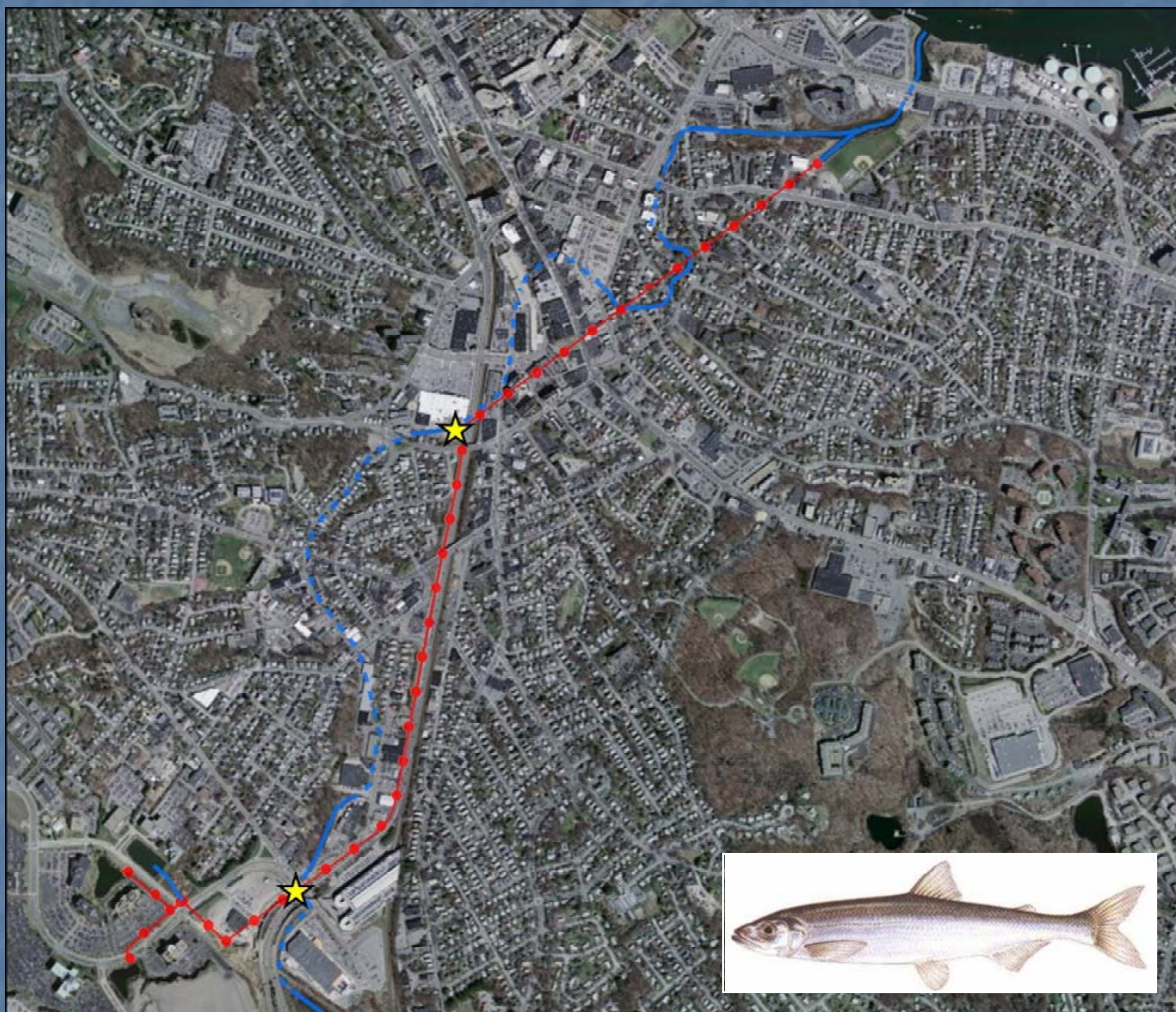
Preliminary Design of Flow Restoration in Town Brook

Quincy, MA



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Town Brook Flow Restoration

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1 INTRODUCTION

Town Brook is located in Quincy, Massachusetts within the Weymouth and Weir River Coastal Drainage Area on the southern side of Boston Harbor. Flows originate from freshwater wetlands in the Blue Hills Reservation, collect in the Old Quincy Reservoir in Braintree, then flow approximately 3.7 miles through urban areas to the Town River Bay. A documented rainbow smelt (*Osmerus mordax*) spawning run utilizes a relatively large amount of spawning habitat in the channelized streambed of Town Brook in downtown Quincy. The Massachusetts Division of Marine Fisheries (MA DMF) has recorded smelt egg deposition along 800 feet of brook channel (Chase, 2006).

In 1998, The US Army Corps of Engineers (ACOE) and MA Department of Conservation and Recreation (DCR)[1] completed the Town Brook Local Protection Project. This project was designed to divert flood flows at several locations throughout the Town Brook watershed, including the Burgin Parkway flood relief conduit and the Town Brook tunnel—an approximately 4,000-foot-long, 12-foot-diameter structure about 190 feet below the city. During environmental permitting, concerns over alterations to the smelt spawning habitat prompted the setting of project targets to not divert dry weather flows and to only divert stormwater in excess of 100 cfs (ACOE, 1980).

The project has served flood control purposes well, but the diversion of base flows and concurrent increased channel sedimentation has degraded the quality of smelt spawning substrate for attraction and egg survival. Smelt egg kills in Town Brook during 1997 and 1998 due to flood control project flow alterations raised concerns within federal and state resource agencies (see Appendices G1 and G2). These events prompted the forming of an interagency Town Brook Smelt Conservation Team (including the ACOE, NMFS, MDC, MA DMF, and City of Quincy) in 1998 to develop an understanding of the flood control project's impact on smelt spawning habitat. The team's efforts contributed significantly to the body of information needed for this report.

This project proposes to restore flows unnecessarily diverted to the Burgin Parkway conduit (and thus to the tunnel) without compromising flood control objectives. Two locations are being considered in this analysis—the Centre Street junction structure where Town Brook crosses over the upstream end of the Burgin Parkway conduit, or at the tunnel intake area downstream where Burgin Parkway outflows (and diverted Town Brook flows) enter the deep rock tunnel. Both structural modifications ('gravity-fed' options) and pumping systems will be assessed.

In addition to analyzing the restoration alternatives, this document is also intended to serve as a compilation of reports, drawings, correspondence, and other information relevant to the Town Brook Local Protection project, which has been included in the attached appendices. Rather than lengthening this report with excessive background information, the appendices are often referred to for additional detail. However, not all appendices are referenced; many were simply included as part of the existing data file.

[1] *Formerly the Metropolitan District Commission (MDC). The DCR, which was proposed by Governor Romney and approved by the Legislature in the FY04 Budget, merges the functions of the former MDC and the former Department of Environmental Management (DEM), with the goal of consolidating the resources of these agencies.*

2 BACKGROUND INFORMATION

2.1 Structures

An overview map showing the general layout of the Town Brook Location Protection project is shown in Figure 2.1-1 in Appendix A. A schematic GIS map providing additional detail of the Town Brook channel and diversions from Centre Street down is shown in Figure 2.1-2. Drawings of the tunnel and appurtenant structures are provided in Appendix E1. Completed in 1998, the project spans the town of Braintree and the city of Quincy (ACOE, 2001). Its upstream extent is the Old Quincy Reservoir dam, which was reconstructed by the Corps in 1996 (ACOE, 1996). From the dam, the majority of water flows through the Howie Road diversion (also constructed by the Corps), while a smaller amount of surface water parallels the diversion and flows through two small culverts built by the MDC. The flows rejoin at the Worthington Circle conduit (Braintree culvert), which was built by the MDC. Combined flow continues through a culvert under Route 3 (built by MA DPW), then crosses into Quincy and enters the Centre Street culvert (built by the MDC and maintained by the City of Quincy).

At the Centre Street junction structure, Town Brook flow exits two twin 48-inch-diameter culverts, flows through a steel trough, and makes a right angle turn to cross Centre Street before daylighting shortly downstream for about 765 feet. Overflow above the capacity of the steel trough spills down into the Centre Street culvert below, which also receives flow from stormwater retention ponds in the Crown Colony Park to the west. Beyond the junction, the lower Centre Street culvert continues as the Burgin Parkway flood diversion conduit (Burgin conduit), which was built by the MDC and generally follows the Burgin Parkway before emptying into the intake area for the Town Brook tunnel near School Street. Meanwhile, surface Town Brook flow that emerged just downstream of Centre Street reenters a culvert and generally follows Brook Road before daylighting again just upstream of the tunnel intake area.

Major features of the Centre Street junction structure are shown in the figure below, and detailed plans and sections are shown in Drawings 0-4 through 0-6 in Appendix C. The Centre Street junction was built by the MDC in 1980, and originally conveyed Town Brook flow through two inverted halves of 20-inch iron pipe (drawings provided in Appendix E2). Modifications, including lowering of the chamber ceiling, were made in 1989 during the reconstruction of Centre Street and Crown Colony Drive (Appendix E4). In 1999, the Corps replaced the two pipe halves with the current steel trough (Appendix E5) to address the pipes' low capacity, which was unnecessarily diverting base flows into the Burgin Conduit below.

Figure 2.1-3 – Inside the Centre Street junction structure, looking upstream and downstream

The Town Brook tunnel is a 12-foot diameter concrete-lined structure that was built by the Corps to convey excess flows beneath the city during flood events. Located approximately 190 feet below ground, it spans 4,060 feet from the intake area near School Street to the outlet into Town River near the Southern Artery (Route 3A). At the tunnel intake area, flow from the Burgin conduit enters a 48-by-50-foot reinforced concrete grit retention chamber, then flows over a weir into the vertical tunnel intake shaft. Alternately, excess surface Town Brook water will overtop a weir and flow through a 30-foot-long, 8-by-10-foot box conduit to the same tunnel intake shaft. An automatic aeration system consisting of a pumped water circulation system and a compressed air and diffuser system maintains dissolved oxygen levels in the tunnel at 6.0 mg/L or above (requirement of Water Quality Certification No. 87W-045, 1989). The pumps, compressor, and monitoring and control equipment are housed in two masonry structures—one located at the tunnel intake and one at the outlet. Major features of the tunnel intake area are shown in the figure below, and detailed plans and sections are shown in Drawings 0-1 through 0-3 in Appendix C.

Figure 2.1-4 – Town Brook tunnel intake area, looking west

From the tunnel intake area, Town Brook base flow continues through culverts under the Burgin Parkway, Hancock Street, and others before emerging downstream of Revere Road. The approximately ¼-mile-long section of open channel between Revere Road and Bigelow Street provides the main area of suitable smelt spawning habitat in the watershed. USGS Gage No. 1105585 is located along this stretch, just downstream of Miller Stiles Road. The brook then crosses under Bigelow and Washington Streets before emerging as Town River. About a third of a mile downstream, outflow from the Town Brook tunnel joins the river after ascending a vertical outlet shaft to a horizontal concrete apron, which widens into five 10-foot-wide bays to convey tunnel discharge flows to the Town River. Combined flows cross under the Southern Artery before emerging for the final time into Town River Bay, then join the Weymouth Fore River and flow into Hingham Bay.

The operation and maintenance manual for the Town Brook Local Protection Project, provided in Appendix F, gives further detail about the various structures associated with the project. Appendix G of this manual describes the project from the perspective of environmental concern for spawning smelt. It includes detailed information about the layout and function of the tunnel intake area and Centre Street junction structure, the importance of sediment and debris removal near these structures, various storm water inflows to the system, and instructions for low flow augmentation discharges from Quincy Reservoir. Please refer to this appendix as a supplement to this section of the report.

2.2 Hydrology

Town Brook lies within the Weymouth and Weir River Coastal Drainage area on the southern side of the Boston Harbor (Chase, 2006). Originating from freshwater wetlands in the Blue Hill Reservation, Town Brook enters the Old Quincy Reservoir in Braintree, then flows approximately 3.7 miles into Quincy and through the various structures described above before reaching the Town River Bay. Downstream of Washington Street, the channel is tidally influenced and is known as Town River. A map of the Town Brook watershed is shown in Figure 2.2-1 in Appendix A.

The natural drainage area (i.e., not considering urban drainage networks) of Town Brook upstream of Washington Street/tidal influence is approximately 4.2 square miles (USGS, 2010). As noted above, a USGS gage (No. 1105585) has recorded flows in Town Brook just downstream of Miller Stiles Road (the area of prime smelt spawning habitat) most years since 1972. Gage No. 01105584 at the tunnel intake area has recorded water elevation in Town Brook since 1999. The gage is located against the left wall of the concrete lined channel, across from the overflow weir (elevation 18.0 feet, NGVD) that carries excess flows into the tunnel. Note that the USGS estimates the drainage area at the gage around 2.0 square miles, but the degree of inflow is unknown. The natural drainage area would be closer to 3.6 square miles (USGS, 2010), but due to flood control diversions (i.e., Centre Street culvert, Burgin conduit), surface flow reaching that point is limited. It is likely that the drainage area for the gage downstream near Miller Stiles Road (reported at 4.11 square miles) does not reflect the diversion. The following table summarizes stream gage information for Town Brook.

Table 2.2-1 – Stream gage information for Town Brook

Gage No.	Gage Name	Drainage Area	Period of Record
01105585	Town Brook at Quincy, MA	4.11 mi^2	09/11/1972 – 09/30/1986 10/04/1998 – present
01105584	Town Brook at Diversion Tunnel at Quincy, MA	about 2.0 mi^2 *(unknown degree of inflow)*	02/1999 – 09/2000 03/2001 – present

Excerpts from the general design and hydrology memorandum published by the Corps during the planning phase of the flood control project are provided in Appendix F1. Appendix B of this memo details pertinent hydrologic information regarding the watershed, climatology, streamflow records, historic floods, flood frequencies, and design criteria including the HEC-1 computer program input/output file for the project design flood.

An analysis was conducted at the Town Brook gage in the area of the smelt spawning habitat (No. 01105585) to determine the impact of the flood control project on flows during smelt spawning. Figure 2.2-2 in Appendix A compares annual flow duration curves at the gage for the pre-flood-control-project period (1972-1986) and the post-flood-control-project period (1998-2010). (Note that provisional USGS gage data for October 1986 through September 1998 were not readily available from USGS and thus were not included in this analysis.) Flow duration curves representing the two periods were also compared for April, the typical month for peak smelt spawning (Figure 2.2-3), as well as for August (Figure 2.2-4). All the curves indicate that flows have generally decreased in the area of prime smelt spawning habitat since the construction of the flood control project. Interestingly, it appears that even during the summer (i.e., August—see Figure 2.2-4), water is being diverted from Town Brook.

A separate analysis was conducted by the MA DMF to compare minimum, maximum, and mean monthly flows along with rainfall trends for the smelt spawning period before and after completion of the flood control project (B.Chase MA DMF, unpublished data). The monthly mean flows during March-May were significantly lower during the 11 years following the flood control project completion than during the 11 years preceding construction. Values are given in Table 2.2-2 in Appendix A and displayed graphically in Figure 2.2-5. Looking at the bottom of the table, it can be seen that the average of mean monthly flows in March for the post-flood-control-project period (7.3 cfs), was less than half that for the pre-flood-control-project period (14.8 cfs), a difference of 7.5 cubic feet per second (cfs). Similarly, the average dropped by 6.3 cfs for April, and by 3.2 cfs for May.

Based on this data, an appropriate flow restoration goal for this project would be to reclaim approximately 3 to 8 cfs during smelt spawning season, depending on the month. The potential to recover flows in this range will be limited by weather-influenced fluctuations in base flow. Restoring brook base flows will reduce acute impacts by improving survival of deposited smelt eggs. Another benefit will be increased scouring and sediment transport which results in improved suitability of smelt spawning habitat. Based on discussions with MA DMF, the options considered for flow restoration should have the capacity to recover flows beyond the estimated range of 3-8 cfs up to 10-12 cfs in order to improve spawning habitat flushing.

Note that although modifications were made to the Centre Street junction structure by the Corps in 1999 to increase its capacity as mentioned above, any resulting changes in flow patterns were not evident in the flow record and possibly obscured by the construction of the larger flood control project occurring around the same time.

2.3 Hydraulics

During the planning phase of the Town Brook Local Protection Project, the Corps also published a hydraulics and water quality memo, provided in Appendix F2 (with an addendum in Appendix F3). This memo includes design discharges and detailed hydraulic analyses of the various structures associated with the project, as well as existing water quality data and a design for the proposed aeration system.

Centre Street Junction Structure Hydraulics

There has been some uncertainty regarding the capacity of the trough carrying Town Brook flows through the Centre Street junction structure. The interagency Town Brook Smelt Conservation Team identified the concern of dry weather flow losses and stormwater diversions well below 100 cfs in 1998. This prompted attention to components of the flood control project including the Centre Street junction structure, which was found to be a source of flow diversions. When the Corps designed the replacement of the former two pipe halves with the current rectangular trough in 1999, the following explanation of hydraulic design assumptions was given by Townsend Barker (from Appendix E5):

> "As best as I could determine, the original design by Metcalf and Eddy, Inc for the Centre Street junction structure was that it should pass 10 cfs before water was diverted into the Burgin

> Parkway conduit. When the pipes were observed on 6 April, they were flowing close to capacity, which I roughly estimated as 4 cfs (although flow may have been restricted by upstream debris I did not see that day). Therefore, the design of the replacement trough was based on the assumption that a minimum of 10 cfs had to be passed before water spilled into the Burgin Parkway conduit, and that hydraulic assumptions that predicted a 10 cfs capacity for the two pipe halves had actually produced a capacity of only 4 cfs."

The Corps used those assumptions to design a new 4-foot-wide by 1-foot-high rectangular trough with a capacity of approximately 10 cfs. For this analysis, the capacity of the trough was checked using the headwater depth chart for box culverts with inlet control from the U.S. Dept. of Transportation's HEC-5 publication (USDOT, 1965 – Chart 1). Assuming an entrance wingwall flare of zero degrees (i.e., not a smooth transition—a conservative assumption), the capacity of the existing trough (with a field-measured width of 4.2 feet and height of 1 foot) was found to be about 10.5 cfs—in accordance with the Corps design. Estimated capacities corresponding to proposed extensions of the vertical sides of the trough are described in Section 3.3.

In summary, the diversion of Town Brook flows that occurred from flood control project construction include chronic losses from the Crown Colony complex through the Centre Street culvert and stormwater flows in excess of 10-11 cfs at the Centre Street junction structure that spill over the weir into the Centre Street culvert. Flows from both sources bypass the Town Brook main channel via the Burgin Parkway conduit and empty to the deep rock tunnel. The above discharge data indicate that the combined flow diversion has averaged approximately 6-7 cfs for the months of March and April since the major flood control structures were constructed. The loss of dry weather flows from the Crown Colony "tributary" have not been quantified. MA DMF staff observations at the Burgin Parkway conduit outlet to the deep rock tunnel entrance indicate that dry weather flows losses during March-May are likely in the range of 1-4 cfs. Flow volumes in this range can commonly represent 25-50% of dry weather flows registered at the USGS streamflow gage station near Miller Stiles Road. The diversion of low levels of stormwater flows at the junction structure weir disrupts natural stream processes that maintain clean riffle habitat for smelt spawning. Hydraulic solutions are proposed below to address both sources of flow diversion.

2.4 Water Quality

Water quality in Town Brook could be relevant for decisions regarding location(s) to recapture diverted flows. However, little information is available addressing water quality at different locations in Town Brook. The Crown Colony complex was constructed with large stormwater retention wetlands with the intent of improving the quality of water exiting to Town Brook. Although causal data are not available, it appears that Crown Colony outflows contribute improved water quality, at least during dry weather. Water quality data collected by MA DMF during smelt habitat monitoring (Appendices G1 & G2) and while evaluating potential impacts from the MBTA train station pumping in downtown Quincy (Appendix H12) indicate that water quality is suitable for smelt spawning during dry weather flows and degrades with stormwater pulses. It may be possible that flows recovered at the Centre Street junction structure would be of higher water quality than those recovered at the tunnel intake area; however, not enough data exists to confirm differences in water quality between the two sites.

3 PROPOSED ALTERNATIVES

The goal of this project was to consider various alternatives to restore Town Brook flows at one of two locations—the tunnel intake area or the Centre Street junction structure.

3.1 Alternative 1 – Tunnel Intake Area Gravity Option

The tunnel intake area channel option represents the gravity pipe connection option for this site. The goal is to connect outflows from the Burgin conduit to the Town Brook channel so that they may augment natural flows in the smelt spawning area downstream rather than bypassing the area via the flood relief tunnel. The figure below shows the schematic concept of the design; see Drawings 1-1 through 1-3 of Appendix C for details. Refer back to Figure 2.1-4 above for additional aerial image detail.

Essentially, a 4-foot-wide concrete channel would be cut to connect the northeast corner (bottom-right, in the figure) of the grit basin area to the Town Brook channel, entering just after the brook passes through a bar rack and before it crosses under the Burgin Parkway (approximate location of proposed channel shown with dashed red lines in the figure). This connection could alternately be a buried pipe; however, an open channel covered with steel grating is proposed for ease of access and maintenance.

Four 8-foot-wide by 7-foot-high stainless steel automated sluice gates would replace the stop logs in the openings between the Burgin conduit outlet area and the grit basins, and a smaller, 4-foot-wide by 3-foot-high sluice gate would be installed at the inlet to the new connecting channel (shown with orange lines in the figure). The operation of these gates could be controlled automatically by two ultrasonic level transducers—one in the Town Brook channel near the overflow weir and another in the Burgin conduit outlet area (indicated by yellow dots in the figure) transmitting water level data to a central transceiver in the existing pump house.

During low and normal flows, the sluice gates in the stop log openings would remain closed, allowing water to pool in the Burgin conduit outlet area to an elevation of 15.9 feet (above a sloping bottom elevation of approximately 11 to 12 feet), at which point it would flow into the new connecting channel (through an open sluice gate) and join the Town Brook channel at an invert elevation of 15.7 feet. During flood flows, rising water levels in either the Town Brook channel or the Burgin conduit outlet area would trigger one of the ultrasonic level transducers to open the sluice gates in the stop log bays and close the sluice gate leading to the new connecting channel, thus reverting the system back to the intended flood control design (flood flows bypass the remainder of Town Brook via the flood relief tunnel). The sensor in the Town Brook channel would likely be set at an elevation slightly below the crest of the overflow weir (which is at approximately 18 feet), while the sensor in the Burgin conduit outlet area would be set somewhere between the new connecting channel invert elevation (15.9 feet) and the top of its sluice gate opening (18.9 feet), probably around 17 feet. Exact levels would require further hydraulic analysis. The proposed sluice gates are electric and can also be operated manually in a power outage.

Considerations

One consideration requiring further analysis for this option is the effect of backwater in the Burgin conduit. When the stop log bay sluice gates are closed, water will pool to an elevation of 15.9 feet, causing a backwater with a depth of approximately 2.6 feet at the outlet of the 10-foot-wide by 8-foot-high Burgin culvert (invert elevation 13.28 feet). The upstream extent of this backwater and its impact on the structural integrity and flood capacity of the Burgin conduit will require hydraulic analysis if this option is pursued.

Another consideration is sedimentation. The grit basins and the widened portion of the Town Brook channel were designed to settle sediment out of flows traveling downstream via the tunnel or brook. With the stop log bay sluice gates closed, sediment will naturally begin to settle out in the Burgin conduit outlet area which will have a depth of about 4 to 5 feet (sloped bottom) in which sediment could accumulate before reaching the invert of the new connecting channel. Sediment built up against the sluice gates could pose a problem when they are opened to pass flood flows (reduced capacity, turbid water, etc.). Periodic opening of the gates or removal of sediment by other means may be necessary.

Equipment Details

The proposed sluice gates are manufactured by Whipps, Inc. located in Athol, Massachusetts. In Whipps' Series 900, rugged, reinforced stainless steel construction is combined with tough, flexible polyethylene seat/seals to provide a heavy-duty assembly. The stainless steel option was selected for its lower cost, higher strength, better corrosion resistance, lower maintenance, and easier customization than cast iron. Further specifications of the proposed sluice gates are provided in Appendix D.

To automate the operation of the sluice gates, a combination of two ultrasonic water level transducers and a single transceiver is proposed. These devices are manufactured by Siemens. The Echomax XRS-5 ultrasonic transducers (pictured at right) provide continuous level monitoring of liquids at a range of one to 26 feet using a beam angle of 10 degrees and a CSM rubber face. A submergence shield can protect the face from potential flooding. The MultiRanger 200 (pictured at left) is a versatile short- to medium-range multi-vessel level monitor/controller that can provide volume and flow measurements in open channels, differential control, and advanced pump (or gate) and alarm functions. Further detail of the proposed ultrasonic control components is provided in Appendix D.

Estimated Costs

High and low cost estimates for the tunnel intake area channel option are presented in Table 3.1-1 on the following page. Including a 25% contingency and all five proposed sluice gates, the estimated cost is approximately $372,000. This is the scenario depicted in the conceptual drawings. To reduce costs, one or more of the proposed 8'x7' sluice gates could be eliminated and the opening(s) controlled instead with the existing stop logs. This strategy could provide a means to spread the cost over the course of several years—starting with one automated sluice gate and three sets of stop logs, for example, and replacing stop logs with additional sluice gates in later stages of the project.

However, stop logs would require manual removal in advance of flooding (and replacement after flooding), and they would be difficult to adjust during flood flows. This lack of automation may not be compatible with the flood control design of the Town Brook Local Protection Project. Additionally, the existing wooden stop logs are leaky and would need to be retrofitted for a tighter fit (or replaced with stainless steel or aluminum stop logs, also manufactured by Whipps).

The low estimate in the table below assumes that the existing stop logs will be used in all four bays in lieu of sluice gates. It does not include costs to retrofit/replace stop logs to reduce leakage. An intermediate number of sluice gates could be added for $50,000 each (plus corresponding increase in general costs and contingency).

As mentioned above, another option for this alternative would be to connect the two channels with a buried pipe rather than a grated open channel. Given the 4-foot-wide by 3-foot-high sluice gate opening, the pipe could have a maximum diameter of 3 feet. Although the rectangular concrete channel would have a higher capacity and allow easier access/maintenance, the buried pipe option could reduce the estimated cost by approximately $30,000.

Table 3.1-1 – Estimated costs for Alternative 1 – Tunnel intake area gravity option

Item	Unit Price	Unit	LOW ESTIMATE *(exist. stop logs)*		HIGH ESTIMATE *(4 gates)*	
			Qty	*Cost*	*Qty*	*Cost*
General contractor requirements *(mob/demob, on-site facilities, etc.; 10% of remaining itemized costs totaled)*	-	%	10%	$6,220	10%	$27,020
8'x7' stainless steel sluice gates *(installed)*	$50,000	EA	0	$0	4	$200,000
4'x3' stainless steel sluice gate *(installed)*	$20,000	EA	1	$20,000	1	$20,000
Ultrasonic level tranducers (2) and controller	$3,000	LS	1	$3,000	1	$3,000
Electric panel and connections to gates/sensors	$4,400	LS	1	$4,400	1	$4,400
Concrete *(for new 4'-wide channel)*	$400	CY	50	$20,000	50	$20,000
Steel grating *(for top of channel)*	$6,800	LS	1	$6,800	1	$6,800
Dewatering	$1,000	DAY	2	$2,000	10	$10,000
Channel excavation	$20	CY	160	$3,200	160	$3,200
Break through concrete walls at ends of channel	$150	CY	4	$600	4	$600
Crushed stone bedding	$50	CY	10	$500	10	$500
Backfill and compaction	$10	CY	70	$700	70	$700
Haul excess spoil from channel trench	$10	CY	100	$1,000	100	$1,000
Subtotal				**$68,420**		**$297,220**
Contingency allowance *(25% of subtotal)*			25%	**$17,105**	25%	**$74,305**
TOTAL Estimated Cost *(2010 $ rounded to nearest $1000)*				**$86,000**		**$372,000**

Items in red indicate differences between high and low estimates. Low estimate uses existing stop logs in all 4 bays to grit basin; high estimate replaces all stop logs with 4 automated sluice gates. Intermediate alternatives include the replacement of some stop logs with 1, 2, or 3 sluice gates (at $50,000 each). Low estimate does not include potential costs to retrofit/replace existing stop logs to prevent excessive leakage.

3.2 Alternative 2 – Tunnel Intake Area Pump Option

Rather than cutting a new channel to connect Burgin conduit outlet flows to the Town Brook channel at the tunnel intake area as in Alternative 1 above, a pump could be installed to perform the same function. The figure below shows the schematic concept of the design—the pump is indicated by a red box and intake/discharge pipes are represented by red dashed lines. See Drawings 2-1 through 2-3 of Appendix C for details and refer back to Figure 2.1-4 above for additional aerial image detail.

Intake Depth/Location Options

Several options are available for a pumping scenario. First is the consideration of whether or not to pool water for pumping. If the pump intake is positioned in the northeast corner of the Burgin conduit outlet area (same location as the proposed channel inlet in Alternative 1 above), both options are possible. The stop log bays could be fitted with 8-foot-wide by 7-foot-high stainless steel automated sluice gates as in Alternative 1 (indicated by orange lines in figure), or stop logs could be used to save costs (existing stop logs retrofitted or replaced to reduce leakage). With a channel bottom elevation of 11-12 feet (sloping surface) and a top elevation of 24 feet, the pump could be set to an invert elevation of 12 feet and Burgin conduit outflow could be pooled to a depth of several feet for continuous pumping. The invert elevation of the discharge pipe in the Town Brook channel (just downstream of the bar rack) would be 15.9 feet, for a net head of 3.9 feet. As in Alternative 1, ultrasonic level transducers could be used in conjunction with a central transceiver to measure water levels in the Town Brook channel and Burgin conduit outlet area and automate the opening and closing of the sluice gates to accommodate flood flows.

Alternately, to reduce costs and simplify the operation, the sluice gates could be eliminated and water could be pumped from the existing level without pooling. Under low flows, the water level in the grit basin and Burgin conduit outlet area is typically controlled by the weir leading to the tunnel intake shaft, which has a crest elevation of 13.3 feet. If the pump intake were installed a few inches off the bottom of the low side of the Burgin outlet area (just upstream of the stop log bays), which has an invert elevation of 11 feet, the depth available for pumping would be approximately 2 feet.

Pumping from the grit basin (invert elevation 6 feet) rather than the Burgin conduit outlet area would provide additional depth (approximately 7 feet), but could lead to problems with disturbing/pumping sediment as it accumulates. (This could also present a problem if water is pooled in the Burgin conduit area; sediment may need to be managed as described in Alternative 1.) Furthermore, due to the nature of the flow requirements (i.e., for smelt spawning habitat), it will be necessary to maintain the augmentation flow as consistently as possible. If additional depth is available for pumping (by pumping from the grit basin or pooling water with sluice gates as described above), that water will be drawn down fairly quickly and then will take some time to refill, causing 'slugs' of water to be sent downstream which could be detrimental to smelt eggs. For example, pumping at a rate of 3 cfs, 2 feet of water depth in the grit basin would be drawn down in approximately 23 minutes. Instead, it may be desirable to pump at a rate approximating outflow from the Burgin conduit, so that a more consistent and natural flow augmentation is achieved.

Pumping Rate Options

The second consideration is how to size the pump for the desired range of flow augmentation. The conceptual drawings depict a 12-inch centrifugal pump, which will pump at a rate of approximately 10 cfs in the given configuration (the upper end of the flow restoration goal as described in Section 2.2). However, it would be desirable to have the option to pump at a lower rate when Burgin conduit outflows are lower to maintain a more consistent flow augmentation as described above. To achieve this, the 12-inch pump could be fitted with a variable frequency drive (VFD) that would reduce the capacity by approximately 70%, resulting in a pumping rate of about 7 cfs (close to the target to reclaim for March).

Alternately, a smaller pump could be used, and additional pumps of the same size could be added (initially or at a later phase) to increase capacity. A 6-inch centrifugal pump from the same manufacturer will pump at a rate of approximately 3 cfs with the proposed head, and one or two additional 6-inch pumps could be added for a total capacity of 6 or 9 cfs, respectively. For about the same cost as a single 12-inch pump, three 6-inch pumps would cover the desired range of flow augmentation (3-10 cfs) relatively well, with the advantage of allowing an even lower pumping rate than the 12-inch pump fitted with a VFD to more closely match Burgin conduit outflows during dryer months (i.e., May). Additionally, by starting with one pump and adding more as needed, the three-pump scenario would allow for more experimentation to fine-tune target flow, as well as delaying of some project costs to later phases.

Construction Options

As shown in the conceptual design drawings, the discharge pipe is proposed to be buried beneath the existing concrete surface. Excavation and fill costs to bury the pipe are represented in the high cost estimate below. However, as another way to reduce project costs (although by a relatively minor amount), piping could simply be laid atop the surface and fed into the open Town Brook channel. Because the tunnel intake area is enclosed within security fencing with restricted access, tampering would not be a great concern (likewise for the pump itself, which is why a vandal-proof cover is not proposed at this site). This could also be used as a temporary configuration, perhaps in conjunction with renting a pump for one smelt spawning season to observe how well the system would meet flow restoration goals before investing in a permanent solution.

Considerations

As mentioned in the discussion of intake location options and described in detail for Alternative 1, if sluice gates or stop logs are used to pool water in the Burgin outlet area for pumping, sediment built up against the gates/logs could pose a problem when they are opened to pass flood flows (reduced capacity, turbid water, etc.). Additionally, sediment may be churned up by pumping, sending it downstream into Town Brook. Periodic opening of the gates or removal of sediment by other means may be necessary with this scenario—one reason it may be desirable to pump from the existing water level without pooling.

Furthermore, as described above, inconsistent flow augmentation may be an issue for spawning smelt and egg coverage downstream, particularly if water is pooled and/or the pumping rate is significantly higher than the Burgin conduit outflow rate. This presents another justification for pumping from the existing water level and using a series of smaller (6-inch) pumps that can adjust to a lower rate (3 cfs).

Lastly, pumping from the existing water level rather than pooling water with sluice gates and/or stop logs would simplify the system, reduce costs, and is less likely to be viewed as a compromise to the flood control intent of the Town Brook Local Protection Project.

Equipment Details

Details for the sluice gates and ultrasonic level transducer system (if used to pool water) are provided in Section 3.1 above, and specification sheets are provided in Appendix D.

Pump recommendations were provided by Rain for Rent, a national company based in Bakersfield, California with an office in Boston. As implied by their name, Rain for Rent also specializes in pump rental services. The recommended pumps are manufactured by Power Prime Pumps, also in Bakersfield, California. Both pump sizes (12-inch and 6-inch) are end suction centrifugal pumps with fully automatic priming systems built into the design, enabling the pumps to self prime from completely dry conditions. The pumps can run dry unattended indefinitely and can handle solids up to 3.5 inches (2.5 inches for the 6-inch pump). While diesel options are available, electric was recommended for this application because pumping during power outages (most likely to occur during winter storms or flooding events) would not be vital. The pumps come mounted on a skid or a trailer (pictured below) for ease of transportation.

The DV-300 model (pictured below, left) has a 150-horsepower, 460-volt motor, a 12-inch suction diameter and 10-inch discharge diameter, and can handle a maximum of 5,000 gallons per minute or 115 feet of head. In this application, it would pump at a rate of about 10 cfs (or 7 cfs when fitted with a variable frequency drive). The DV-150 model (pictured below, right), has a 50-horsepower, dual 230/460-volt motor, 6-inch suction/discharge diameters, and can handle a maximum of 2,000 gallons per minute or 100 feet of head. It would pump about 3 cfs in this application. Specification sheets for the pumps are provided in Appendix D.

DV-300 12" Pump

DV-150 6" Pump

Estimated Costs

The broad range of options for the tunnel intake area pump alternative as described above is reflected in the difference between high and low price estimates in Table 3.2-1 below. The low estimate of $57,000 assumes one 6-inch pump (3 cfs capacity) with an above-ground discharge pipe and no pooling of water (or use of existing stop logs without retrofit/replacement). The high estimate of $426,000 assumes a 12" pump fitted with a variable frequency drive (for a capacity ranging from 7-10 cfs), a buried discharge pipe, and replacement of all stop logs with four automated sluice gates and accompanying ultrasonic level transducer system. Intermediate alternatives include supplementing the single 6-inch pump with one or two additional 6-inch pumps (at $30,000 each) for a total capacity of 6 or 9 cfs, and/or replacement of some stop logs with sluice gates (at $50,000 each). The recommended scenario for this alternative—three 6-inch pumps with no pooling of water—would cost approximately $139,000.

Note that neither this nor the low estimate factor in the relatively minor differences in cost due to smaller (6-inch) PVC piping and/or additional pipe lengths for more than one pump. It is assumed that the required 230/460-volt supply is available on site (likely, due to the presence of other large pumps in the pump house); additional costs to supply a connection were not included. A quote for the variable frequency drive (for the 12-inch pump) could not be obtained. Finally, the long-term cost of electricity to run the pump(s) was not considered. Note that these pumps may also be rented for $2,500 (6-inch pump) to $7,500 per month (12-inch pump).

Table 3.2-1 – Estimated costs for Alternative 2 – Tunnel intake area pump option

Item	Unit Price	Unit	LOW ESTIMATE (6" pump, no gates)		HIGH ESTIMATE (12" pump, 4 gates)	
			Qty	*Cost*	*Qty*	*Cost*
General contractor requirements *(mob/demob, on-site facilities, etc.; 10% of remaining itemized costs totaled)*	-	%	10%	$4,110	10%	$22,311
Centrifugal pump *(6-inch for low est. or 12-inch for high est.)*	*varies*	EA	1	$30,000	1	$90,000
8'x7' stainless steel sluice gates *(installed)*	$50,000	EA	0	$0	4	$200,000
Ultrasonic level tranducers (2) and controller	$3,000	LS	0	$0	1	$3,000
Electric panel; connect to gates, sensors, and pump	$4,400	LS	1	$4,400	1	$4,400
12-inch PVC pipe, bends	$2,000	LS	1	$2,000	1	$2,000
10-inch PVC pipe, bends	$2,700	LS	1	$2,700	1	$2,700
Dewatering	$1,000	DAY	2	$2,000	10	$10,000
Excavation	$20	CY	0	$0	27	$540
Crushed stone bedding	$50	CY	0	$0	4	$200
Backfill and compaction	$10	CY	0	$0	27	$270
Subtotal				**$45,210**		**$335,421**
Contingency allowance *(25% of subtotal)*			25%	**$11,303**	25%	**$83,855**
TOTAL Estimated Cost *(2010 $ rounded to nearest $1000)*				**$57,000**		**$419,000**

Items in red indicate differences between high and low estimates. Low estimate assumes one 6" pump (3 cfs capacity) with an above-ground discharge pipe and no pooling (or existing stop logs in all 4 bays); high estimate assumes a 12" pump with a variable frequency drive (7-10 cfs), a buried discharge pipe, and replacement of all stop logs with 4 automated sluice gates. Intermediate alternatives include supplementing the 6" pump with 1 or 2 additional 6" pumps (at $30,000 each) for a total capacity of 6 or 9 cfs, and/or replacement of some stop logs with sluice gates (at $50,000 each). Low estimate does not include potential costs to retrofit/replace existing stop logs to prevent excessive leakage, if stop logs are used to pool water for pumping. It also does not factor in the reduction in cost from using smaller diameter PVC piping.

3.3 Alternative 3 – Centre Street Junction Structure Gravity Option

At the Centre Street junction structure, gravity pipe connections were considered to re-route flow being diverted into the lower Centre Street culvert into the upper Town Brook channel instead. For example, a 42" drain discharging into the Centre Street culvert just upstream of the junction (shown in Appendix E2, Drawing No. 3) seemed to be contributing a significant amount of flow during a July 28, 2010 site visit. However, the approximately 5-foot difference in elevation between the invert of the drain pipe and the Town Brook trough was not feasible to overcome in such a short distance. Likewise, the concept of reconstructing the Centre Street culvert upstream of the junction structure to allow flows to enter the junction at the same invert elevation as Town Brook faces challenging feasibility due to the length of culvert that would have to be excavated. As shown in Drawing 3 of Appendix E2, the Town Brook invert elevation of approximately 24 feet in the junction structure is not matched in the Centre Street culvert until approximately 700 feet upstream, above the transition structure. Furthermore, any drain connections with an invert elevation below 24 feet would have to be rerouted as well. Such an option may be possible, but would require a more thorough analysis of the drainage network in the area and would have high construction costs.

Instead, the chosen 'gravity' option at the Centre Street junction is one of the simplest alternatives—prevent excess Town Brook flows from spilling into the lower Centre Street/Burgin Parkway conduit by raising the vertical side walls of the steel trough. As discussed in Section 2.3, the capacity of the existing trough appears to be approximately 10 cfs. Using the same headwater depth chart from HEC-5 (USDOT, 1965), it was determined that raising the height of the side walls by 0.5 feet (for a total height of 1.5 feet) would increase the capacity to approximately 19.3 cfs (assuming a wingwall flare of zero degrees). That would correspond to a gain of about 9 cfs, which is within the target flow restoration range of 3-10 cfs. Raising the wall height by 1 foot (for a total height of 2 feet) would increase capacity to approximately 29.4 cfs—more than necessary for the goal of this project.

Thus, this alternative proposes to weld ¼-inch-thick, 8-inch-high steel extensions (with 2-inch overlap, for a total height increase of 6 inches) onto the vertical side walls of the trough in the Centre Street junction structure to increase the capacity to approximately 19.3 cfs. Details for this alternative are shown in Drawings 3-1 and 3-2 of Appendix C.

Due to the increased weight load of the additional water, a 12-inch-high wide flange steel support beam is proposed to be welded underneath the trough. However, this recommendation is based upon simple analysis and would need further study for a final design. To improve the efficiency of the transition between the outlet of the twin 48-inch culverts and the entrance to the trough, the existing concrete bench (with an approximate elevation of 25.1 feet) is proposed to be filled with additional concrete to an elevation of 25.4 feet, with 9-inch-high bent steel plates attached to the edge to direct flow towards the trough (see partial plan on Drawing 3-1 in Appendix C for details).

Considerations

It is important to note that this option would address average flow losses that have reduced stream scouring and sediment transport processes that are important for maintaining healthy smelt spawning habitat, but would not recapture chronic dry weather losses of base flow from the Crown Colony tributary. To address both flow losses, this alternative should be conducted in conjunction with another alternative that recaptures flows bypassed from Crown Colony.

This analysis did not consider the impact of the 12-inch-high support beam encroaching into the Centre Street conduit below and the corresponding reduction in flood capacity. Further study would be necessary for a final design.

Another consideration for this alternative is the replacement of the entire trough with a larger capacity trough, rather than retrofitting the existing trough. Further analysis would be necessary to assess the condition of the trough and determine whether it would be more economical in the long term to repair or replace. A replacement trough would have the added benefit of being designed to handle the increased capacity, thus eliminating the need for a reinforcing beam underneath.

Estimated Costs

Low and high estimates to extend the height of the steel trough in the Centre Street junction structure are provided in Table 3.3-1 below. The only difference between the two is the elimination of the concrete bench fill as a potential way to reduce costs for the low estimate ($19,000). However, the higher estimate of $33,000 to fill in the concrete bench and improve flow efficiency is recommended.

Table 3.3-1 – Estimated costs for Alternative 3 – Centre Street junction gravity option

Item	Unit Price	Unit	LOW ESTIMATE *(no concrete bench)*		HIGH ESTIMATE *(concrete bench)*	
			Qty	*Cost*	*Qty*	*Cost*
General contractor requirements *(mob/demob, on-site facilities, etc.; 10% of remaining itemized costs totaled)*	-	%	10%	$1,400	10%	$2,400
1/4-inch-thick galvanized steel	$1,000	LS	1	$1,000	1	$1,000
12-inch steel support beam *(for under trough)*	$3,000	LS	1	$3,000	1	$3,000
Concrete *(for upstream bench area)*	$400	CY	0	$0	25	$10,000
Dewatering	$1,000	DAY	5	$5,000	5	$5,000
Prep steel for welding	$2,000	LS	1	$2,000	1	$2,000
Weld steel plate extensions to trough	$2,000	LS	1	$2,000	1	$2,000
Bend steel angles and anchor to concrete upstream of trough	$1,000	LS	1	$1,000	1	$1,000
Subtotal				**$15,400**		**$26,400**
Contingency allowance *(25% of subtotal)*			25%	**$3,850**	25%	**$6,600**
TOTAL Estimated Cost *(2010 $ rounded to nearest $1000)*				**$19,000**		**$33,000**

Items in red indicate differences between high and low estimates. Low estimate does not include concrete to raise the bench upstream of the trough and thus smooth the transition from the twin culvert outlets.

3.4 Alternative 4 – Centre Street Junction Structure Pump Option

The final alternative considered in this study is to pump flow from the lower Centre Street conduit up to the Town Brook channel. As with the tunnel intake area pump option (Alternative 2), several pumping scenarios are possible. There is also the option of simultaneously extending the vertical sides of the Town Brook trough to increase its capacity to accommodate the pumped flows. Details for a 12-inch pump in conjunction with a trough height extension are shown in Drawings 4-1 and 4-2 of Appendix C.

The pump would be located above ground on the median strip above the Centre Street junction, near the manhole access to the upstream end of the structure. The suction and discharge pipes would enter the structure underground, run along the ceiling, and descend vertically to pull water from the Centre Street conduit on the upstream side of the chamber and discharge it into the Town Brook channel. A single 8-inch-wide by 16-inch-high timber stop log could be inserted into the existing stop log groove to span the Burgin conduit just downstream of the junction and pool water for pumping (see Drawings 4-2 and 0-6 in Appendix C for details). For this site, a vandal-proof cover would be needed for the pump as it will be located in the open on a median strip (not depicted in the drawings).

For pump sizing options, as discussed for Alternative 2, a series of one, two, or three 6-inch pumps would be preferred over a 12-inch pump fitted with a variable frequency drive for a lower range of pumping rates (3-9 cfs vs. 7-10 cfs)—particularly at this site which is further up in the watershed and may not have as much flow in the Centre Street/Burgin conduit.

A 0.5-foot vertical extension to the side walls of the trough is recommended to help accommodate the increased flows pumped from below. See Alternative 3 for details of this modification. As discussed, additional concrete fill on the bench upstream of the trough with 9-inch steel plates attached to the edges would help smooth the transition between the twin culvert outlets and the entrance to the trough, but this improvement is also optional.

Considerations

This analysis did not consider the impact of the encroachments of the 12-inch-high support beam, the suction/drainage pipes, or the stop log into the Centre Street conduit and the Town Brook channel. These encroachments would result in a reduction in flood capacity and would need to be properly secured to protect against flood damage. Further study would be necessary for a final design. As with Alternative 3, replacement of the steel trough should also be considered.

Equipment Details

Details for the pumps are provided in Section 3.3 above, and specification sheets are provided in Appendix D.

Estimated Costs

As for the tunnel intake area pump alternative, the broad range of options for this alternative is reflected in the relatively large difference between low and high cost estimates in Table 3.4-1 below. The low estimate of $67,000 assumes the addition of a pump only, without the corresponding raising of the trough side walls (not recommended, since the trough capacity may already be too low). It also assumes a single 6-inch pump for a rate of 3 cfs, which may be actually be sufficient at this site. (A second 6-inch pump could be added to increase the pumping rate to 6 cfs.) The high estimate of $189,000 assumes a 12-inch pump with VFD and a simultaneous increase in the capacity of the trough.

The recommended intermediate option of two 6-inch pumps and raising of the trough side walls (including concrete bench improvements) would cost approximately $148,000.

Note that neither this nor the low estimate factor in the relatively minor differences in cost due to smaller (6-inch) PVC piping and/or additional pipe lengths for more than one pump. It is assumed that the required 230/460-volt supply is available nearby (possibly for traffic control equipment); additional costs to supply a connection were not included. A quote for the variable frequency drive (for the 12-inch pump) could not be obtained. The cost of a vandal-proof cover to house the pump(s) was not included, and the long-term cost of electricity to run the pump(s) was not considered.

Table 3.4-1 – Estimated costs for Alternative 4 – Centre Street junction pump option

Item	Unit Price	Unit	LOW ESTIMATE *(6" pump, no ext.)*		HIGH ESTIMATE *(12" pump, ext.)*	
			Qty	*Cost*	*Qty*	*Cost*
General contractor requirements *(mob/demob, on-site facilities, etc.; 10% of remaining itemized costs totaled)*	-	%	10%	$4,850	10%	$13,250
Centrifugal pump *(6-inch for low est. or 12-inch for high est.)*	*varies*	EA	1	$30,000	1	$90,000
Electrical connection	$2,500	LS	1	$2,500	1	$2,500
12-inch PVC pipe, bends	$7,000	LS	1	$7,000	1	$7,000
10-inch PVC pipe, bends	$3,000	LS	1	$3,000	1	$3,000
Timber stop log	$1,000	LS	1	$1,000	1	$1,000
1/4-inch-thick galvanized steel	$1,000	LS	0	$0	1	$1,000
12-inch steel support beam *(for under trough)*	$3,000	LS	0	$0	1	$3,000
Concrete *(for upstream bench area)*	$400	CY	0	$0	25	$10,000
Dewatering	$1,000	DAY	5	$5,000	10	$10,000
Prep steel for welding	$2,000	LS	0	$0	1	$2,000
Weld steel plate extensions to trough	$2,000	LS	0	$0	1	$2,000
Bend steel angles and anchor to concrete upstream of trough	$1,000	LS	0	$0	1	$1,000
Subtotal				**$53,350**		**$145,750**
Contingency allowance *(25% of subtotal)*			25%	**$13,338**	25%	**$36,438**
TOTAL Estimated Cost *(2010 $ rounded to nearest $1000)*				**$67,000**		**$182,000**

Items in red indicate differences between high and low estimates. Low estimate uses one 6" pump (3 cfs capacity) leaves the overflow trough as-is; high estimate uses a 12" pump with a variable frequency drive (7-10 cfs) and adds a ½-foot extension to the vertical walls of the trough to increase capacity (same as Alternative 3). Intermediate alternatives include supplementing the 6" pump with 1 or 2 additional 6" pumps (at $30,000 each) for a total capacity of 6 or 9 cfs, and/or extending the trough without raising the concrete bench.

4 RECOMMENDATIONS

4.1 Recommended Alternatives

The tunnel intake area seems to be the more feasible site for a significant increase in flows to the Town Brook surface water system that will reach the smelt spawning area. Although restoring the Centre Street junction structure would result in additional surface water further upstream in the watershed, the only section of open Town Brook channel between there and the tunnel intake area is an approximately 765-foot-long stretch just downstream of Centre Street, which is not considered to be accessible for smelt spawning. Additionally, the tunnel intake area presents the opportunity for a larger volume of recovered flows, due to various stormwater inputs along the Burgin conduit. Furthermore, if no changes are made at the tunnel intake area, flows restored at Centre Street may still be unnecessarily diverted into the tunnel due to sedimentation issues at the Town Brook overflow weir at the intake area. Lastly, the tunnel intake area is preferable from a logistical standpoint because it is easily accessible, enclosed by security fencing, and has a structure with electrical connections on site.

That being said, increasing the capacity of the Town Brook trough in the Centre Street junction structure by raising the side walls is an attractive option because it is simple and economical (at $19,000 to $33,000 it is by far the cheapest alternative). This option on its own is a logical fix of low-level stormwater diversions that would provide habitat restoration through increased substrate scouring and sediment transport and but not address the base flow diversions as the Centre Street culvert passes flows directly to the Burgin Parkway conduit. If budget permits, this option would present a valuable solution to be performed in conjunction with any alternative.

Therefore, if just one alternative is chosen, restoration at the tunnel intake area will result in the greatest potential for continuous flow augmentation in the smelt spawning area. Cutting a connecting channel to carry Burgin conduit outflows to the Town Brook channel by gravity (Alternative 1) is desirable from a maintenance standpoint, because it does not involve the costs of operating and repairing a pump. However, the automated sluice gates are expensive and without them (i.e., using stop logs instead), personnel would need to be dedicated to manually remove stop logs in advance of flood conditions, which may prove difficult or impractical. There is also the concern of sediment build-up in the Burgin conduit outlet area against the sluice gates.

Therefore, the recommended alternative is to pump Burgin conduit outflows to the Town Brook channel (Alternative 2) without the use of sluice gates or stop logs to pool the water (i.e., from existing water level). The recommended pump configuration is to start with one 6-inch pump and add one or two additional 6-inch pumps as needed (wait to bury pipes until the desired configuration is determined). This scenario will provide the greatest flexibility in maintaining consistent flow augmentation even during lower flows, and will be most compatible with the intended flood control goals of the Town Brook Local Protection project. This option also will not deter the City of Quincy from considering other more expensive and structurally complex alternatives in the future. The decision-making process for all options will require consultation with the ACOE and DCR to ensure that the flood control project objectives in Town Brook will not be compromised.

4.2 Sediment Management Recommendations

Sediment management is an ongoing concern within the Town Brook system. Sediment accumulation near both the Centre Street junction and the tunnel intake area has resulted in unnecessary diversion of low flows into the flood control tunnel. Debris and sediment in the open channel just downstream of Centre Street have caused water to back up into the junction structure and spill over the edge of the trough into the Burgin conduit below, thereby diverting it to the flood control tunnel. Likewise, accumulation of sediment at the tunnel intake area in the widened section of Town Brook just before it enters the culvert under Burgin Parkway (pictured at right) have caused low flows to spill across the overflow weir into the tunnel intake shaft.

Thorough sediment and debris management protocols are detailed in Appendix G of the Town Brook Local Protection Project Operation and Maintenance Manual (provided in Appendix F4 of this document). This manual includes protocols for regular sediment maintenance in the Town Brook sediment trap at the tunnel intake area (i.e., measuring sediment at least twice a year and removal when half-full), and routine and emergency clearing of debris from the trash racks at the tunnel intake area and within the Centre Street junction structure. It also includes recommendations for sediment maintenance in the open channel downstream of Centre Street, but required protocols are vague. An in-stream sump could be considered at this location to help capture sediment that would otherwise cause a backwater into the Centre Street junction structure.

According to the manual, sediment levels in the Town Brook sediment trap at the tunnel intake area should be measured at least twice a year and removed when half-full (avoiding disturbance during smelt spawning season). If adhered to, these protocols should be sufficient to prevent significant diversion of low flows across the overflow weir and into the tunnel intake shaft due to excess sediment. Based on discussions with the Town of Quincy and the MA DMF, sediment maintenance has improved over the years. However, if unnecessary diversion continues to be an issue at this location (particularly if additional flows are being augmented from Burgin conduit outflows via a connecting channel or pump, as proposed in the alternatives above), modification of the weir could be considered. Automated inflatable crest gates or a 'bending weir' could be affixed to the top of the existing weir to increase the amount of low flow that can remain in the Town Brook channel, while higher flows would trigger lowering of the weir back to the original elevation for flood protection. However, the impact of a higher backwater upstream in the Town Brook channel would require further analysis, and the preferred solution would be regular sediment maintenance.

5 REFERENCES

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