2009 Monitoring Report
For Barkers Brook, Newry, Maine

Prepared For: Maine Department of Transportation

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PARISH geomorphic

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1) ACOE Permit # - NAE-2006-1793
Maine DOT Pin – 9184.00
Maine DEP Permit Number – L-23115-TH-A-N

2) Report Prepared by - Parish Geomorphic Ltd. 346 Queen St, Suite 203, Fredericton, NB E3B 1B2. Phone 506-472-8440, Fax 506-472-6250 **Monitoring Survey Conducted -** September 26th, 2009 by Parish Geomorphic Ltd.

3) *Project Description.* The purpose of this project was to mitigate the loss of wetland functions resulting from the reconstruction of Route 2 through the Sunday River Watershed. Approximately 1.60 acres of Barkers Brook was restored below the Sunday River Road in September of 2007 as compensation. The restoration aimed to modify channel planform and dimensions to improve sediment transport, provide flood storage, and improve aquatic habitat function. The design process included a geomorphic survey of Barkers Brook watershed to insure appropriate channel dimensions and function. At the initial assessment (2004) Barkers Brook exhibited extensive bank erosion throughout its length, areas of sediment accumulation, and a lowering of channel bed (a fish passage barrier). See Wetland Mitigation Plan for the Bethel-Gilead Highway Improvement Project, MDOT PIN 9184.00 June, 2006 for more detail.

On July 11, 2007, just months prior to construction of this project, a significant rainfall event occurred within the Barker's Brook watershed. Pat Cole, an engineer with the Town of Bethel, described the event as a 500-Year to 1000-Year rain event, with a localized intensity of 7-9 inches of rain in 2 hours. During this event an earthen dam used to impound water on the Sunday River Ski Resort for snowmaking purposes breached. The dam was constructed in-stream on Barkers Brook. According to Mr. Cole, the breach resulted in the complete loss of the dam structure to erosion and in the creation of a "gorge" downstream of the dam. The failure contributed a massive volume of sediment to the channel and floodplain from the ski hill to just above the project site.

This sedimentation was observed by Parish Staff in September 2007, just weeks prior to the channel construction. Our staff noted a thick layer of sandy material on the floodplain, sand embedded in the stream gravels and in large depositional features within the channel. Floodplain deposition was in excess of 12 inches in many areas and occasionally exceeded 18 inches. In addition to the sandy deposits, a large number of woody debris jams had developed. This deposition and excess sediment was observed to extend from the ski area to approximately 1 mile upstream of the project site.


These photographs of the same location on Barkers Brook show the extent of the instream sedimentation as a result of the July 2007 storm; the first was taken in 2003 at the time of the watershed assessment and the second was taken in September of 2007. Photographs are approximately 0.5 miles upstream of the project site.

Designs, performance goals and standards for the Barkers Brook Restoration Project were based on the watershed conditions as documented in 2003. The restoration project was constructed in September of 2007 as originally designed, despite the newly observed change to the condition of the upper watershed. The sediment stored in the upper watershed began impacting the project site almost immediately upon completion of construction. By October of 2007, just one month after construction, the pools had completely filled in with sand. By the following summer, in August of 2008, sand and gravel stored in the upper watershed had moved into the project reach causing the channel to aggrade throughout the reach and avulse in several locations (i.e. fill up with sediment and relocate, thereby changing its planform geometry). The newly deposited instream sediments and bar formations were soft and unconsolidated. By fall of 2009 the channel bed had coarsened and hardened; however, most all of the constructed pools and riffles remained buried below the new channel or below new bar formations. While some bank treatments have held up well, others are either completely abandoned by the new channel, buried to the top of the bank, or are failing because the re-aligned channel subjects them to forces greater than they were designed to withstand.


These photographs show the view looking upstream from Station 5+40. They demonstrate the dramatic changes to the channel planform, grade, and cross-sectional geometry between September of 2007 and September of 2009.

4) *Directions from Bethel, Maine.* From Bethel, Maine take the number 2 interstate (south) turn onto the Mayville Rd (also the number 2, 26 and 5) towards Newry, turn left onto the Sunday River Road and travel approximately 1.76 miles to the bridge over Barkers Brook. The Starwood

Ranch is directly across from the restoration site (upstream side of the bridge). The project is to the right or to the downstream side of the bridge.

5) *Important Dates*. The geomorphic assessment was completed in June of 2004, the design in December 2005, and the construction occurred in September 2007. The post construction survey was completed in October of 2007. Monitoring for Year 2008 was conducted in August of 2008. Monitoring for Year 2009 was completed in September of 2009.

6) *Performance Standard.* Barkers Brook was restored using the principals of fluvial geomorphology and natural channel design to promote a dynamically stable channel. Inherent performance goals for natural channel design are to increase channel stability, provide habitat diversity, and provide floodplain access for water, sediments and nutrients. The Wetland Mitigation Plan (June 2006) listed five minor channel adjustments that could be expected after exposure to the annual range of flows. These adjustments included: re-organization of riffles, siltation in pools, planform adjustment, bank erosion, and bar formation. In addition, as the work was a natural channel design, the objective was to create a dynamic channel, with the ability to continually adjust to changes in flow and/or sediment regimes.

The 2008 Monitoring Report attempted to reconcile these performance standards between observations made in 2008 and the constructed channel conditions of 2007. It is our belief that there is little value to regulators in comparing yearly site conditions to the constructed channel. The constructed channel was over-run by a large slug of sediment which moved into the project reach in the spring of 2008, following the 500-Year flood event of July 2007. The flood and the subsequent failure of the earthen dam were episodic events, and as such, they were unforeseen and no mitigation for such events was incorporated into the design or implementation of the project. Changes at the project site were of such a drastic nature that it makes no sense to compare current observations to the "*pre-event*" condition. Benefit can be realized, however, by comparing yearly changes to the "*post-event*" condition, thereby documenting the recovery of the site from the avulsion in 2008.

In addition from changing the baseline condition from the constructed channel to the "*post-event*" condition, the performance standards used to monitor the recovery of the project site should change from those originally proposed for the project. The post construction condition was designed to be dynamically stable for the watershed condition for which it was designed, meaning that features such as bank treatments, riffles, and pools were fixed in location. We anticipated only slight changes in location and condition over time. The 2008 "*post-event*" condition, however, was highly transitional, meaning that significant changes to planform, grade, bed bathymetry, aquatic habitat, and riparian condition could be expected. Many such changes were documented in 2009. Such dramatic changes make it difficult to monitor the location and condition of individual features, lending itself better to "site average" or "site total" type performance standards. The following performance standards are therefore proposed:

1. Riffle habitat. The 2008 "*post-event*" condition was typical of an aggraded system, having very little development in bed bathymetry (pools and riffles). As the channel becomes better defined and sediment moves out of the system, the total number of feet of riffle habitat should increase.
2. Pool habitat. As the channel becomes better defined and sediment moves out of the system, the total area, expressed in number of feet of pool habitat should also increase.

3. Width to depth ratio. The average width to depth ratio of the bankfull channel should decrease from year to year as Barkers Brook establishes a more stable channel through the aggraded portion of this reach.
4. Inter-riffle grade. The average slope between riffle crests should increase as the channel head-cuts and migrates through the deposited sediment.
5. Average pool depth. The average pool depth should increase from year to year as the channel stabilizes.
6. Planform adjustment. The channel will likely establish a single dominant channel with elevated flood chutes, rather than a multi-thread channel as was the case in 2008.

Table 1 demonstrates the changes in the revised performance standards between 2008 and 2009.

Table 1 - Performance Monitoring, Barkers Brook, Year 2009

Performance Standard	Baseline - 2008	2009
Riffle habitat	99.4 ft (count 5)	183.8 ft (count 10)
Pool habitat	419.6 ft (count 7)	517.5 ft (count 12)
Average width to depth ratio	18.3	15.5
Average inter-riffle grade	0.61 %	0.70 %
Average pool depth	0.93 ft	0.99 ft
Planform adjustment	Multi thread, mid channel bars dominate	Single thread, a few mid channel bars, transverse bars dominate

7) *Corrective Measures Taken.* In September of 2009 MDOT undertook corrective measures to remove coir fabric that was no longer functioning as indented or was threatening the stability of the stream. Fabric was removed where the stream had relocated such that it crossed directly over a constructed bank treatment location or where leaving the fabric in place would be detrimental to the recovery of the stream.


These photographs show examples of where remnants of bank construction using coir cloth were impeding the natural flow of water and sediment in Barkers Brook. MDOT staff removed the fabric in these and other similar areas in September of 2009.

8) *Further Recommendations.* The project team considered the value of implementing additional restoration work at the site to mitigate the impact of the accumulated sediment; however, upon a survey of the watershed conditions above the project site, further restoration is not recommended. There are several locations upstream that still retain large amounts of in-stream sediment from the 2007 event. The flood event also destabilized many banks. Any additional work at the project site could easily be compromised once these sediments are mobilized downstream. At the current time there are no recommendations beyond continuing to monitor performance standards and documenting the recovery of the project site.

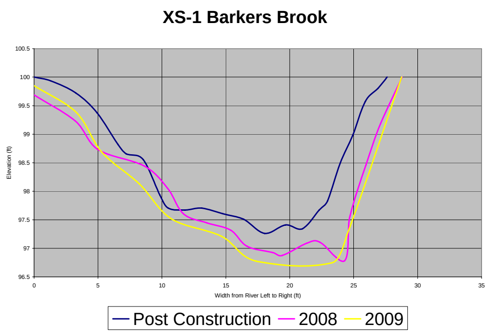
Requirements

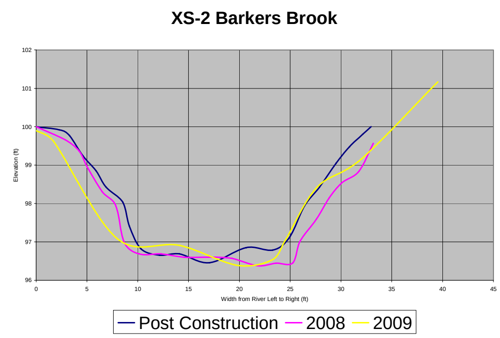
Monitoring requirements commenced with the Post Construction Survey completed in October of 2007. This report outlines methods proposed for performance monitoring to be repeated every year for the next three years, until 2012. An adaptive management approach has been adopted by Maine DOT, and thus our monitoring strategy has changed to better reflect the current site conditions. The framework will allow DOT to learn how the project site will recover from events precipitating from the dam failure in the upper watershed.

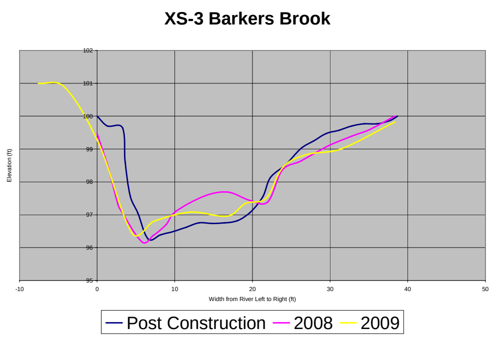
Summary Data 2009

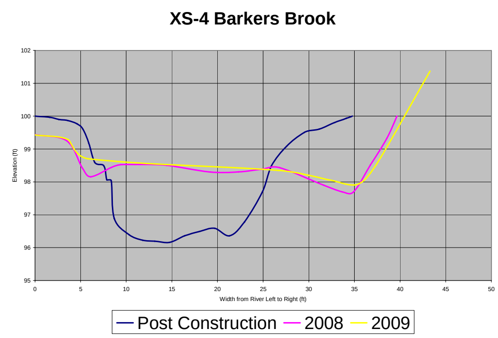
Site Location: Barker Brook Maine
Length surveyed: 820 Ft
Number of cross-sections: 6
Date of Survey: 22-Sep-09
Surrounding Land Use: Farmland Ski hills
General Riparian Vegetation: Maple/Ash/Birch/ Alders/ Willows
Existing Channel Disturbances: Bridge
Woody Debris: Minor
Upstream Drainage Area: 3.38 square miles

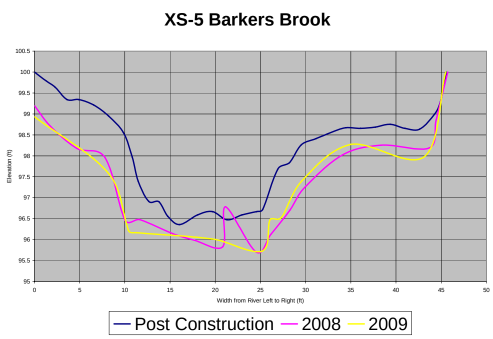
Cross-Section Surveys

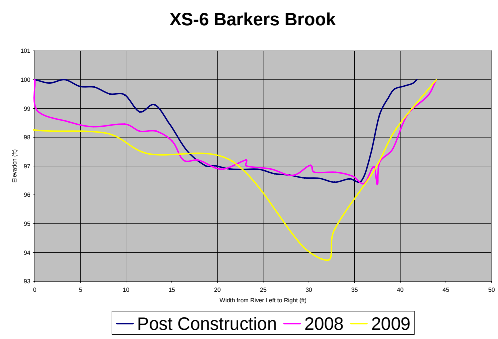








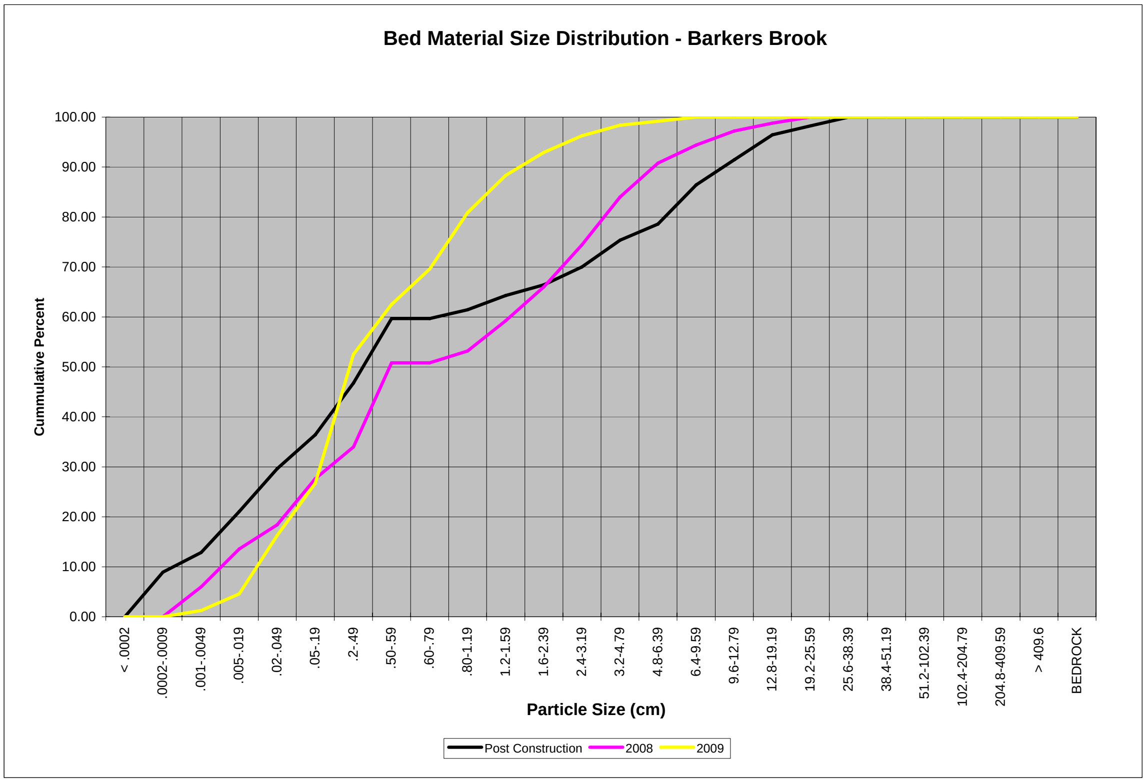




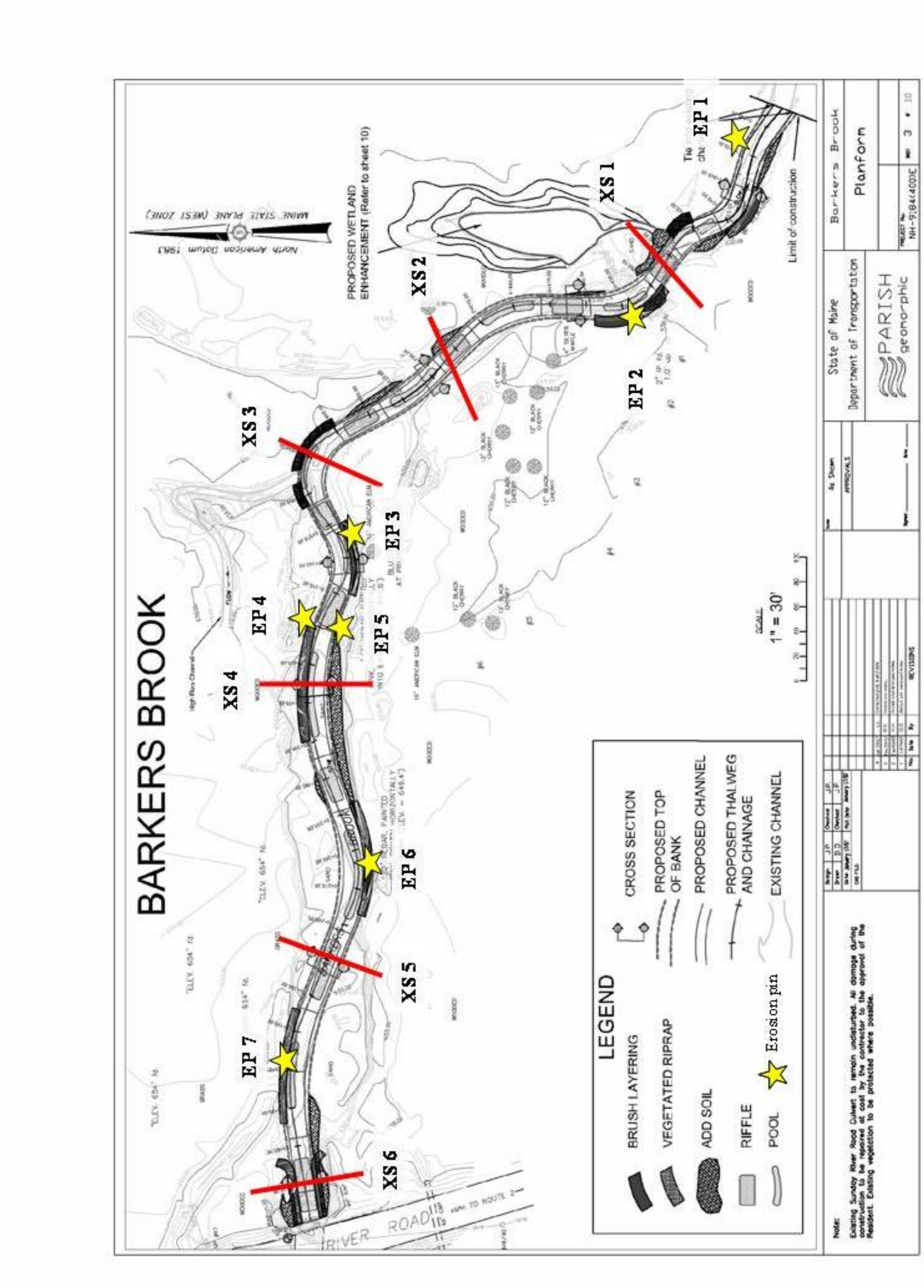
Profile


Thalweg Profile Barkers Brook
329
328
327
326
325
324
323
322
321
320
Elevation (ft)
0
200
400
600
800
1000
1200
River Length (ft)
Post Cosnstrucyion
2008
2009

Pebble Counts – Bed Sediment



Maps



Map 1 - Location of monitoring cross sections and erosion pins for Barkers Brook restoration.

Bench marked photos taken October 2008 and September 2009.

View from bridge looking east down stream

Left Bank – Cross-section 6

Right Bank – Cross-section 6

Left Bank – Cross-section 5

Right Bank – Cross-section 5

Left Bank – Cross-section 4

Right Bank – Cross-section 4

Looking upstream (west) from Cross-section 3

Bench marked photos taken October 2008 and September 2009.


Left Bank – Cross-section 3


Right Bank – Cross-section 3


Left Bank – Cross-section 2


Right Bank – Cross-section 2


Left Bank – Cross-section 1


Right Bank – Cross-section 1

Conclusions

Barkers Brook was restored in the fall of 2007 using the principals of fluvial geomorphology and natural channel design to promote a dynamically stable channel. Riffles were installed to create habitat and provide grade control. Bioengineered banks and beds were designed to provide stability, but also to be flexible enough to accommodate normal fluctuation of sediment or flow regimes in the watershed. The flood and dam failure in the summer of 2007 mobilized massive amounts of sand and gravel and stored them temporarily in the stream channel and on the floodplain in the watershed above the project site. Immediately following construction, subsequent flooding events (as early as spring of 2008) moved the excess sediment into the project site. Though the restoration was designed for high flow events, the large amount of sediment introduced into the system was not anticipated at the time of the design. As a result, the project has undergone significant changes since construction, primarily the in-filling of the cross-sectional flow area with sand and gravel.

Changes at the project site were of such a drastic nature that it makes little sense to continue to compare current observations to the constructed condition. Benefit can be realized, however, by comparing yearly changes to the "*post-event*" condition, thereby documenting the recovery of the site from the avulsion in 2008. Performance standards were modified to include more "site averaging" metrics rather than measurement to changes of specific features. This will allow MDOT and regulators to best track the recovery of the dynamic changes which we anticipate to occur at the site from year to year.

Monitoring results of the performance standards indicate the channel condition has improved in 2009 over the 2008 condition. Both the length and count of riffle and pools has increased, as well as the average maximum depth of the pools. The average inter-riffle grade has also increased, meaning that more frequent and steeper riffles are forming. Width to depth ratios have decreased, meaning the channel is getting deeper, forming a thalweg through the deposited sediments, and the channel is transitioning from a multi-thread channel to a single thread channel (see **Table 1**).

Restoration efforts at the site have not been in vain, despite the unforeseen changes. Components of the original restoration objectives have proved very effective; namely, the development of a more dense and stable riparian corridor through the floodplain planting and the establishment of the off-channel wetland. Both of these features have improved markedly from the pre-restoration condition. In addition, there is a strong likelihood that the in-stream restoration work actually minimized the impact of the 2007 flood event on the project site. The restoration of the channel and floodplain provided sediment transport capacity and sediment storage capacity that was not available prior to the restoration work. Had the restoration work not occurred, the 2007 event would likely have created even greater changes at the site, possibly including large changes in planform and riparian corridor relocation.