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Newman Road Tidal Assessment
Newbury, Massachusetts

Geosyntec consultants

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COMMONWEALTH OF MASSACHUSETTS
Division of Ecological Restoration

Prepared by:

Geosyntec Consultants
289 Great Road, Suite 105
Acton, MA 01720

Prepared for:

MA Dept. of Fish & Game
Division of Ecological Restoration
251 Causeway Street, Suite 400
Boston, MA 02114

Project Background

The Newman Road Site (Site) is located in Newbury, Massachusetts adjacent to the Old Town Hill Reservation operated by the Trustees of the Reservations. A tidal assessment was conducted in May 2005 to determine the performance of an existing 48-inch diameter corrugated metal pipe. Data proved that the existing pipe was restricting flow into the salt marsh. In 2010, the 48-inch pipe was replaced with a 6-foot by 12-foot precast concrete box culvert to allow for more tidal flushing into the salt marsh and allow for restoration of the habitat which had previously been degraded. According to the New York State Salt Marsh Restoration and Monitoring Guidelines, the most basic means of restoring salt marshes is reintroduction of tidal regime (Niedowski, 2000). To assess the post-construction restoration, a tidal assessment was conducted and used for comparison to the pre-construction tidal assessment data.

Tidal Survey

To assess the post-construction restoration at the Site, two tide-gauges were installed on April 7, 2011. Tide-gauges consisted of Onset® HOBO U20 Water Level Data Loggers that have operational ranger from 0 to 30 feet with ±0.02 ft accuracy. One tide-gauge was installed in the marsh (N2) located upstream of the Newman Road box culvert (Photo 1) and one downstream (N1) of the Newman Road box culvert (locations shown in Attachment A). The tide-gauges were deployed to collect continuous water level data at 6-minute intervals for 28 days, spanning the monthly spring tide. The tide-gauges were assigned elevations using a known benchmark at the Site, which was a P.K. nail (elevation 7.03 NAVD 88) found in bituminous pavement along the north side of Newman Road to the east of the box culvert.

Photo 1. Newman Road Upstream (N2) Tide-Gauge

UMASS Dartmouth School for Marine Science and Technology (SMAST) collected pre-construction data at Newman Road for 11-days from May 3 to May 14 of 2005 (data was provided by Massachusetts Division of Ecological Restoration). Figure 1 is a plot of 7-days of pre-construction data for the Site. The data shows that the upstream marsh functions differently than the downstream. From the pre-construction data it appears that the upstream marsh was restricted and did not have enough time between tide cycles to effectively drain through the former 48-inch pipe. Also, based on the existing conditions survey it appears that the upstream channel is impounded by a perched culvert (i.e., outlet elevated above the downstream water surface, allowing a freefall condition). During large storms events, water overtops the road and then causes a drainage lag due the large volume of water on the upstream side draining through the small culvert.

Geosyntec Consultants, Inc. (Geosyntec) collected post-construction restoration data at the Site for 30-days from April 7 to May 7 of 2011. Figure 2 is a plot of water elevation data over the complete tidal assessment period and Figure 3 is a plot of 7-days of water elevation data from April 16 to April 22 of

2011. To determine the differences between pre-construction and post-construction and evaluate restoration, tidal metrics were evaluated on the tidal assessment data sets. The tidal metrics include:

- Mean Higher-High Water – the average of the higher-high water height of each tidal days within the survey period;
- Mean High Water – the average of all observed high water levels;
- Mean Tide Level – mean of high water and low water levels;
- Mean Low Water – average of all observed low water levels;
- Mean Lower-Low Water – average of the lower-low water height of each tidal day within the survey period;
- Tidal Maximum – highest tide during the survey period;
- Tidal Minimum – lowest tide during the survey period;
- Mean Tide Range – difference in height between Mean High Water and Mean Low Water;
- Tidal Range Ratio – ratio of upstream (restricted) mean tide range over downstream mean tide range; and
- Maximal Tidal Dampening and Associated Phase Delay – largest disparity between up and downstream gauges and associated time delay between peak water elevations.

Tidal Assessment

Prior to deployment of the tide-gauges at the Site, the gauge calibration, completed by the manufacturer, were verified by Geosyntec to ensure that the loggers were accurately recording water depth. The tide-gauges were verified by resting the gauges in a bucket of fresh water for approximately 15-minutes and recording water level during this time. The downstream and upstream gauges appeared to be accurately recording water level. At the end of the deployment period, the depth of water was measured prior to removing the gauges and used as verification that the gauges were accurately recording water depth during the deployment period. Since the gauges appeared to be accurately recording water level, no correction factors needed to be applied to the data.

On-site elevation surveys of the tide-gauges were conducted by Geosyntec on April 26 of 2011. Each of the tide gauges were assigned an elevation using the existing Site benchmark (P.K. Nail at El. = 7.03 ft NAVD 88). It was determined that the upstream tide-gauge was installed at an elevation of - 4.68 ft NAVD 88 and the downstream gauge was installed at an elevation of - 3.07 ft NAVD 88. During the on-site elevation survey, the tide-gauges were removed from their stilling well housings and downloaded to ensure they were collecting data. When the tide-gauges were replaced in the housing Geosyntec observed that the upstream tide-gauge stilling well had approximately 1.7 inches or 0.14 feet of accumulated sediment in the bottom (the sediment apparently had accumulated in the annular space between the tide gauge and the interior wall of the stilling well and collapsed into the bottom of the stilling well when the tide gauge was removed for download). When the tide-gauge was returned to the stilling well, it rested on top of the sediment and therefore, the data from April 26 to May 7 of 2011 was corrected to account for this difference in elevation. The offset measurement was verified following removal of the equipment; the thickness of sediment was confirmed by measuring from the top of the stilling well to the top of the sediment and then to the invert of the stilling well following cleaning.

Figure 2 shows that the post-construction tidal cycles for the upstream (marsh) and downstream tide-gauges are almost identical, indicating that the tidal regime has been altered when compared to the pre-construction condition. Rain events on April 13 (0.1 inches) and April 17 (0.3 inches) of 2011 are recorded in the hydrograph and are evidenced by the elevated height of low tide recorded on those days.

To determine differences between pre-construction and post-construction for the upstream and downstream systems, the tide metrics were calculated and are presented in Table 1. Table 2 presents the tidal metrics to assess the overall pre-construction and post-construction restriction severity.

Table 1. Newman Road Upstream and Downstream Tidal Metrics

Tidal Metrics	Upstream Condition		Downstream Condition	
	Pre-Construction[1] Water Elevation (ft)	Post-Construction[2] Water Elevation (ft)	Pre-Construction[1] Water Elevation (ft)	Post-Construction[2] Water Elevation (ft)
Mean Higher-High Water	4.96	4.79	5.53	4.78
Mean High Water	4.52	4.44	5.25	4.28
Mean Tide Level	2.75	1.39	1.84	0.99
Mean Low Water	0.97	-1.67	-1.57	-2.29
Mean Lower-Low Water	0.89	-1.76	-1.65	-2.43
Tidal Maximum	6.11	5.90	6.65	5.91
Tidal Minimum	0.67	-1.86	-1.71	-2.55
Mean Tide Range	3.55	6.12	6.82	6.57

Notes:

1. Pre-construction tidal data collected in May 2005 and includes 11 days of data.
2. Post-construction tidal data collected in April-May 2011 and includes 30 days of data.

Table 2. Newman Road Pre-Construction and Post-Construction Tidal Metrics

Tidal Metrics	Pre-Construction	Post-Construction
Tidal Range Ratio	52%	93%
Maximal Tidal Dampening (feet)	0.86	0.04
Phase Delay (minutes)	26	<6

The Tidal Metrics indicate the following tidal assessment results:

- Upstream and downstream Mean Higher-High Water and Tidal Maximum are approximately the same for the post-construction tidal assessment period, indicating that the upstream and downstream marshes are responding hydrologically similar during tidal cycles;
- Post construction Mean High Water is marginally greater on the upstream side when compared to the downstream side. This could be the result of continued inflow of upstream freshwater sources into the marsh during high tide;
- Upstream Mean Tide Range increased by more than 2.5 feet from pre- to post-construction, showing a change in the tidal regime in the marsh due to replacement of a perched culvert with a culvert with inverts set at the channel grade allowing free flow of water;

- Mean Low Water and Mean Lower-Low Water elevations in the upstream marsh decreased during low tide events between pre and post-construction suggesting that the marsh drains more completely post-construction;

- Maximal Tidal Dampening for the system decreased by 95% from 0.86 ft pre-construction to 0.04 ft.post construction; and

- The Phase Delay for pre-construction was estimated to be 26 minutes. The Phase Delay for the post-construction is less than 6 minutes. The post-construction Maximal Tidal Dampening of 0.04 feet was recorded on four occasions: an associated Phase Delay of 0 minutes was observed on three of the four occasions, with a 6 minute Phase Delay observed on a single occasion. Note, the recording interval for the data loggers was 6 minutes; therefore, the actual Phase Delay is likely close to zero, but was reported based on the recording interval.

A good indicator of the severity of the restriction is the Tidal Range Ratio, which represents the tidal range of the upstream side over the tidal range of the downstream side (Carlisle, et. al., 2002). Under the pre-construction condition the Tidal Range Ratio was 52%, indicating that the upstream side receives only 52% of the tidal range. Under the post-construction, the Tidal Range Ratio is 93%, showing that the upstream marsh receives almost all of the tidal range available. The Tidal Range Ratio is a clear indicator that the culvert replacement has been successful in restoring the tidal regime.

In summary, it appears the restoration objectives to increase tidal regime in the upstream marsh, replace the perched culvert, and prevent overtopping of the road were achieved. Upstream tidal range increased by 2.5 feet and the tidal range ratio shows that the upstream marsh is receiving 93 percent of the available tide range. The mean low tide dropped by more than a foot, showing that the new culvert is allowing the upstream marsh to drain during low tide events. The replacement of the culvert has allowed for more flushing and is allowing more salt water to enter the marsh.

References

Carlisle, B.K., A.M. Donovan, A.L. Hicks, V.S. Kooken, J.P. Smith, and A.R. Wilbur. 2002. *A Volunteer's Handbook for Monitoring New England Salt Marshes.* Massachusetts Office of Coastal Zone Management, Boston, MA.

Niedowski, N.L. 2000 *New York State Salt Marsh Restoration and Monitoring Guidelines.* New York State Department of State Division of Coastal Resources and Department of Environmental Conservation, Albany, NY.

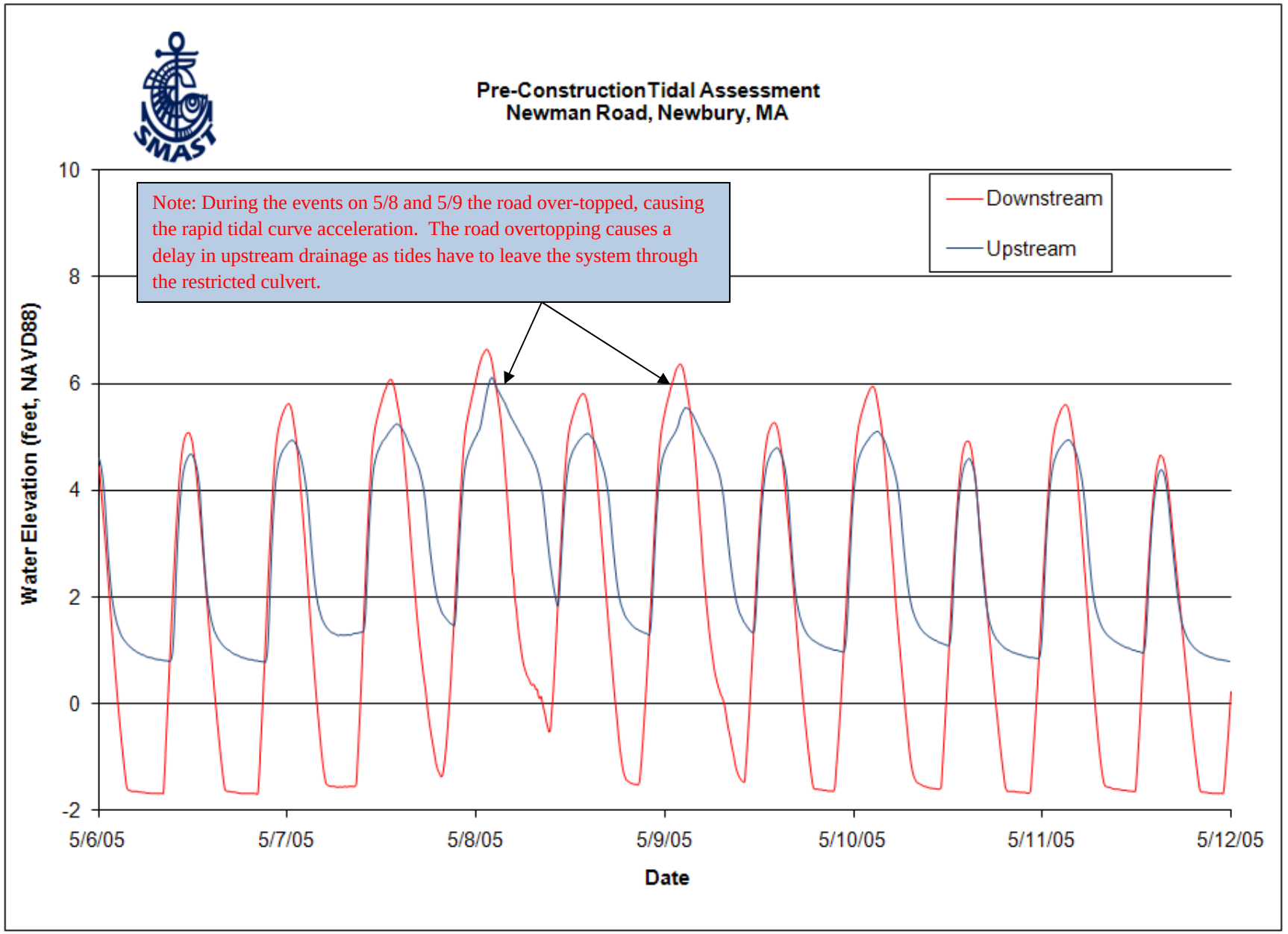

Figure 1. Pre-construction tidal assessment at Newman Road.

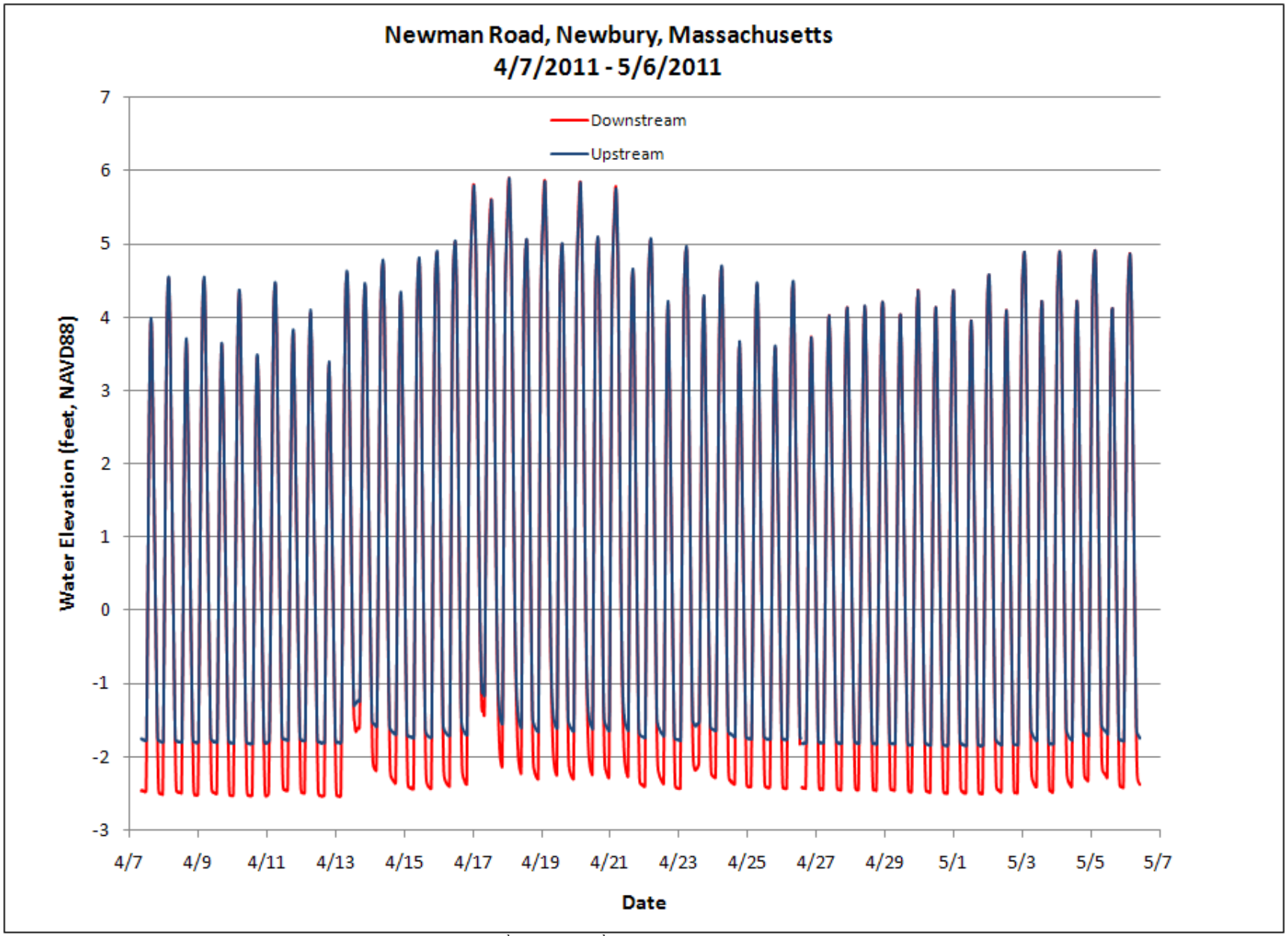

Figure 2. Post-construction restoration data from April 7th to May 7th of 2011.

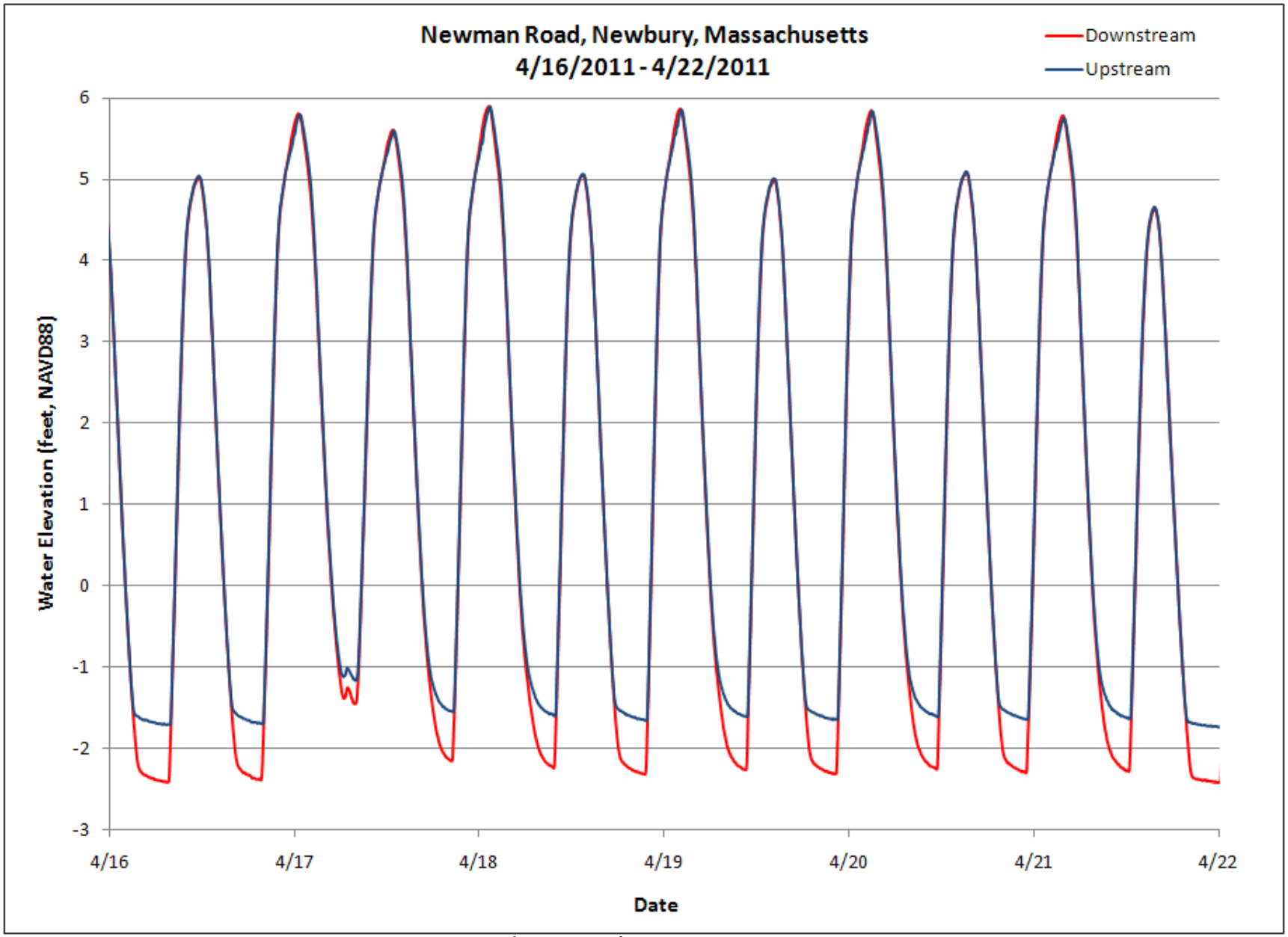

Figure 3. Post-construction restoration data from April 16th – April 22th of 2011.

50 25 0 50 100
Feet

Legend

Tide-gauge Location (Geosyntec, 2011)

Notes:
1. Aerial image via MassGIS, 2008.
2. Elevations of transducers included in survey data sheets included in this report.
3. Elevations refer to NAVD88.

Tide-gauge Locations

Newman Road
Newbury, MA

Acton, Massachusetts
JUNE 2011

Geosyntec consultants

Attachment
A

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