1)	D.O. (mg/L) (No. 2)	D.O. (mg/L) (No. 3)	D.O. (mg/L) (No. 4)	D.O. (mg/L) (No. 5)	D.O. (mg/L) Mean	D.O. (mg/L) SD	D.O. RSD
3/29/2013	TB		1																
4/3/2013	TB		1																
4/5/2013	TB		1																
4/8/2013	TB		1																
4/12/2013	TB		1																
4/17/2013	TB		1																
4/22/2013	TB		1																
4/24/2013	TB		1																
4/25/2013	TB		1																
5/1/2013	TB		1																
5/3/2013	TB		1																
5/8/2013	TB		1																
5/10/2013	TB		1																
5/14/2013	TB		1																
5/16/2013	TB		1																
5/20/2013	TB		1																
5/22/2013	TB		1																
5/29/2013	TB		1																
5/31/2013	TB		1																
3/29/2013	TB		2	15.07	15.08	15.09	15.08		15.08	0.00816	0.05%	12.96	12.89	12.9	12.88		12.9075	0.03594	0.28%
4/3/2013	TB		2	1.376	1.376	1.375	1.375	1.376	1.3756	0.00055	0.04%	16.24	16.22	16.2	16.17	16.14	16.194	0.03975	0.25%
4/5/2013	TB		2	1.268	1.268	1.267	1.266	1.266	1.267	0.00100	0.08%	13.03	13.03	13.01	12.98	12.95	13	0.03464	0.27%
4/8/2013	TB		2	1.25	1.251	1.251	1.252	1.253	1.2514	0.00114	0.09%	12.59	12.59	12.58	12.56	12.55	12.574	0.01817	0.14%
4/12/2013	TB		2	1.128	1.127	1.126	1.126	1.125	1.1264	0.00114	0.10%	12.8	12.83	12.86	12.88	12.91	12.856	0.04278	0.33%
4/17/2013	TB		2	1.22	1.221	1.22	1.22	1.22	1.2202	0.00045	0.04%	11.89	11.88	11.87	11.86	11.86	11.872	0.01304	0.11%
4/22/2013	TB		2	1.149	1.15	1.15	1.149	1.15	1.1496	0.00055	0.05%	11.25	11.26	11.23	11.25	11.24	11.246	0.01140	0.10%
4/24/2013	TB		2	1.096	1.096	1.096	1.097	1.097	1.0964	0.00055	0.05%	8.73	8.75	8.74	8.76	8.75	8.746	0.01140	0.13%
4/25/2013	TB		2	1.221	1.221	1.22	1.221	1.22	1.2206	0.00055	0.04%	6.74	6.83	6.86	6.9	6.92	6.85	0.07071	1.03%
5/1/2013	TB		2	0.944	0.944	0.944	0.945	0.945	0.9444	0.00055	0.06%	4.13	4.25	4.32	4.38	4.41	4.298	0.11212	2.61%
5/3/2013	TB		2	0.952	0.951	0.951	0.952	0.952	0.9516	0.00055	0.06%	4.8	4.71	4.96	5	5.02	4.898	0.13609	2.78%
5/8/2013	TB		2	0.995	0.993	0.993	0.992	0.992	0.993	0.00122	0.12%	5.01	5.06	5.09	5.11	5.13	5.08	0.04690	0.92%
5/10/2013	TB		2	1.097	1.097	1.097	1.097	1.097	1.097	0.00000	0.00%	4.19	4.24	4.28	4.31	4.34	4.272	0.05891	1.38%
5/14/2013	TB		2	0.86	0.86	0.859	0.859	0.859	0.8594	0.00055	0.06%	13.16	13.15	13.15	13.14	13.14	13.148	0.00837	0.06%
5/16/2013	TB		2	0.837	0.837	0.837	0.837	0.837	0.837	0.00000	0.00%	11.3	11.29	11.29	11.29	11.28	11.29	0.00707	0.06%
5/20/2013	TB		2	0.86	0.86	0.861	0.861	0.861	0.8606	0.00055	0.06%	11.53	11.53	11.52	11.52	11.52	11.524	0.00548	0.05%
5/22/2013	TB		2	0.809	0.809	0.809	0.809	0.81	0.8092	0.00045	0.06%	12.9	12.84	12.87	12.87	12.87	12.87	0.02121	0.16%
5/29/2013	TB		2	0.493	0.492	0.491	0.492	0.492	0.492	0.00071	0.14%	13.89	13.9	13.9	13.89	13.9	13.896	0.00548	0.04%
5/31/2013	TB		2	0.826	0.826	0.826	0.826	0.826	0.826	0.00000	0.00%	12.71	12.71	12.72	12.72	12.72	12.716	0.00548	0.04%
3/29/2013	TB		3	15.1	15.11	15.11	15.11		15.1075	0.00500	0.03%	13.33	13.32	13.31	13.3		13.315	0.01291	0.10%
4/3/2013	TB		3	1.383	1.385	1.384	1.385	1.384	1.3842	0.00084	0.06%	16.11	16.11	16.12	16.13	16.12	16.118	0.00837	0.05%
4/5/2013	TB		3	1.273	1.27	1.27	1.267	1.269	1.2698	0.00217	0.17%	12.75	12.73	12.71	12.71	12.7	12.72	0.02000	0.16%
4/8/2013	TB		3	1.257	1.258	1.259	1.262	1.265	1.2602	0.00327	0.26%	12.38	12.4	12.41	12.4	12.39	12.396	0.01140	0.09%
4/12/2013	TB		3	1.168	1.166	1.165	1.163	1.162	1.1648	0.00239	0.20%	12.45	12.43	12.42	12.4	12.39	12.418	0.02387	0.19%
4/17/2013	TB		3	1.221	1.22	1.221	1.22	1.219	1.2202	0.00084	0.07%	12.06	12.09	12.12	12.13	12.14	12.108	0.03271	0.27%
4/22/2013	TB		3	1.173	1.174	1.173	1.173	1.174	1.1734	0.00055	0.05%	11.39	11.37	11.33	11.36	11.35	11.36	0.02236	0.20%
4/24/2013	TB		3	1.112	1.11	1.109	1.109	1.108	1.1096	0.00152	0.14%	8.36	8.41	8.43	8.44	8.45	8.418	0.03564	0.42%
4/25/2013	TB		3	1.24	1.239	1.239	1.24	1.241	1.2398	0.00084	0.07%	7.16	7.14	7.15	7.16	7.17	7.156	0.01140	0.16%
5/1/2013	TB		3	0.959	0.957	0.96	0.959	0.958	0.9586	0.00114	0.12%	3.85	3.92	4.07	4.15	4.21	4.04	0.15199	3.76%
5/3/2013	TB		3	0.988	0.985	0.983	0.982	0.982	0.984	0.00255	0.26%	4.01	4.22	4.31	4.39	4.45	4.276	0.17199	4.02%
5/8/2013	TB		3	1.033	1.031	1.029	1.028	1.027	1.0296	0.00241	0.23%	4.51	4.57	4.63	4.66	4.68	4.61	0.06964	1.51%
5/10/2013	TB		3	1.099	1.099	1.098	1.098	1.098	1.0984	0.00055	0.05%	3.64	3.67	3.7	3.72	3.74	3.694	0.03975	1.08%
5/14/2013	TB		3	0.867	0.866	0.866	0.865	0.865	0.8658	0.00084	0.10%	13.27	13.26	13.26	13.27	13.26	13.264	0.00548	0.04%
5/16/2013	TB		3	0.863	0.862	0.862	0.861	0.861	0.8618	0.00084	0.10%	11.59	11.58	11.58	11.57	11.56	11.576	0.01140	0.10%
5/20/2013	TB		3	0.882	0.881	0.882	0.883	0.882	0.882	0.00071	0.08%	11.77	11.74	11.72	11.71	11.7	11.728	0.02775	0.24%
5/22/2013	TB		3	0.827	0.826	0.826	0.825	0.825	0.8258	0.00084	0.10%	12.89	12.88	12.88	12.87	12.86	12.876	0.01140	0.09%
5/29/2013	TB		3	0.446	0.441	0.439	0.438	0.437	0.4402	0.00356	0.81%	14.01	14.07	14.11	14.12	14.14	14.09	0.05148	0.37%
5/31/2013	TB		3	0.857	0.857	0.857	0.857	0.856	0.8568	0.00045	0.05%	12.76	12.74	12.75	12.75	12.76	12.752	0.00837	0.07%

Date	River	Time	Transect	Sp. Cond. (mS/cm) (No. 1)	Sp. Cond. (mS/cm) (No. 2)	Sp. Cond. (mS/cm) (No. 3)	Sp. Cond. (mS/cm) (No. 4)	Sp. Cond. (mS/cm) (No. 5)	Sp. Cond. (mS/cm) Mean	Sp. Cond. (mS/cm) SD	Sp. Cond. RSD	D.O. (mg/L) (No. 1)	D.O. (mg/L) (No. 2)	D.O. (mg/L) (No. 3)	D.O. (mg/L) (No. 4)	D.O. (mg/L) (No. 5)	D.O. (mg/L) Mean	D.O. (mg/L) SD	D.O. RSD
3/29/2013	TB		4	14.95	14.99	15	15.02		14.99	0.02944	0.20%	13.26	13.23	13.2	13.18		13.2175	0.03500	0.26%
4/3/2013	TB		4	1.369	1.371	1.372	1.373	1.374	1.3718	0.00192	0.14%	16.3	16.3	16.31	16.3	16.31	16.304	0.00548	0.03%
4/5/2013	TB		4	1.254	1.255	1.254	1.257	1.258	1.2556	0.00182	0.14%	13.18	13.19	13.2	13.21	13.22	13.2	0.01581	0.12%
4/8/2013	TB		4	1.201	1.209	1.213	1.216	1.22	1.2118	0.00726	0.60%	13.11	13.07	13.03	13.01	12.98	13.04	0.05099	0.39%
4/12/2013	TB		4	1.117	1.12	1.122	1.123	1.124	1.1212	0.00277	0.25%	13.07	13	12.98	12.97	12.96	12.996	0.04393	0.34%
4/17/2013	TB		4	1.178	1.181	1.184	1.186	1.189	1.1836	0.00428	0.36%	12.25	12.31	12.34	12.36	12.35	12.322	0.04438	0.36%
4/22/2013	TB		4	1.128	1.129	1.13	1.13	1.131	1.1296	0.00114	0.10%	11.05	11.07	11.08	11.09	11.1	11.078	0.01924	0.17%
4/24/2013	TB		4	1.087	1.09	1.089	1.09	1.091	1.0894	0.00152	0.14%	9	8.93	8.9	8.89	8.88	8.92	0.04848	0.54%
4/25/2013	TB		4	1.228	1.229	1.23	1.23	1.229	1.2292	0.00084	0.07%	4.87	5.05	5.14	5.2	5.25	5.102	0.14957	2.93%
5/1/2013	TB		4	0.966	0.966	0.956	0.964	0.964	0.9632	0.00415	0.43%	3.18	3.26	3.4	3.5	3.58	3.384	0.16517	4.88%
5/3/2013	TB		4	0.955	0.953	0.954	0.955	0.955	0.9544	0.00089	0.09%	3.17	3.84	4.03	4.09	4.14	3.854	0.39891	10.35%
5/8/2013	TB		4	1.01	1.011	1.011	1.012	1.012	1.0112	0.00084	0.08%	2.4	2.44	2.48	2.51	2.53	2.472	0.05263	2.13%
5/10/2013	TB		4	1.085	1.086	1.086	1.087	1.087	1.0862	0.00084	0.08%	3.21	3.24	3.28	3.31	3.35	3.278	0.05541	1.69%
5/14/2013	TB		4	0.868	0.866	0.868	0.865	0.864	0.8662	0.00179	0.21%	13.25	13.27	13.28	13.28	13.28	13.272	0.01304	0.10%
5/16/2013	TB		4	0.855	0.854	0.854	0.853	0.852	0.8536	0.00114	0.13%	11.56	11.51	11.49	11.48	11.47	11.502	0.03564	0.31%
5/20/2013	TB		4	0.879	0.878	0.878	0.878	0.878	0.8782	0.00045	0.05%	11.51	11.5	11.5	11.51	11.51	11.506	0.00548	0.05%
5/22/2013	TB		4	0.841	0.841	0.839	0.838	0.837	0.8392	0.00179	0.21%	13.04	13.02	13	12.99	12.97	13.004	0.02702	0.21%
5/29/2013	TB		4	0.202	0.201	0.201	0.201	0.2	0.201	0.00071	0.35%	14.15	14.15	14.16	14.16	14.16	14.156	0.00548	0.04%
5/31/2013	TB		4	0.841	0.842	0.841	0.841	0.842	0.8414	0.00055	0.07%	12.76	12.78	12.79	12.8	12.82	12.79	0.02236	0.17%
3/29/2013	TB		5																
4/3/2013	TB		5																
4/5/2013	TB		5																
4/8/2013	TB		5																
4/12/2013	TB		5																
4/17/2013	TB		5																
4/22/2013	TB		5																
4/24/2013	TB		5																
4/25/2013	TB		5																
5/1/2013	TB		5																
5/3/2013	TB		5																
5/8/2013	TB		5																
5/10/2013	TB		5																
5/14/2013	TB		5																
5/16/2013	TB		5																
5/20/2013	TB		5																
5/22/2013	TB		5																
5/29/2013	TB		5																
5/31/2013	TB		5																
3/29/2013	TB		6																
4/3/2013	TB		6																
4/5/2013	TB		6																
4/8/2013	TB		6																
4/12/2013	TB		6																
4/17/2013	TB		6																
4/22/2013	TB		6																
4/24/2013	TB		6																
4/25/2013	TB		6																
5/1/2013	TB		6																
5/3/2013	TB		6																
5/8/2013	TB		6																
5/10/2013	TB		6																
5/14/2013	TB		6																
5/16/2013	TB		6																
5/20/2013	TB		6																
5/22/2013	TB		6																
5/29/2013	TB		6																
5/31/2013	TB		6																

Town Brook Rainbow Smelt Monitoring:

Water Chemistry Measurements

Year: 2013

State: Massachusetts

Date	River	Time	Transect	Depth (ft) (No. 1)	Depth (ft) (No. 2)	Depth (ft) (No. 3)	Depth (ft) (No. 4)	Depth (ft) (No. 5)	Depth (cm) Mean	Depth (cm) SD	Depth RSD	pH (No. 1)	pH (No. 2)	pH (No. 3)	pH (No. 4)	pH (No. 5)	pH Mean	pH SD	pH RSD
3/29/2013	TB		1	0.45	0.7	1	0.9	0.7	0.75	0.21213	28.28%								
4/3/2013	TB		1	0.5	0.65	0.9	0.8	0.7	0.71	0.15166	21.36%								
4/5/2013	TB		1	0.6	0.85	0.95	0.75	0.6	0.75	0.15411	20.55%								
4/8/2013	TB		1	0.7	0.9	1	0.8	0.5	0.78	0.19235	24.66%								
4/12/2013	TB		1	0.55	0.75	0.9	0.8	0.6	0.72	0.14405	20.01%								
4/17/2013	TB		1	0.5	0.8	1	0.75	0.6	0.73	0.19235	26.35%								
4/22/2013	TB		1	0.6	0.8	1	0.85	0.65	0.78	0.16047	20.57%								
4/24/2013	TB		1	0.55	0.8	1	0.75	0.65	0.75	0.16956	22.61%								
4/25/2013	TB		1	0.6	0.85	1	0.8	0.6	0.77	0.17176	22.31%								
5/1/2013	TB		1	0.6	0.8	1	0.8	0.5	0.74	0.19494	26.34%								
5/3/2013	TB		1	0.6	0.8	0.9	0.75	0.6	0.73	0.13038	17.86%								
5/8/2013	TB		1	0.5	0.75	0.9	0.8	0.6	0.71	0.15969	22.49%								
5/10/2013	TB		1	0.7	0.9	1.1	0.85	0.65	0.84	0.17819	21.21%								
5/14/2013	TB		1	0.6	0.8	0.9	0.85	0.6	0.75	0.14142	18.86%								
5/16/2013	TB		1	0.65	0.8	0.9	0.8	0.6	0.75	0.12247	16.33%								
5/20/2013	TB		1	0.5	0.7	0.9	0.75	0.6	0.69	0.15166	21.98%								
5/22/2013	TB		1	0.6	0.8	1	0.85	0.6	0.77	0.17176	22.31%								
5/29/2013	TB		1	1.1	1.4	1.5	1.3	1.1	1.28	0.17889	13.98%								
5/31/2013	TB		1	0.6	0.7	0.8	0.8	0.7	0.72	0.08367	11.62%								
3/29/2013	TB		2	0.38	0.58	0.75	0.67	0.50	0.575	0.14554	25.31%	7.15	7.13	7.13	7.13		7.135	0.01000	0.14%
4/3/2013	TB		2	0.5	0.8	0.9	0.8	0.7	0.74	0.15166	20.49%	7.16	7.15	7.15	7.15	7.14	7.15	0.00707	0.10%
4/5/2013	TB		2	0.55	0.75	0.9	0.8	0.7	0.74	0.12942	17.49%	7.15	7.14	7.13	7.11	7.1	7.126	0.02074	0.29%
4/8/2013	TB		2	0.5	0.95	0.85	0.75	0.6	0.73	0.18235	24.98%	7.12	7.12	7.12	7.12	7.12	7.12	0.00000	0.00%
4/12/2013	TB		2	0.6	0.75	0.9	0.8	0.65	0.74	0.11937	16.13%	7.04	7.03	7.03	7	7	7.02	0.01871	0.27%
4/17/2013	TB		2	0.55	0.65	0.75	0.8	0.6	0.67	0.10368	15.47%	7.22	7.23	7.24	7.25	7.24	7.236	0.01140	0.16%
4/22/2013	TB		2	0.5	0.6	0.85	0.75	0.6	0.66	0.13874	21.02%	7.28	7.27	7.27	7.26	7.27	7.27	0.00707	0.10%
4/24/2013	TB		2	0.55	0.7	0.85	0.8	0.65	0.71	0.11937	16.81%	7.19	7.19	7.18	7.18	7.18	7.184	0.00548	0.08%
4/25/2013	TB		2	0.5	0.7	0.9	0.8	0.7	0.72	0.14832	20.60%	7.15	7.14	7.14	7.15	7.15	7.146	0.00548	0.08%
5/1/2013	TB		2	0.5	0.65	0.85	0.75	0.6	0.67	0.13509	20.16%	7.04	7.04	7.04	7.05	7.05	7.044	0.00548	0.08%
5/3/2013	TB		2	0.5	0.7	0.85	0.7	0.6	0.67	0.13038	19.46%	7.19	7.18	7.18	7.18	7.18	7.182	0.00447	0.06%
5/8/2013	TB		2	0.5	0.65	0.75	0.6	0.55	0.61	0.09618	15.77%	7.12	7.1	7.1	7.1	7.1	7.104	0.00894	0.13%
5/10/2013	TB		2	0.6	0.75	0.9	0.7	0.65	0.72	0.11511	15.99%	7.09	7.08	7.07	7.06	7.06	7.072	0.01304	0.18%
5/14/2013	TB		2	0.45	0.7	0.8	0.7	0.55	0.64	0.13874	21.68%	7.18	7.16	7.16	7.16	7.16	7.164	0.00894	0.12%
5/16/2013	TB		2	0.6	0.75	0.8	0.7	0.6	0.69	0.08944	12.96%	7.37	7.36	7.37	7.36	7.36	7.364	0.00548	0.07%
5/20/2013	TB		2	0.6	0.7	0.8	0.7	0.65	0.69	0.07416	10.75%	7.36	7.36	7.35	7.35	7.35	7.354	0.00548	0.07%
5/22/2013	TB		2	0.55	0.65	0.8	0.75	0.6	0.67	0.10368	15.47%	7.31	7.29	7.28	7.27	7.27	7.284	0.01673	0.23%
5/29/2013	TB		2	0.95	1.2	1.3	1.1	1	1.11	0.14318	12.90%	7.12	7.1	7.1	7.1	7.09	7.102	0.01095	0.15%
5/31/2013	TB		2	0.45	0.6	0.7	0.7	0.6	0.61	0.10247	16.80%	7.16	7.16	7.16	7.15	7.15	7.156	0.00548	0.08%
3/29/2013	TB		3	0.8	1	1.1	0.9	0.7	0.9	0.15811	17.57%	7.16	7.15	7.16	7.15		7.155	0.00577	0.08%
4/3/2013	TB		3	0.7	0.8	1	0.9	0.8	0.84	0.11402	13.57%	7.19	7.18	7.18	7.18	7.18	7.182	0.00447	0.06%
4/5/2013	TB		3	0.4	0.55	0.75	0.7	0.5	0.58	0.14405	24.84%	7.12	7.13	7.13	7.13	7.13	7.128	0.00447	0.06%
4/8/2013	TB		3	0.45	0.6	0.9	0.8	0.4	0.63	0.21679	34.41%	7.13	7.12	7.11	7.11	7.11	7.116	0.00894	0.13%
4/12/2013	TB		3	0.6	0.8	0.9	0.8	0.6	0.74	0.13416	18.13%	7.07	7.06	7	7.07	7.07	7.054	0.03050	0.43%
4/17/2013	TB		3	0.6	0.7	0.85	0.7	0.6	0.69	0.10247	14.85%	7.24	7.23	7.23	7.25	7.25	7.24	0.01000	0.14%
4/22/2013	TB		3	0.6	0.65	0.75	0.6	0.5	0.62	0.09083	14.65%	7.23	7.22	7.22	7.21	7.21	7.218	0.00837	0.12%
4/24/2013	TB		3	0.7	0.95	1	0.9	0.5	0.81	0.20736	25.60%	7.24	7.23	7.23	7.22	7.22	7.228	0.00837	0.12%
4/25/2013	TB		3	0.5	0.75	0.95	0.7	0.6	0.7	0.16956	24.22%	7.19	7.18	7.19	7.19	7.19	7.188	0.00447	0.06%
5/1/2013	TB		3	0.6	0.75	0.85	0.8	0.55	0.71	0.12942	18.23%	7.03	7.04	7.03	7.03	7.03	7.032	0.00447	0.06%
5/3/2013	TB		3	0.6	0.7	0.75	0.7	0.5	0.65	0.10000	15.38%	7.2	7.19	7.19	7.18	7.18	7.188	0.00837	0.12%
5/8/2013	TB		3	0.55	0.65	0.8	0.7	0.55	0.65	0.10607	16.32%	7.12	7.12	7.12	7.11	7.11	7.116	0.00548	0.08%
5/10/2013	TB		3	0.65	0.75	0.85	0.8	0.65	0.74	0.08944	12.09%	7.11	7.09	7.09	7.08	7.07	7.088	0.01483	0.21%
5/14/2013	TB		3	0.55	0.65	0.7	0.6	0.4	0.58	0.11511	19.85%	7.2	7.19	7.19	7.19	7.19	7.192	0.00447	0.06%
5/16/2013	TB		3	0.6	0.7	0.75	0.7	0.55	0.66	0.08216	12.45%	7.36	7.37	7.37	7.37	7.37	7.368	0.00447	0.06%
5/20/2013	TB		3	0.6	0.65	0.7	0.55	0.45	0.59	0.09618	16.30%	7.38	7.36	7.35	7.34	7.34	7.354	0.01673	0.23%
5/22/2013	TB		3	0.5	0.6	0.75	0.65	0.5	0.6	0.10607	17.68%	7.29	7.28	7.28	7.28	7.28	7.282	0.00447	0.06%
5/29/2013	TB		3	0.95	1.2	1.3	1.1	0.9	1.09	0.16733	15.35%	7.16	7.14	7.13	7.13	7.12	7.136	0.01517	0.21%
5/31/2013	TB		3	0.6	0.65	0.7	0.55	0.45	0.59	0.09618	16.30%	7.14	7.15	7.14	7.14	7.14	7.142	0.00447	0.06%

				Depth	Depth	Depth	Depth	Depth	Depth	Depth	Depth	pH	pH	pH	pH	pH	pH	pH	pH
				(ft)	(ft)	(ft)	(ft)	(ft)	(cm)	(cm)										
Date	River	Time	Transect	(No. 1)	(No. 2)	(No. 3)	(No. 4)	(No. 5)	Mean	SD	RSD	(No. 1)	(No. 2)	(No. 3)	(No. 4)	(No. 5)	Mean	SD	RSD
3/29/2013	TB		4	0.4	0.45	0.55	0.4	0.4	0.44	0.06519	14.82%	7.21	7.2	7.2	7.19		7.2	0.00816	0.11%
4/3/2013	TB		4	0.5	0.55	0.6	0.55	0.5	0.54	0.04183	7.75%	7.2	7.21	7.22	7.22	7.21	7.212	0.00837	0.12%
4/5/2013	TB		4	0.4	0.5	0.55	0.4	0.3	0.43	0.09747	22.67%	7.18	7.18	7.18	7.18	7.18	7.18	0.00000	0.00%
4/8/2013	TB		4	0.5	0.4	0.45	0.4	0.3	0.41	0.07416	18.09%	7.3	7.24	7.2	7.19	7.19	7.224	0.04722	0.65%
4/12/2013	TB		4	0.4	0.5	0.5	0.5	0.4	0.46	0.05477	11.91%	7.11	7.11	7.11	7.1	7.1	7.106	0.00548	0.08%
4/17/2013	TB		4	2.3	2.5	2.3	2.1	1.9	2.22	0.22804	10.27%	7.21	7.22	7.22	7.24	7.23	7.224	0.01140	0.16%
4/22/2013	TB		4	0.45	0.4	0.4	0.4	0.3	0.39	0.05477	14.04%	7.29	7.28	7.27	7.25	7.26	7.27	0.01581	0.22%
4/24/2013	TB		4	0.4	0.5	0.5	0.55	0.5	0.49	0.05477	11.18%	7.28	7.27	7.27	7.26	7.27	7.27	0.00707	0.10%
4/25/2013	TB		4	0.5	0.45	0.4	0.45	0.5	0.46	0.04183	9.09%	7.08	7.05	7.03	7.04	7.05	7.05	0.01871	0.27%
5/1/2013	TB		4	0.5	0.4	0.4	0.3	0.25	0.37	0.09747	26.34%	7.17	7.16	7.15	7.14	7.12	7.148	0.01924	0.27%
5/3/2013	TB		4	0.45	0.4	0.4	0.45	0.4	0.42	0.02739	6.52%	7.23	7.22	7.22	7.22	7.22	7.222	0.00447	0.06%
5/8/2013	TB		4	0.4	0.35	0.45	0.4	0.4	0.4	0.03536	8.84%	7.16	7.14	7.14	7.13	7.13	7.14	0.01225	0.17%
5/10/2013	TB		4	0.55	0.5	0.45	0.45	0.4	0.47	0.05701	12.13%	7.1	7.09	7.09	7.09	7.09	7.092	0.00447	0.06%
5/14/2013	TB		4	0.5	0.35	0.35	0.3	0.3	0.36	0.08216	22.82%	7.28	7.25	7.24	7.23	7.23	7.246	0.02074	0.29%
5/16/2013	TB		4	0.45	0.35	0.4	0.3	0.25	0.35	0.07906	22.59%	7.61	7.59	7.58	7.58	7.57	7.586	0.01517	0.20%
5/20/2013	TB		4	0.45	0.4	0.4	0.36	0.25	0.372	0.07530	20.24%	7.4	7.39	7.39	7.39	7.39	7.392	0.00447	0.06%
5/22/2013	TB		4	0.55	0.4	0.35	0.3	0.25	0.37	0.11511	31.11%	7.36	7.35	7.34	7.34	7.33	7.344	0.01140	0.16%
5/29/2013	TB		4	0.95	0.8	0.85	0.8	0.75	0.83	0.07583	9.14%	7.31	7.29	7.28	7.28	7.27	7.286	0.01517	0.21%
5/31/2013	TB		4	0.4	0.35	0.4	0.3	0.25	0.34	0.06519	19.17%	7.17	7.16	7.17	7.17	7.17	7.168	0.00447	0.06%
3/29/2013	TB		5	0.4	0.45	0.5	0.4	0.4	0.43	0.04472	10.40%								
4/3/2013	TB		5	0.5	0.5	0.6	0.55	0.5	0.53	0.04472	8.44%								
4/5/2013	TB		5	0.4	0.45	0.5	0.5	0.4	0.45	0.05000	11.11%								
4/8/2013	TB		5	0.4	0.45	0.5	0.45	0.4	0.44	0.04183	9.51%								
4/12/2013	TB		5	0.3	0.4	0.5	0.5	0.5	0.44	0.08944	20.33%								
4/17/2013	TB		5	0.4	0.5	0.5	0.4	0.4	0.44	0.05477	12.45%								
4/22/2013	TB		5	0.4	0.4	0.45	0.5	0.45	0.44	0.04183	9.51%								
4/24/2013	TB		5	0.35	0.4	0.4	0.5	0.45	0.42	0.05701	13.57%								
4/25/2013	TB		5	0.4	0.45	0.5	0.5	0.45	0.46	0.04183	9.09%								
5/1/2013	TB		5	0.4	0.4	0.5	0.4	0.3	0.4	0.07071	17.68%								
5/3/2013	TB		5	0.4	0.45	0.45	0.4	0.45	0.43	0.02739	6.37%								
5/8/2013	TB		5	0.4	0.4	0.45	0.5	0.4	0.43	0.04472	10.40%								
5/10/2013	TB		5	0.4	0.5	0.5	0.55	0.6	0.51	0.07416	14.54%								
5/14/2013	TB		5	0.4	0.4	0.4	0.45	0.45	0.42	0.02739	6.52%								
5/16/2013	TB		5	0.45	0.4	0.4	0.4	0.45	0.42	0.02739	6.52%								
5/20/2013	TB		5	0.4	0.35	0.4	0.3	0.3	0.35	0.05000	14.29%								
5/22/2013	TB		5	0.4	0.45	0.4	0.4	0.4	0.41	0.02236	5.45%								
5/29/2013	TB		5	0.95	1	0.9	0.95	0.9	0.94	0.04183	4.45%								
5/31/2013	TB		5	0.4	0.45	0.4	0.45	0.5	0.44	0.04183	9.51%								
3/29/2013	TB		6	0.4	0.5	0.6	0.5	0.5	0.5	0.07071	14.14%								
4/3/2013	TB		6	0.45	0.55	0.6	0.6	0.5	0.54	0.06519	12.07%								
4/5/2013	TB		6	0.3	0.45	0.3	0.5	0.6	0.43	0.13038	30.32%								
4/8/2013	TB		6	0.3	0.4	0.5	0.6	0.6	0.48	0.13038	27.16%								
4/12/2013	TB		6	0.4	0.5	0.6	0.45	0.4	0.47	0.08367	17.80%								
4/17/2013	TB		6	0.4	0.5	0.55	0.5	0.5	0.49	0.05477	11.18%								
4/22/2013	TB		6	0.2	0.4	0.5	0.55	0.6	0.45	0.15811	35.14%								
4/24/2013	TB		6	0.25	0.35	0.4	0.55	0.6	0.43	0.14405	33.50%								
4/25/2013	TB		6	0.25	0.3	0.35	0.45	0.5	0.37	0.10368	28.02%								
5/1/2013	TB		6	0.25	0.3	0.45	0.5	0.6	0.42	0.14405	34.30%								
5/3/2013	TB		6	0.25	0.3	0.4	0.5	0.55	0.4	0.12748	31.87%								
5/8/2013	TB		6	0.2	0.3	0.4	0.45	0.4	0.35	0.10000	28.57%								
5/10/2013	TB		6	0.2	0.35	0.4	0.45	0.5	0.38	0.11511	30.29%								
5/14/2013	TB		6	0.2	0.3	0.4	0.4	0.5	0.36	0.11402	31.67%								
5/16/2013	TB		6	0.25	0.35	0.4	0.45	0.6	0.41	0.12942	31.57%								
5/20/2013	TB		6	0.2	0.3	0.4	0.45	0.5	0.37	0.12042	32.54%								
5/22/2013	TB		6	0.25	0.4	0.45	0.5	0.55	0.43	0.11511	26.77%								
5/29/2013	TB		6	1	1.1	1.2	1.35	1.4	1.21	0.16733	13.83%								
5/31/2013	TB		6	0.2	0.35	0.4	0.45	0.5	0.38	0.11511	30.29%								

Town Brook Rainbow Smelt Monitoring:

Water Chemistry Measurements

Year: 2013

State: Massachusetts

Date	River	Time	Transect	Turbidity (NTU) *(No. 1)*	Turbidity (NTU) *(No. 2)*	Turbidity (NTU) *(No. 3)*	Turbidity (NTU) *(No. 4)*	Turbidity (NTU) *(No. 5)*	Turbidity (NTU) **Mean**	Turbidity (NTU) **SD**	Turbidity **RSD**	**Notes**
3/29/2013	TB		1									
4/3/2013	TB		1									
4/5/2013	TB		1									
4/8/2013	TB		1									
4/12/2013	TB		1									
4/17/2013	TB		1									
4/22/2013	TB		1									
4/24/2013	TB		1									
4/25/2013	TB		1									
5/1/2013	TB		1									
5/3/2013	TB		1									
5/8/2013	TB		1									
5/10/2013	TB		1									
5/14/2013	TB		1									
5/16/2013	TB		1									
5/20/2013	TB		1									
5/22/2013	TB		1									
5/29/2013	TB		1									
5/31/2013	TB		1									
3/29/2013	TB		2	1.3	0.9	1.2	1.5		1.225	0.25000	20.41%	
4/3/2013	TB		2	0.2	0.2	0.2	0.1	0.2	0.18	0.04472	24.85%	
4/5/2013	TB		2	0.4	0.6	1.6	0.7	0.8	0.82	0.46043	56.15%	
4/8/2013	TB		2	0.6	0.3	0.4	0.5	0.5	0.46	0.11402	24.79%	
4/12/2013	TB		2	1.3	0.9	0.8	1	0.5	0.9	0.29155	32.39%	
4/17/2013	TB		2	0.8	0.7	0.3	0.5	0.2	0.5	0.25495	50.99%	
4/22/2013	TB		2	1.1	0.8	0.5	1.3	0.7	0.88	0.31937	36.29%	
4/24/2013	TB		2	0.6	0.3	0.7	0.3	0.5	0.48	0.17889	37.27%	
4/25/2013	TB		2	0.9	0.6	0.5	0.7	0.5	0.64	0.16733	26.15%	
5/1/2013	TB		2	0.8	1	0.6	0.7	0.9	0.8	0.15811	19.76%	
5/3/2013	TB		2	0.7	0.7	0.8	0.9	0.4	0.7	0.18708	26.73%	
5/8/2013	TB		2	0.3	0.6	0.2	0.4	0.3	0.36	0.15166	42.13%	
5/10/2013	TB		2	1.6	0.8	0.9	0.4	0.6	0.86	0.45607	53.03%	
5/14/2013	TB		2	2	0.6	0.3	0.2	0.4	0.7	0.74162	105.95%	
5/16/2013	TB		2	0.7	0.2	0.4	0.2	0.2	0.34	0.21909	64.44%	
5/20/2013	TB		2	0.6	0.3	0.5	0.4	0.4	0.44	0.11402	25.91%	
5/22/2013	TB		2	1.1	0.4	0.6	0.3	0.3	0.54	0.33615	62.25%	
5/29/2013	TB		2	1.2	0.5	0.3	0.5	0.4	0.58	0.35637	61.44%	
5/31/2013	TB		2	0.4	0.3	0.5	0.2	0.3	0.34	0.11402	33.53%	
3/29/2013	TB		3	2	1.9	1.9	1.7		1.875	0.12583	6.71%	
4/3/2013	TB		3	1.1	0.9	0.8	0.7	1	0.9	0.15811	17.57%	
4/5/2013	TB		3	1	0.8	0.3	0.1	0.2	0.48	0.39623	82.55%	
4/8/2013	TB		3	0.8	0.7	0.3	1.2	0.4	0.68	0.35637	52.41%	
4/12/2013	TB		3	8.1	3.6	4.2	5.1	3.9	4.98	1.83221	36.79%	
4/17/2013	TB		3	0.9	0.6	0.8	1	0.8	0.82	0.14832	18.09%	
4/22/2013	TB		3	1.7	0.8	0.2	0.6	0.4	0.74	0.58138	78.56%	
4/24/2013	TB		3	0.5	0.6	1.1	0.8	0.6	0.72	0.23875	33.16%	
4/25/2013	TB		3	0.2	0.8	0.8	0.8	0.7	0.66	0.26077	39.51%	
5/1/2013	TB		3	0.4	0.2	0.2	0.4	0.3	0.3	0.10000	33.33%	
5/3/2013	TB		3	3.5	0.8	1.1	0.9	0.6	1.38	1.19875	86.87%	
5/8/2013	TB		3	3.8	1.2	0.9	1.7	1.3	1.78	1.16490	65.44%	
5/10/2013	TB		3	0.8	0.6	0.5	1	0.8	0.74	0.19494	26.34%	
5/14/2013	TB		3	0.8	0.4	0.3	0.6	0.5	0.52	0.19235	36.99%	
5/16/2013	TB		3	0.9	1.1	0.8	0.6	0.7	0.82	0.19235	23.46%	
5/20/2013	TB		3	1.1	0.8	1	0.6	0.9	0.88	0.19235	21.86%	
5/22/2013	TB		3	0.9	1.3	0.8	1.1	1	1.02	0.19235	18.86%	
5/29/2013	TB		3	16.3	12.1	11.8	13.2	10.4	12.76	2.21653	17.37%	
5/31/2013	TB		3	0.8	1.1	0.7	0.7	0.9	0.84	0.16733	19.92%	

Date	River	Time	Transect	Turbidity (NTU) *(No. 1)*	Turbidity (NTU) *(No. 2)*	Turbidity (NTU) *(No. 3)*	Turbidity (NTU) *(No. 4)*	Turbidity (NTU) *(No. 5)*	Turbidity (NTU) **Mean**	Turbidity (NTU) **SD**	Turbidity **RSD**	**Notes**
3/29/2013	TB		4	0.3	0.3	0.4	0.3		0.325	0.05000	15.38%	
4/3/2013	TB		4	0.2	0.1	0.3	0.3	0.4	0.26	0.11402	43.85%	
4/5/2013	TB		4	0.6	0.5	0.6	0.7	0.6	0.6	0.07071	11.79%	
4/8/2013	TB		4	0.9	0.8	0.8	0.7	0.6	0.76	0.11402	15.00%	
4/12/2013	TB		4	0.2	0.3	0.2	0.1	0.2	0.2	0.07071	35.36%	
4/17/2013	TB		4	0.9	0.6	0.7	0.4	0.5	0.62	0.19235	31.02%	
4/22/2013	TB		4	0.8	0.5	0.7	0.4	0.5	0.58	0.16432	28.33%	
4/24/2013	TB		4	1.3	0.8	0.6	0.7	0.5	0.78	0.31145	39.93%	
4/25/2013	TB		4	0.7	0.8	0.7	0.7	0.8	0.74	0.05477	7.40%	
5/1/2013	TB		4	0.5	0.4	0.6	0.6	0.5	0.52	0.08367	16.09%	
5/3/2013	TB		4	0.4	0.7	0.6	0.6	0.5	0.56	0.11402	20.36%	
5/8/2013	TB		4	0.4	0.2	0.3	0.4	0.4	0.34	0.08944	26.31%	
5/10/2013	TB		4	0.2	0.4	0.2	0.3	0.3	0.28	0.08367	29.88%	
5/14/2013	TB		4	0.4	0.6	0.4	0.3	0.4	0.42	0.10954	26.08%	
5/16/2013	TB		4	0.3	0.5	0.4	0.3	0.3	0.36	0.08944	24.85%	
5/20/2013	TB		4	0.7	0.5	0.5	0.4	0.6	0.54	0.11402	21.11%	
5/22/2013	TB		4	1.2	0.5	0.3	0.5	0.4	0.58	0.35637	61.44%	
5/29/2013	TB		4	19.8	17.1	17.9	12.4	14.5	16.34	2.91084	17.81%	
5/31/2013	TB		4	1.5	0.9	0.4	0.3	0.4	0.7	0.50498	72.14%	
3/29/2013	TB		5									
4/3/2013	TB		5									
4/5/2013	TB		5									
4/8/2013	TB		5									
4/12/2013	TB		5									
4/17/2013	TB		5									
4/22/2013	TB		5									
4/24/2013	TB		5									
4/25/2013	TB		5									
5/1/2013	TB		5									
5/3/2013	TB		5									
5/8/2013	TB		5									
5/10/2013	TB		5									
5/14/2013	TB		5									
5/16/2013	TB		5									
5/20/2013	TB		5									
5/22/2013	TB		5									
5/29/2013	TB		5									
5/31/2013	TB		5									
3/29/2013	TB		6									
4/3/2013	TB		6									
4/5/2013	TB		6									
4/8/2013	TB		6									
4/12/2013	TB		6									
4/17/2013	TB		6									
4/22/2013	TB		6									
4/24/2013	TB		6									
4/25/2013	TB		6									
5/1/2013	TB		6									
5/3/2013	TB		6									
5/8/2013	TB		6									
5/10/2013	TB		6									
5/14/2013	TB		6									
5/16/2013	TB		6									
5/20/2013	TB		6									
5/22/2013	TB		6									
5/29/2013	TB		6									
5/31/2013	TB		6									

Appendix D: Town Brook Monitoring Procedure (February 2013)

Town Brook Monitoring Procedure
Quincy, Massachusetts

Submitted to

City of Quincy

By:

URS Corporation
260 Franklin Street
Boston, MA 02110

February 2013

Table of Contents

Introduction

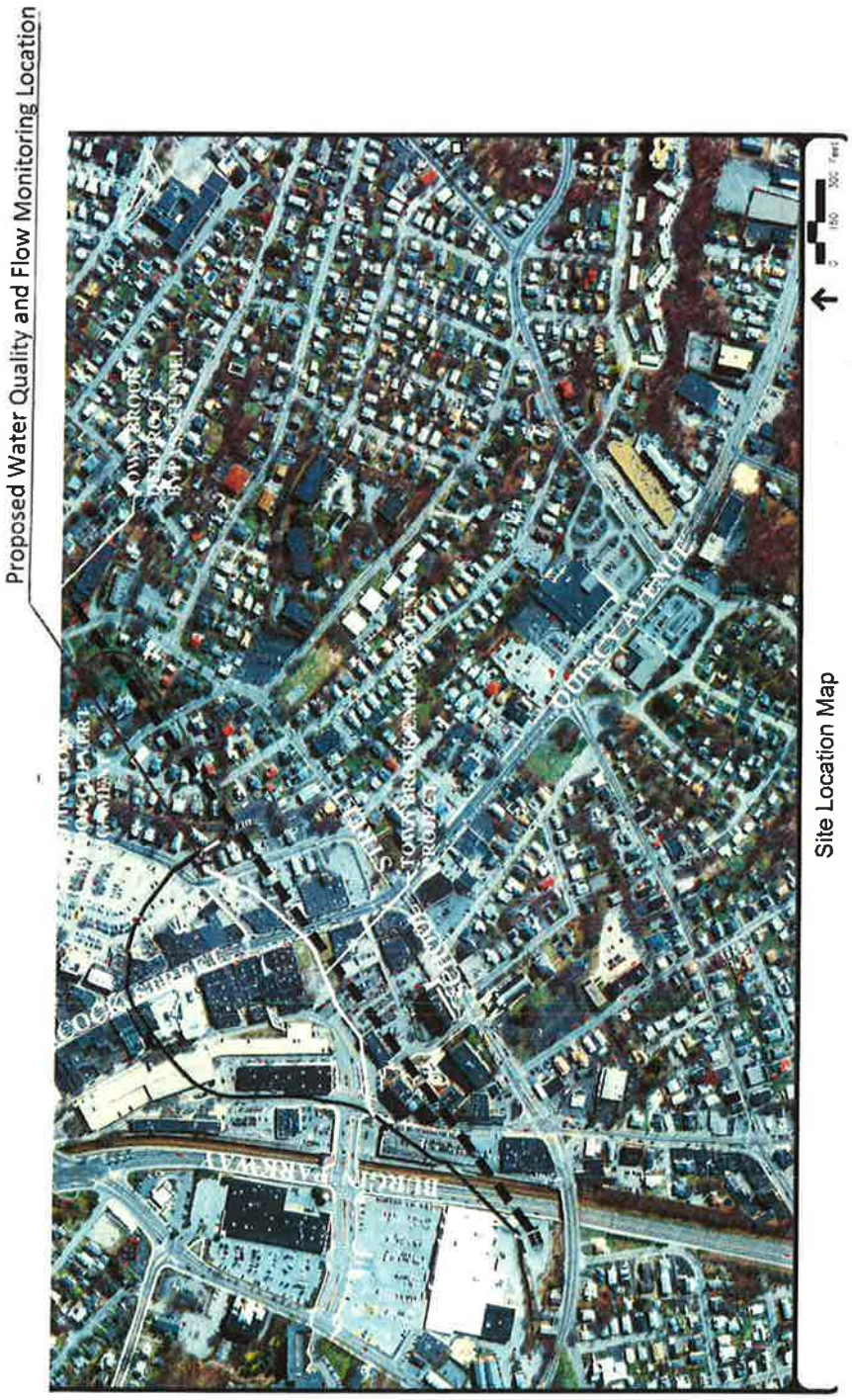
The Town Brook Relocation project proposes to realign 1700 linear feet of culverted river from the Quincy Center to a new location as part of the Quincy Center Urban Revitalization District Plan. The proposed new alignment will consist of 1200 linear feet of channel of which approximately 264 feet will be open channel.

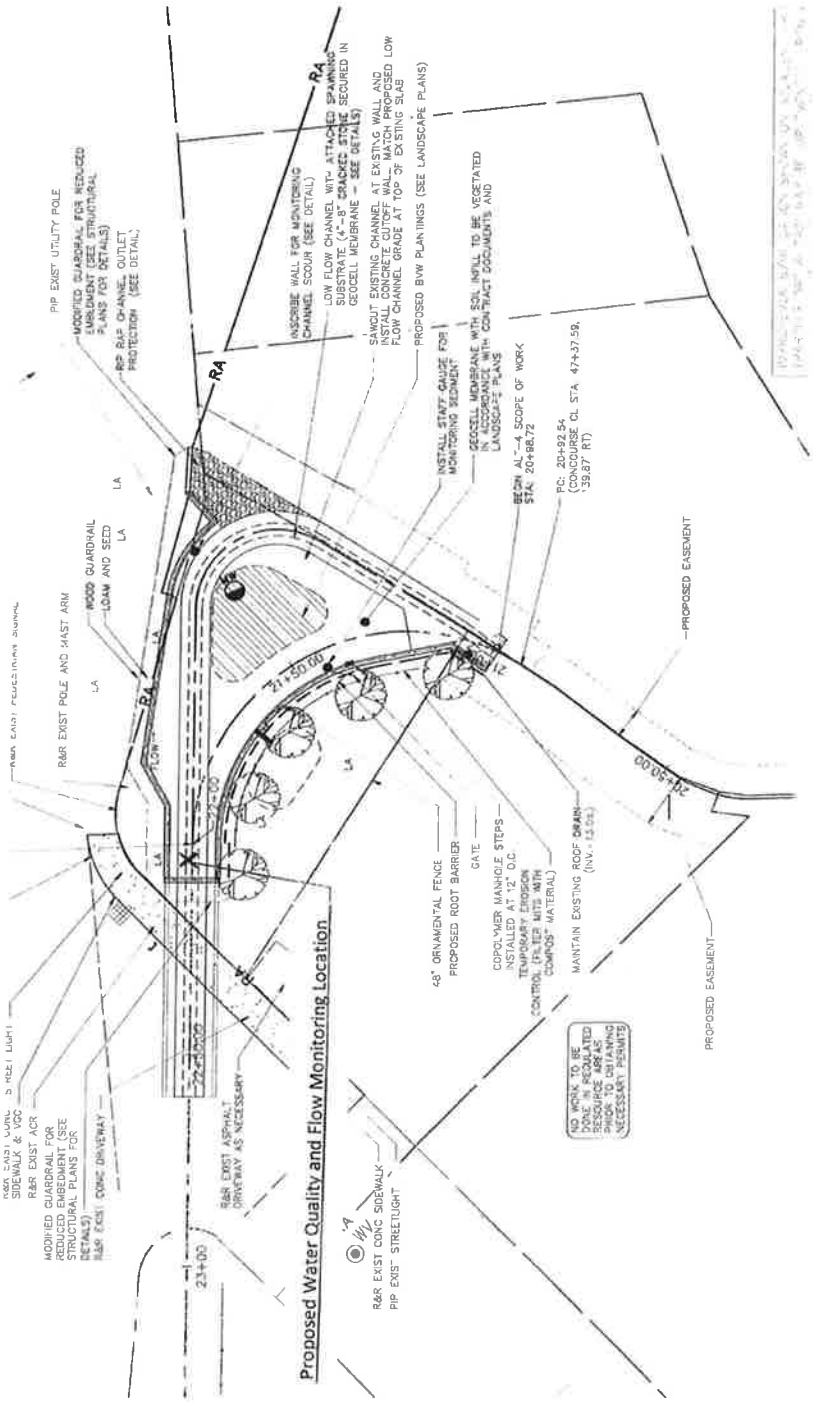
Several features have been incorporated into the proposed project to provide mitigation. The realigned channel will provide for new sections of open channel. This open channel section will incorporate a low-flow channel with spawning substrate secured to the channel bottom. The low flow channel is designed to achieve attraction velocities for smelt during low flows and include resting pools to allow smelt to rest during spawning events.

Wetland plantings are proposed within the open-channel section of the Town Brook just upstream of the connection with the existing channel. The width of the channel in this location provide an opportunity to reduce velocities and create an island with an elevation just above base flow elevations.

Town Brook has been historically subject to diversion of flows such that the smelt run has suffered acute impacts including egg mortality and spawning habitat loss. Maintaining appropriate base flows within Town Brook is a critical Factor in sustaining the existing smelt habitat. To assist in the project's success this Monitoring Plan has been prepared to comply with the Massachusetts Department of Environmental Protection's Order of Conditions # 40 thru #46.

To comply with the Water Quality and Water Flow requirements, electronic instrumentss will be installed in the low flow channel that will monitor the water quality parameters and water flow and depth characteristics on a 15 minute interval. The water quality and water flow information will be collected by telemetry to a web based location for inspection by all interested parties approved for viewing. Monthly reports will summarize the information gathered during the reporting month for review by MassDEP and the Division of Marine Fisheries. The monthly reports will be the basis for remedial action and system revisions, if required, in accordance with Condition #22 and #44.


Proposed Water Quality and Flow Monitoring Location
Site Location Map



MONITORING DEVICE LOCATION PLAN

FROM DRAWINGS PREPARED BY Stephenson Design Group

URS

Monitoring Instruments

The quality and velocities of Town Brook are paramount to providing an appropriate environment for the smelt spawning. It is proposed to install a flow monitoring device that will measure the depth and velocity of the brook. A SonTek IQ Plus flow monitor is proposed for the project. The sensor will measure the flow velocity and depth of the brook and store the information in a water tight data collection enclosure. The instrument will be located at the bottom of the low flow channel and anchored to the geocell grid. The Product Specification and Technical Data is provide in Appendix A.

A YSI EXO – 2 is proposed to measure water quality. Sensors in the instrument will measure Temperature, pH, Disolved Oxygen, and Turbidity. The instrument will be placed in a PVC perforated sleeve that will allow water to move freely through the sensors and will protect the device from debris and vandalism. The instrument will be located at the bottom of the low flow channel and anchored to the geocell grid. A wiper system has been included with the instrument to assist in preventing biofouling and reduce maintenance. Information collected from the EXO-2 will be stored in a water tight data collection enclosure. The Product Specification and Technical Data is provide in Appendix B.

Both instruments have the ability to operate continuously provided power is available to operate the system. It is proposed to provide continuous power to the instruments by a solar powered battery recharging system that will be incorporated into the water tight data collection enclosure. It is proposed to collect and report data on a 15 minute interval. A picture of the water tight data collection enclosure with solar panel is provided in Appendix C.

Instrument Location

It is proposed to place both instruments in series near the easterly headwall at Station 22+90, just east of Mechanic Street. This location is proposed due to the straight channel section that will provide stable flow characteristics beneficial to the SonTek Plus measurements and proximity to the spawning habitat. The flow monitoring device can be placed under the roadway as a deterrent to vandalism. The slope of the channel and anticipated water depth appear to be suitable for the 5 inch minimum depth requirement needed for proper operation of the device. The EXO-2 water quality device will be placed downstream from the SonTek Plus. This location is also upstream of the main spawning habitat. This location is shown on the monitoring device location plan in Appendix B.

Information Reporting

Flow monitoring and water quality data reduction and review will be performed on all data obtained on a monthly basis for a period of three years. Site visits will be conducted on a monthly basis noting that bi-weekly visits will occur during March and April for fish observations. The data obtained will be reduced, evaluated, and presented in report form. The monthly report will also include observations from the monthly site and maintenance visits. Copies of the completed report will be submitted to the City of Quincy with electronic versions sent to MassDEP and Massachusetts Division of Marine Fisheries. This will include tabular data based on 15-minute time increments.

The tabular report will be provided and include a summary of daily flow information for a selected time period. The summary presents, for each day, the minimum flow rate, peak flow rate, total daily flow. The summary will also include the total flow volume and average daily flow, for the selected time period.

Water quality sampling results will be provided in a tabular form and a summary of the data provided.

Daily data will be posted to a secure password protected web site that will allow project personnel (as determined by the City of Quincy) access to flow and water quality recorded data. Users then can prepare and review detailed flow reports, graphs and tables. Comparison between wet and dry periods as well as net flows per sub system calculations may also be performed. Online data export format capabilities are available in Excel.

Instrument Installation and Maintenance

During the installation process, the flow meter will be operated in such a way as to instantaneously obtain and display both depth and velocity readings. Manuel depth measurements will be obtained and compared to meter readings, any differences will be corrected to within 0.10 inches. Using a hand held velocity meter, readings will be obtained and compared to the metered velocity readings and adjustments to the installed equipment will be made until a reasonable match is obtained. Monthly site visits will verify that the proper depth is recorded.

Prior to installation of the EXO-2, the instrument will be calibrated on site. Once the instrument is installed sampling results will be reviewed from the data collector. Monthly site visits will be conducted to remove the instrument from the stream bed, calibrate and reinstall the instrument.

Appendix A
Sontek IQ- Plus Flow Monitoring

SonTek-IQ™ Series
Standard, Plus and Pipe

FLOW, TOTAL VOLUME, LEVEL AND VELOCITY

SonTek

a xylem brand

Built to Last. Made to Perform.

Developed with assistance from the Cooperative State Research, Education, and Extension Service of the U.S. Department of Agriculture, the SonTek-IQ Series are three products that provide high quality flow, total volume, level and velocity data for challenging conditions that fit your budget. Custom flow algorithms, carefully designed and tested, ensure all these products in the Series will deliver the data you need to make smart decisions about your water. Each system offers four independent velocity beams that work to accurately map the cross-section velocity and feed this data to the flow computation algorithms. This means velocity indexing is not required to get high-accuracy flow data. Additionally, the built-in pressure sensor (standard with each system), works in tandem with the vertical acoustic beam to measure the water level, so you always know what the stage is.

- Fully self-contained, all-in-one design
- Measure flow in man-made or natural channels, pipes or streams between 8 cm (3 inches) and 5 m (16 ft) deep
- Four, pulsed Doppler velocity beams for great section coverage
- RS-232, SDI-12, Modbus, Analog communication/output
- Specialized flow algorithms for open channels and/or closed pipes
- Uses SonTek's exclusive SmartPulse^{HD}* adaptive sampling technology
- Self-calibrating water level using vertical beam and pressure sensor
- Standard package includes instrument, SonTek-IQ Software, easy mounting hardware, cable, adaptor and power supply

*Patent pending

Whether you need just a practical and cost-effective solution for a single canal, or you operate a large public utility with dozens of monitoring sites, there's a SonTek-IQ right for your application. Simply input the channel geometry using the intuitive SonTek-IQ software and you are outputting accurate flow data in minutes!

The SonTek-IQ software package is the starting point for interfacing with the instrument.

The "SmartPage" has built-in icons that guide users through the configuration steps to collect the best possible data. Want to run some statistics on the data? You can do that too, with just one click.

SonTek-IQ Standard: Big Quality for Small Budgets

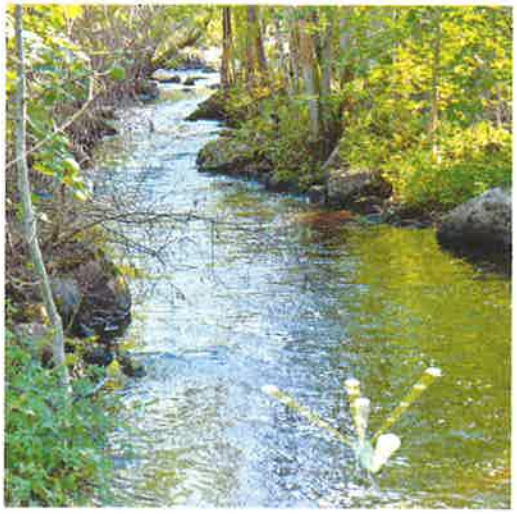
The SonTek-IQ Standard version is a "no frills" option for the budget-minded operator. But with the SonTek-IQ Standard, low budgets do not mean low quality data! Using the same powerful SmartPulse^{HD} technology that is used in the SonTek-IQ Plus system, you won't be sacrificing quality while monitoring your flow.

The Standard version allows measurement for depths up to 1.5 m in open-channels only, and basic data parameters output for display or export based on a dynamic, single integrated velocity cell.

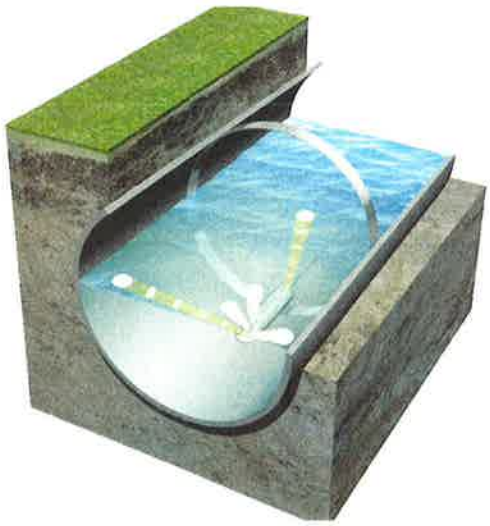
SonTek-IQ Plus: Monitoring in Complex Environments

The SonTek-IQ Plus version offers a flow monitoring solution for larger canals and natural environments with depths up to 5 m. With the ability to collect velocity profiling data in cells as small as 2 cm across a channel horizontally and vertically, this version offers the user complete flexibility in applications and detailed flow velocity parameters for those times when "just flow" isn't enough.

The SonTek-IQ Plus is capable of handling not just regular trapezoidal canals, but any irregular/naturally-shaped channel, up to 5 m deep, where flow, velocity and/or level need to be measured. And with the flexibility of the SonTek-IQ software, the opportunities are endless.



SonTek-IQ Pipe: Accurate Flow in Totally or Partially Full Pipes



The SonTek-IQ Pipe is intended as either a bottom or top mounted flow meter that can be used in most industrial or agricultural applications. Unlike many other flow meters available today, the SonTek-IQ Pipe automatically determines if the pipe is full or partially full, and the best technique to use to measure the velocity of the water. This information is then used to compute flow, along with accurate water level data provided by the vertical beam and/or pressure sensor. All this without additional configuration.

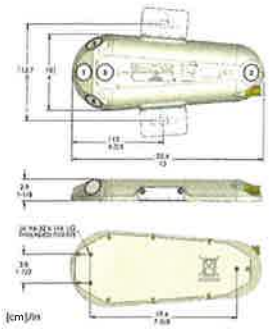
With a special form factor, the SonTek-IQ Pipe can provide accurate flow values in pipes from 0.5 all the way to 5.0 m, independent of whether these pipes are full or have only a few inches of water in them.

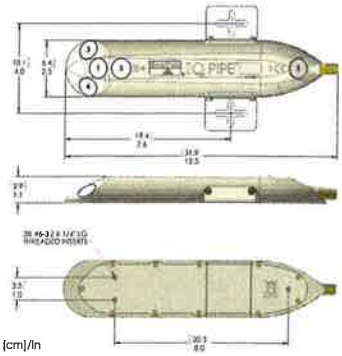
SonTek-IQ ACCESSORIES AND SPECIFICATIONS

Custom-fit for the IQ Pipe, this easy to use mounting ring will make system installation a breeze. Fits pipe diameters from 16 in (41 cm) to 36 in (91 cm).

With the press of a single button, data is yours with the SonTek-IQ Flow Display. No PC required!

Product Dimensions





Specifications	SonTek-IQ Standard	SonTek-IQ Plus	SonTek-IQ Pipe
Application	Regular Canals	All Open Channels	Pipes & Culverts
Velocity Measurement			
-Sampling Range	0.08 – 1.5 m (0.3 - 5 ft)	0.08 – 5.0 m (0.3 - 16 ft)	0.08 – 5.0 m (0.3 - 16 ft)
-Number of Cells	1	Up to 100	Up to 100
-Cell Size	Dynamically integrated	2 cm – 10 cm (0.8 - 4 in)	2 cm – 10 cm (0.8 - 4 in)
Advanced Data Reprocessing	N/A	✓	✓
Increased Number of Data Fields	N/A	✓	✓

Velocity Measurement	
-Velocity Range	±5 m/s (16 ft/s)
-Resolution	0.0001 m/s (0.0003 ft/s)
-Accuracy	±1% of measured velocity, ±0.5 cm/s (0.2 in/s)
Water Level	
-Vertical Beam Range	0.05 – 1.5 m (0.2 - 5 ft) (Standard); 0.05 - 5.0 m (0.2 - 16 ft) (Plus/Pipe)
-Water Level Accuracy	0.1% of measured depth or ±0.003 m (0.01 ft) whichever is greater
-Pressure Sensor Range[1]	30 m (98 ft; 42 psi)
-Pressure Sensor Accuracy	0.1% of full scale
Acoustics	
-Acoustic Frequency	3.0 MHz
-(2) Along Axis Beams	25° off vertical axis, along axis of channel
-(2) Skew Beams	60° off vertical and 60° off center axis of channel (Standard/Plus); 37° off vertical and 45° off center axis of channel (Pipe)
Communications	RS232, SDI-12, Modbus, Analog (via optional Flow Display)
Data Storage	4 GB (approximately 1 year)
Operating/Storage Temperature	-5 to 60° C (23 - 140° F)
Temperature Sensor	Accuracy ± 0.2° C; Resolution ± 0.01° C
Tilt Sensor	Accuracy ± 1.0°
SmartPulse[HD]	Yes
Power	
-Input	8-15 VDC
-Consumption	0.5 – 1.0 W (0.02 when idle)

[1]For use in pressurized pipes. Housing rated to 42 psi.

xylem
Let's Solve Water

Founded in 1992 and advancing environmental science globally, SonTek manufactures acoustic Doppler instrumentation for water velocity measurement in oceans, rivers, lakes, harbors, canals, estuaries, industrial pipes and laboratories. SonTek's sophisticated and proprietary technology serves as the foundation for some of the industry's most trusted flow data collection systems. SonTek is headquartered in San Diego, California, and is a division of Xylem Inc.

SonTek
9940 Summers Ridge Road
San Diego CA 92121
Tel +1.858.546.8327
Fax +1.858.546.8150
www.sontek.com

YSI, Inc.
1700/1725 Brannum Lane
Yellow Springs, Ohio 45387
Tel +1.937.767.7241
Fax +1.937.767.9353
www.ysi.com

Xylem, Inc.
1133 Westchester Avenue
White Plains, NY 10604
Tel +1.914.323.5700
Fax +1.914.323.5800
www.xyleminc.com

www.sontek.com

S16-01

This material is based upon work supported by the Cooperative State Research, Education, and Extension Service, U.S. Department of Agriculture, under Agreement No. 2008-33610-19458. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the authors and do not necessarily reflect the view of the U.S. Department of Agriculture.

SonTek
YSI incorporated

Sound Principles. Good Advice.

White Paper

Product Introduction: The SonTek-IQ

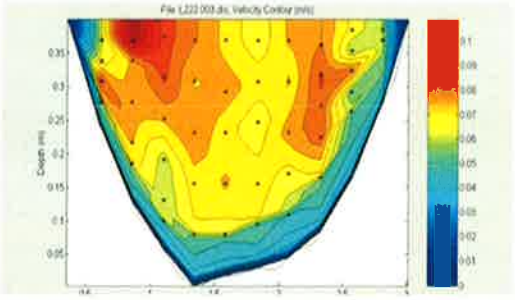
Over the years the demand for monitoring flow in open channels has evolved significantly. Climate change and water scarcity issues have increased the demand to quantify increasingly smaller flows. In the past, the irrigation community has applied a variety of technologies for "good enough" or "close enough" flow measurements and total volume deliveries. SonTek has been involved in measuring flow for almost 20 years, and decided to take on the challenge of developing an affordable instrument that can accurately measure flow.

Combining our previous expertise with feedback from the flow monitoring industry, engineers at SonTek took on the challenge. Working with funding from a Small Business Innovation Research (SBIR) grant from the United States Department of Agriculture (USDA) SonTek has a developed an innovative and advanced solution for monitoring in open channels; the SonTek-IQ or commonly known as the IQ. The IQ has been extensively tested at flow laboratories and field sites making sure that the solution is not only robust and provides high quality data, but also is user friendly and easy to use.

The IQ is an intelligent flow meter specifically designed for measuring flow in open channels. The innovative 5-beam design incorporates a vertical beam and four velocity profiling beams. The vertical beam works in tandem with a high-resolution pressure sensor to define water level that is then used to compute channel cross-sectional area (via a user entered cross-sectional survey). The four velocity profiling beams measure the horizontal and vertical distribution of velocities in the channel - in the end the IQ provides accurate flow data that you can make decisions on. There are two versions of the IQ, a standard version and a **SonTek-IQ Plus** version.

The IQ is a bottom mounted system or otherwise known as an "up-looker". The IQ collects the horizontal and vertical distribution of water velocity as well as water level data to determine flow. After talking extensively with water managers in the water industry, SonTek determined that having reliable and dependable flow data from the field is important for decision making. Existing technologies provide data, but the data have limitations due to the accuracy that can create problems.

For example, is an Irrigation District providing the farmer the right amount of water? Not enough water means an unhappy farmer; while too much water means that the Irrigation District could have sold that water elsewhere and made more money. Bottom line is that water is a valuable resource and the IQ can give you data that you can make sound decisions on.



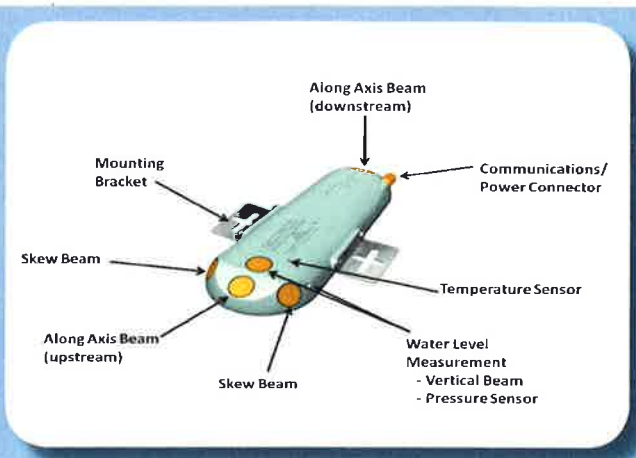
Here is an example of a FlowTracker measurement and corresponding isovel map – data from these measurements and hundreds more were used to define beam geometries and flow algorithms. In the end, the IQ is a that collects data that you can make decisions on.

	Operating Range (m)	Velocity Output	Software
IQ	0.08 - 1.5 m	SmartPulse^{HD} Average Velocity	Standard data display, no data reprocessing
IQ Plus	0.08 - 5.0m	SmartPulse^{HD} Velocity Profiles (cell sizes as small as 2 cm)	Advanced data display and data reprocessing

The SonTek-IQ software package is the starting point for interfacing with the instrument. The "SmartPage" has built-in icons that guide users through the configuration steps

SonTek-IQ Attributes:

- Two along-axis velocity profiling beams (25° off the vertical axis)
  - Measures vertical stratification of channel velocities
- Two skew velocity profiling beams (60° off the vertical axis and horizontal axis)
  - Measures the horizontal distribution of channel velocities
- Intelligent adaptive sampling via SmartPulse^{HD}
  - Dynamic selection and optimization of the acoustic pulsing scheme based on water depth, flow velocity and turbulence
- Robust water level
  - Combines data from vertical beam and integrated pressure sensor



- High resolution temperature sensor
- Communicates via RS-232, SDI-12 and Modbus
- Mounting brackets allow for a quick and easy installation
- External power (7- 15 VDC) required
- 4 GB internal recorder provides data storage for years

to collect the best possible data. After configuring the IQ, data collection and downloading is easy. Simply connect to the system to download data files – the software organizes data files like a database; files can be sorted by Site name, File name, IQ Serial number and Operator name, allowing users to find and use data quickly and easily. The organized structure of icons at the top of the screen provides users quick an easy option for creating graphs and viewing tabular data. Creating reports are easy – graphs generated by the IQ software can be copied and saved and then pasted or inserted into any document. Want to run some statistics on the data? You can do that too, with just one click.

Water users will come to the conclusion quickly that the SonTek-IQ was designed and built with the end user in mind. From installation and integration to configuration for data collection to downloading and data processing, the IQ is remarkably easy to use. In addition, water managers around the world will appreciate the accuracy of the IQ; finally an easy to use and affordable flow monitoring solution that provides flow data that can be used for decision making.

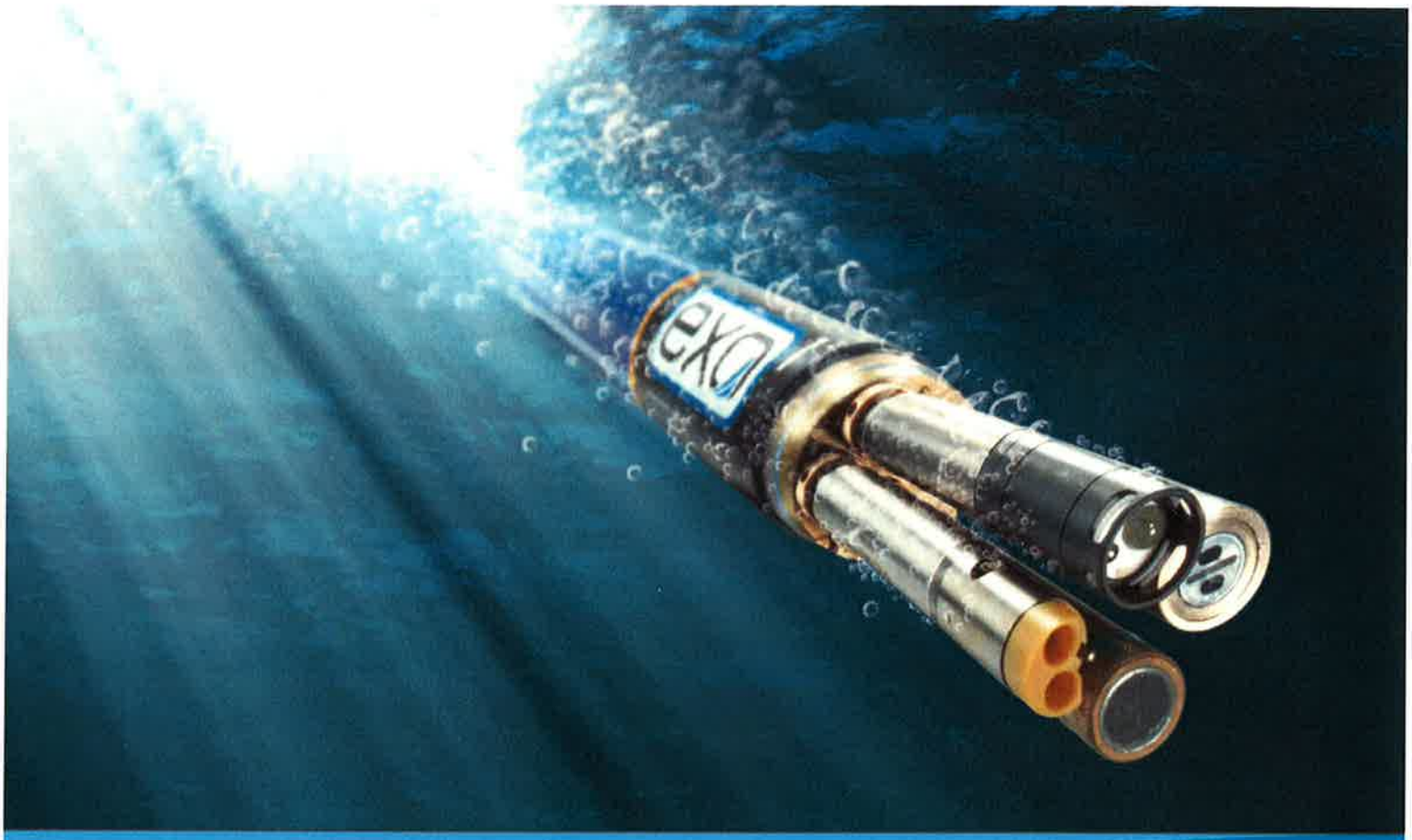
IQ Software SmartPage

Example of the SonTek-IQ installation in a small canal.

SonTek/YSI, founded in 1992 and advancing environmental science in over 100 countries, manufactures affordable, reliable acoustic Doppler instruments for water velocity measurement in oceans, rivers, lakes, harbors, estuaries, and laboratories. SonTek, and SonTek-IQ are trademarks of YSI Inc., Yellow Springs, OH, USA. The SonTek-IQ is made in the USA. Specifications are subject to change without notice. This material is based upon work supported by the Cooperative State Research, Education, and Extension Service, U.S. Department of Agriculture, under Agreement No. 2008-33610-19458. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the authors and do not necessarily reflect the view of the U.S. Department of Agriculture.

 +1 858 546 8327 Fax +1 858 546 8150 inquiry@sontek.com www.sontek.com/iq

Appendix B
YSI – EXO – 2 Water Quality Sonde



EXO

ADVANCED WATER QUALITY MONITORING PLATFORM

YSI®

a xylem brand

E102-02

Breaking the sonde barrier.

EXO represents the intersection of the Environment and Observation and a new generation of monitoring technology.

Features You'll Find Only with YSI:

Smart QC
Automatically checks for faults and errors to ensure successful deployments

Auto-recognition
and set-up of all sensors with background data routing

Cable-free Operation
through the use of wireless communications

Biofouling Protection
with copper-alloy components and anti-fouling wipers

Assisted Calibration
Graphical KOR software speeds the calibration process while reducing reagent consumption

Titanium Sensors
with wet-mateable, hermaphroditic connectors

A smart, field-ready water monitoring platform. EXO offers a wide range of capabilities to those dedicated to monitoring natural aquatic environments such as oceans, estuaries, rivers, lakes, and ground water.

Inside the EXO platform you'll find innovations resulting in greater ruggedness, increased accuracy and improved ease-of-use in the collection and transmission of water quality data–cost-effective now and adaptable for the future.

Like you, our engineers and scientists have spent years in the field, deploying and using the products we make. That passion for producing the most advanced and reliable monitoring equipment is how we break the sonde barrier.

www.EXOwater.com

Water quality monitoring that's field-ready

With a highly efficient power management platform, robust construction, and a chemistry-free anti-fouling system, EXO allows accurate data collection for up to 90 days between service intervals.

Surface Water & Ground Water Monitoring

Capturing accurate data in freshwater environments is easy with EXO.

Out of the box, EXO is ready to go with:

- Pre-installed sensors for easy set-up of factory-configured systems
- Wireless communication reduces number of field cables
- Onboard diagnostics mitigate set-up and configuration errors

Calibrates multiple sensors simultaneously, typically in 15 minutes; no cables required

Quick and Easy Calibration

Complete calibration in less than 15 minutes using EXO's suite of smart sensors and intuitive KOR interface software. Sondes can now be turned around and redeployed in the timespan of a typical sample interval.

Go Wireless

Set up, calibrate, and deploy your instrument without a single cable. No more trips to the field and discovering you don't have the right cables. The wireless handheld and sonde are the perfect pair.

Reduce Biofouling

There's no escaping biofouling in underwater measurements. To keep it from interfering with data, EXO uses copper-alloy parts and anti-fouling wipers to prolong deployments and improve data accuracy.

Smart Controls for Quality Data

Guided calibration and sensor feedback make EXO an extremely reliable water monitoring platform. Guided prompts and internal calibration logs not only speed up the calibration, but reduce the opportunity for errors.

Smart Probes. Smart Ports.

Never worry a bad probe will compromise your data. Active port monitoring automatically detects sensors and, if damage to a sensor occurs, can shut down that port to prevent damage to the sonde or other sensors.

Smart Sonde

Onboard monitoring systems automatically scan for configuration errors, monitor memory status, and verify sensor operation. Numerous onboard tests ensure successful deployments.

www.EXOwater.com

Expandable design that's network-ready

EXO's welded titanium sensors and high-impact body is built for high pressure and depths to 820 feet (250 meters)

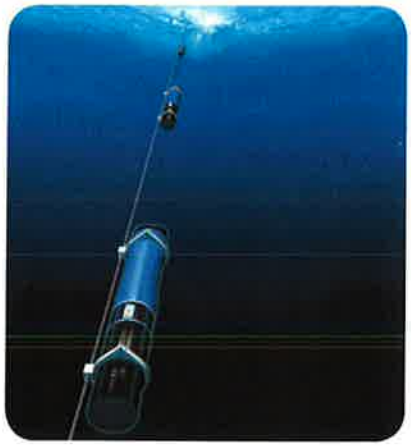
Estuary & Ocean Monitoring:

High-quality multisensor suite in small and durable package

In harsh conditions, EXO is a practical alternative to traditional CTDs with:

- The ability to integrate seamlessly with marine monitoring systems
- Quick and easy re-configuration and calibration
- Large suite of high-performance sensors, which eliminates individual cables and connectors

Combine traditional CTD sensing with additional sensors in a compact device which readily integrates with remote monitoring platforms



Compact and Accurate

The EXO platform offers a completely new approach–highly accurate, quick-response sensors in a small, easy-to-deploy and easy-to-maintain package. Gone are large and complicated sensor arrangements requiring complex integration.

Smart Probes

All EXO sensors have onboard memory and processing, allowing users to easily calibrate and configure sensors at one location and distribute to various field sites.

Measurable Sensor Performance

A new metrology system specifically for EXO offers improved accuracy of conductivity and temperature sensors to better address oceanographic challenges.

Monitor without Interruption

EXO's patented reinforced structure, welded Titanium tubes, improved power management, and stable sensor performance allow you to gather data for long periods of time and with fewer interruptions, even in the toughest conditions.

Smart Ports

Wet-mateable connectors allow for swaps in wet conditions, while the smart ports shut down any excessive current draws to prevent damage.

Self-Routing Sensors

Automatic routing enables a string of sondes to pass messages to individual probes. Anytime the configuration changes, the system automatically recognizes it. A "kick" allows any device to send alerts back up the chain.

www.EXOwater.com

Enhance Data Collection with these EXO Components

EXO Handheld

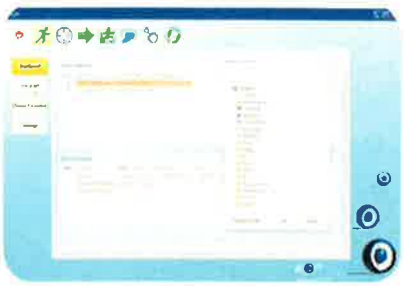
The EXO handheld provides an extremely durable, portable, weather-proof interface to the EXO sondes. The handheld uses a mobile version of the KOR interface software.

Additional standard features:

- GPS
- Temperature-compensated barometer
- Backlit alphanumeric keypad
- Microphone/speaker
- Wet-mate wireless connector
- Bluetooth communication
- Color LED screen
- 2 GB of storage
- Rechargeable battery capable

Interface with the EXO Sonde using the EXO Handheld Display

KOR Interface Software



The KOR Software offers users the capability to easily manage, visualize, and organize large amounts of field data. KOR also provides an interface to the EXO products for fast calibration, configuration, QA/QC or data collection.

- New calibration processes for long-term monitoring
- Graphical user interface for quick data analysis
- Multiple languages

Multiple Data Output Options

Sonde output is readable by YSI handheld instruments, interface software, and data telemetry modules. In addition to the cable (standard), these communication interfaces are also available:

DCP Signal Output Adapter

Wires into the end of the YSI field cable via flying leads and converts signal to RS-232 or SDI-12 for datalogger applications.

DCP Signal Output Adapter

USB Adapter

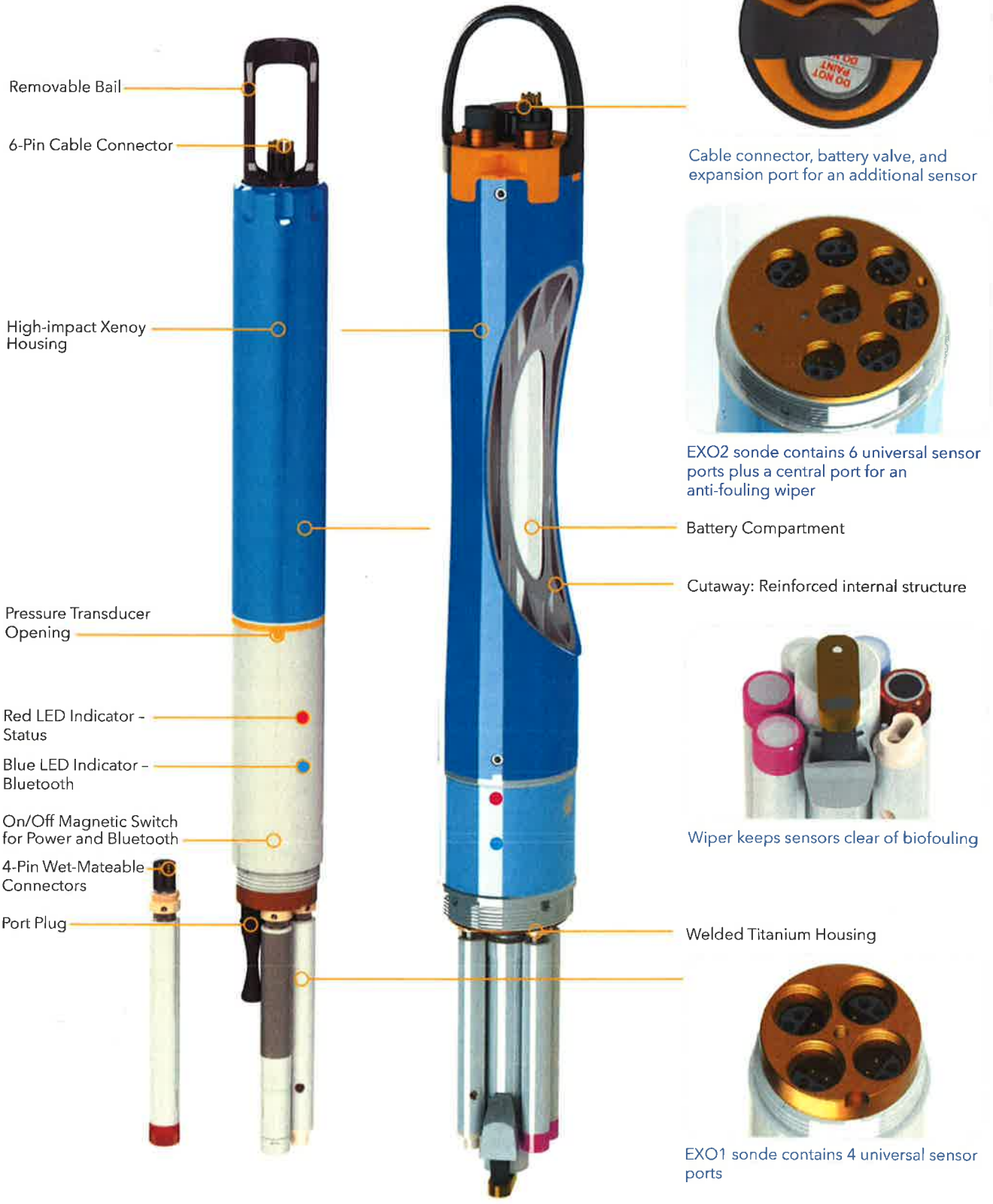
Allows connections between an EXO sonde and a PC.

USB Adapter

Bluetooth Wireless Technology

Enables communication between a sonde and a user in the lab and pre-deployment in the field.

Sondes: EXO1 EXO2



Cable connector, battery valve, and expansion port for an additional sensor

EXO2 sonde contains 6 universal sensor ports plus a central port for an anti-fouling wiper

Wiper keeps sensors clear of biofouling

EXO1 sonde contains 4 universal sensor ports

Instrument Specifications*

EXO1 Sonde		
Ports	4 sensor ports Peripheral port: 1 power communication port	
Size	Diameter: 4.70 cm (1.85 in) Length: 64.77 cm (25.50 in)	
Weight	1.42 kg (3.15 lbs) with 4 probes, guard and batteries installed	
EXO2 Sonde		
Ports	7 sensor ports (6 ports available when central wiper used) Peripheral ports: 1 power communication port; 1 auxiliary expansion port	
Size	Diameter: 7.62 cm (3.00 in) Length: 71.10 cm (28.00 in)	
Weight	3.60 kg (7.90 lbs) with 5 probes, guard and batteries installed	
Sondes		
Operating Temperature	-5 to 50°C	
Storage Temperature	-20 to 80°C (except 0 to 60°C for pH and pH/ORP sensors)	
Depth Rating	0 to 250 m (0 to 820 ft)	
Communications	Computer Interface: Bluetooth wireless technology, RS-485, USB Output Options: USB with signal output adapter (SOA); RS-232 & SDI-12 with DCP-SOA	
Sample Rate	Up to 4 Hz	
Battery Life	90 days**	
Data Memory	512 MB total memory; >1,000,000 logged readings	
Sensors		**Calculated Parameters**
Ammonium**	ORP	Salinity
Chloride**	pH	Specific Conductance
Conductivity	Temperature	Total Dissolved Solids
Depth	Total Algae (Chlorophyll + BGA-PC or PE**)	Total Suspended Solids
Dissolved Oxygen	Turbidity	
Fluorescent Dissolved Organic Matter (fDOM)	Vented Level**	
Nitrate**		
EXO Handheld		
Size	Width: 12.00 cm (4.72 in) Height: 25.00 cm (9.84 in)	
Weight	0.71 kg (1.56 lbs) without batteries	
Operating System	Windows CE 5.0	
Operating Temperature	-10 to 50°C	
Storage Temperature	-20 to 80°C	
IP Rating	IP-67	
Data Memory	2 GB total memory; >2,000,000 data sets	
Accessories		
Cables (non-vented)	Flow cells	Sonde/sensor guard
Carrying case	KOR software	Calibration cup
DCP Signal Output Adapter	USB Signal Output Adapter	Anti-fouling components
Warranty		
1 Year	pH, ORP, and optical DO membranes	
2 Years	Cables, sondes (bulkheads), handheld, and the following sensors: conductivity, temperature, depth, and optical sensors	

* Specifications indicate typical performance and are subject to change. Please check EXOwater.com for up-to-date information.

** Typically 90 days at 20°C at 15-minute logging interval; temperature/conductivity, pH/ORP, DO, and turbidity sensors installed on EXO1; or temperature/conductivity, pH/ORP, DO, total algae, and turbidity sensors installed with central wiper that rotates once per logging interval on EXO2. Battery life is heavily dependent on sensor configuration.

EXO Bluetooth modules comply with Part 15C of FCC Rules and have FCC, CE Mark and C-tick approval. Bluetooth-type approvals and regulations can be country specific. Check local laws and regulations to insure that the use of wireless products purchased from Xylem are in full compliance.

** Release in 2013. BGA-PE specs TBD.

Sensor Specifications*

Sensor	Range	Accuracy*	Response	Resolution
Ammonium** [11] (ammonia with pH sensor)	0 to 200 mg/L [1]	±10% of reading or 2 mg/L-N, w.i.g.	-	0.01 mg/L
Barometer	375 to 825 mmHg	±1.5 mmHg from 0 to 50°C	-	0.1 mmHg
Blue-green Algae Phycocyanin (PC) or Phycoerythrin (PE)** (part of Total Algae sensor)	0 to 100 µg/L PC; 0 to 100 RFU	Linearity: $R^2 > 0.999$ for serial dilution of Rhodamine WT solution from 0 to 100 µg/mL PC equivalents Detection Limit: 0.04 µg/L PC	T63<2 sec	0.01 µg/L PC; 0.01 RFU
Chloride** [11]	0 to 1000 mg/L [2]	±15% of reading or 5 mg/L, w.i.g.	-	0.01 mg/L
Chlorophyll (part of Total Algae sensor)	0 to 400 µg/L Chl; 0 to 100 RFU	Linearity: $R^2 > 0.999$ for serial dilution of Rhodamine WT solution from 0 to 400 µg/L Chl equivalents Detection Limit: 0.09 µg/L Chl	T63<2 sec	0.01 µg/L Chl; 0.01 RFU
Conductivity [3]	0 to 200 mS/cm	0 to 100: ±0.5% of reading or 0.001 mS/cm, w.i.g.; 100 to 200: ±1% of reading	T63<2 sec	0.0001 to 0.01 mS/cm (range dependent)
Depth [4] (non-vented)	0 to 10 m (0 to 33 ft)	±0.04% FS (±0.004 m or ±0.013 ft)	T63<2 sec	0.001 m (0.001 ft) (auto-ranging)
	0 to 100 m (0 to 328 ft)	±0.04% FS (±0.04 m or ±0.13 ft)		
	0 to 250 m (0 to 820 ft)	±0.04% FS (±0.10 m or ±0.33 ft)		
Vented Level**	0 to 10 m (0 to 33 ft)	±0.03% FS (±0.003 m or ±0.010 ft)		
Dissolved Oxygen Optical	0 to 500% air saturation	0 to 200%: ±1% of reading or 1% saturation, w.i.g.; 200 to 500%: ±5% of reading [5]	T63<5 sec [6]	0.1% air saturation
	0 to 50 mg/L	0 to 20 mg/L: ±0.1 mg/L or 1% of reading, w.i.g.; 20 to 50 mg/L: ±5% of reading [5]		0.01 mg/L
fDOM	0 to 300 ppb Quinine Sulfate equivalents (QSE)	Linearity: $R^2 > 0.999$ for serial dilution of 300 ppb QS solution Detection Limit: 0.07 ppb QSE	T63<2 sec	0.01 ppb QSE
Nitrate** [11]	0 to 200 mg/L-N [1]	±10% of reading or 2 mg/L-N, w.i.g.	-	0.01 mg/L
ORP	-999 to 999 mV	±20 mV in Redox standard solutions	T63<5 sec [7]	0.1 mV
pH	0 to 14 units	±0.1 pH units within ±10°C of calibration temp; ±0.2 pH units for entire temp range [8]	T63<3 sec [9]	0.01 units
Salinity (Calculated from Conductivity and Temperature)	0 to 70 ppt	±1.0% of reading or 0.1 ppt, w.i.g.	T63<2 sec	0.01 ppt
Specific Conductance (Calculated from Conductivity and Temperature)	0 to 200 mS/cm	±0.5% of reading or .001 mS/cm, w.i.g.	-	0.001, 0.01, 0.1 mS/cm (auto-scaling)
Temperature	-5 to 50°C	-5 to 35°C: ±0.01°C [10] 35 to 50°C: ±0.05°C [10]	T63<1 sec	0.001 °C
Total Dissolved Solids (TDS) (Calculated from Conductivity and Temperature)	0 to 100,000 g/L Cal constant range 0.30 to 1.00 (0.64 default)	Not Specified	-	variable
Total Suspended Solids (TSS) (Calculated from Turbidity and TDS)	0 to 1500 mg/L	Not Specified	T63<2 sec	variable
Turbidity [11]	0 to 4000 FNU	0 to 999 FNU: 0.3 FNU or ±2% of reading, w.i.g.; 1000 to 4000 FNU: ±5% of reading [12]	T63<2 sec	0 to 999 FNU: 0.01 FNU; 1000 to 4000 FNU: 0.1 FNU

All sensors have a depth rating to 250 m (820 ft), except shallow and medium depth sensors and ISEs. EXO sensors are not backward compatible with 6-Series sondes.

* Specifications indicate typical performance and are subject to change. Please check EXOwater.com for up-to-date information.
Accuracy specification is attained immediately following calibration under controlled and stable environmental conditions. Performance in the natural environment may vary from quoted specification.

[1] 0-30°C [2] 0-40°C w.i.g. = whichever is greater
[3] Outputs of specific conductance (conductivity corrected to 25°C) and total dissolved solids are also provided. The values are automatically calculated from conductivity according to algorithms found in *Standard Methods for the Examination of Water and Wastewater* (Ed. 1989).
[4] Accuracy specifications apply to conductivity levels of 0 to 100,000 µS/cm.
[5] Relative to calibration gases
[6] When transferred from air-saturated water to stirred deaerated water
[7] When transferred from water-saturated air to Zobell solution
[8] Within the environmental pH range of pH 4 to pH 10
[9] On transfer from water-saturated air to rapidly stirred air-saturated water at a specific conductance of 800 µS/cm at 20°C; T63<5 seconds on transfer from water-saturated air to slowly-stirred air-saturated water.
[10] Temperature accuracy traceable to NIST standards
[11] Calibration: 1-, 2-, or 3-point, user-selectable
[12] Specification is defined in AMCO-AEPA Standards

** Release in 2013. BGA-PE specs TBD.

What can Xylem do for you?

Xylem (XYL) is a leading global water technology provider, enabling customers to transport, treat, test and efficiently use water in public utility, residential and commercial building services, industrial and agricultural settings. The company does business in more than 150 countries through a number of market-leading product brands, and its 12,000 people bring broad applications expertise with a strong focus on finding local solutions to the worldís most challenging water and wastewater problems.

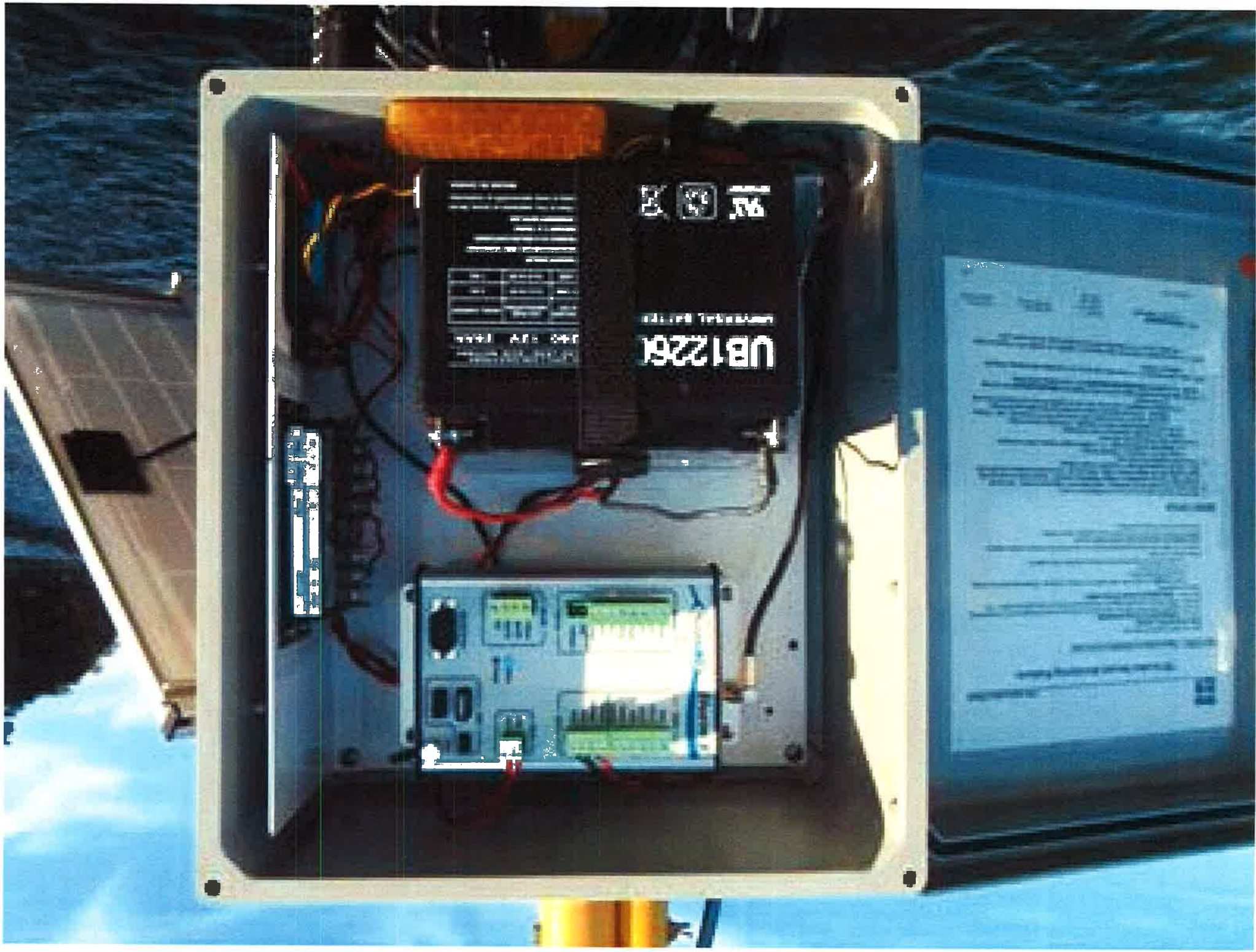
www.xyleminc.com

xylem
Let's Solve Water

YSI Inc.
1725 Brannum Lane
Yellow Springs, OH 45387 USA
Tel +1.937.767.7241
800.897.4151

www.EXOwater.com

Appendix C
Water Tight Data Collection Enclosure with Solar Panel


UB1226K