July 24, 2003

Dear Mr. XXXX,

I am writing you this letter to provide you with comments on your planned restoration for the Little Island Salt Marsh in West Falmouth. In this letter, I also attempt to explain and summarize some of the complex engineering and permitting issues that surround this project, so others interested in this project can better understand them.

As you know, in May 2002, the Buzzards Bay Project sent a notice to landowners around Buzzards Bay about our program to restore tidally restricted salt marshes. You contacted Buzzards Bay Project Natural Resource Planner Aria Brissette in my office to say that you were interested in our program, and potential grant funding. Specifically, you hoped to replace a one-foot diameter blocked culvert to a salt marsh near your home ("Little Island Salt Marsh"). Sediments had largely blocked the culvert during Hurricane Bob in 1991, but some modest tidal flow apparently does enter the marsh. This salt marsh system is actually composed of an upper marsh component, covering roughly two-thirds of the system, separated from the lower marsh area by a second culvert. A locus map of the site, with these features, is shown in Figure 1.

When you contacted Ms. Brissette, you indicated that you and your neighbors had already contracted with the engineering firm, Warwick and Associates Inc., and the environmental consultants Woods Hole Group. Warwick and Associates Inc. had prepared an engineering plan and designs to replace the existing blocked 1-foot diameter, 346-foot long pipe, with a new 1-foot diameter ABS pipe. Although the pipe diameter was the same, the proposed new inflow "invert" (i.e., the elevation of the base of the inside of the pipe) from West Falmouth Harbor was depressed from 2.57 feet to 1.0 feet NGVD29, while the invert on the restricted salt marsh pond side was elevated slightly from 1.77 to 2.00 feet. The original plans for the culvert replacement were prepared in December 1999, with revisions made in 2000, and a last revision dated June 25, 2003. The plans do not include any replacement for the shorter culvert serving the upper marsh. Water is believed to flow largely unimpeded through this second culvert, which has an invert toward the ocean flow direction of 2.02 feet and an inland side invert elevation of 2.34 feet. Water in the upper marsh pond beyond this second culvert stands at 3.22 feet. A summary of these elevations, and other information referenced in this letter, is shown in Figure 2.

In June 2002, Woods Hole Group completed a report evaluating the improved flushing with the proposed designs of Warwick Associates (i.e., a new pipe of the same diameter, but with the different invert elevations). They compared the new predicted flushing to the existing pipe design if it were unobstructed. With the new invert elevations, Woods Hole Group concluded that tidal exchange volumes would increase from 4,300 cubic feet at neap tides to 23,000 cubic feet during neap tides, and an increase from 31,600 cubic feet to 46,480 cubic feet at spring tides. The report also noted the increase in water level within the pond in the upper marsh "would be 0.25 feet [i.e., 3 inches]" with the new pipe. We presume this would occur at high tide, and at low tide the pond could drain to no lower than the invert elevation of 2.34 feet.

Figure 1. Existing culvert pipe, approximate property boundary (red lines), and topographic contours (light green = 9 feet, bright green = 19 feet) in the vicinity of Little Island Salt Marsh. Property bounds from Town of Falmouth. Contours from MassGIS based on photo interpretation.

At a meeting last summer involving the Buzzards Bay Project, my staff discussed with you and your engineers what information would be necessary to obtain permits for this project, or to obtain funding from state or federal agencies. Key information needed for a permit included existing marsh elevations and nearby structure elevations to determine if tidal inundation would adversely affect any nearby properties. If federal or state grant funding were sought for this project, we noted that a larger pipe size would be preferred to maximize tidal flushing, especially if there were no adverse effects from tidal inundation of adjoining properties. A larger pipe would also be considered for this site because the largest expense associated with this project is not the pipe, but the excavation costs. Pipe costs might amount to only 30% of total project cost, and the increase in cost associated with a larger pipe would be a small percentage of the total project cost.

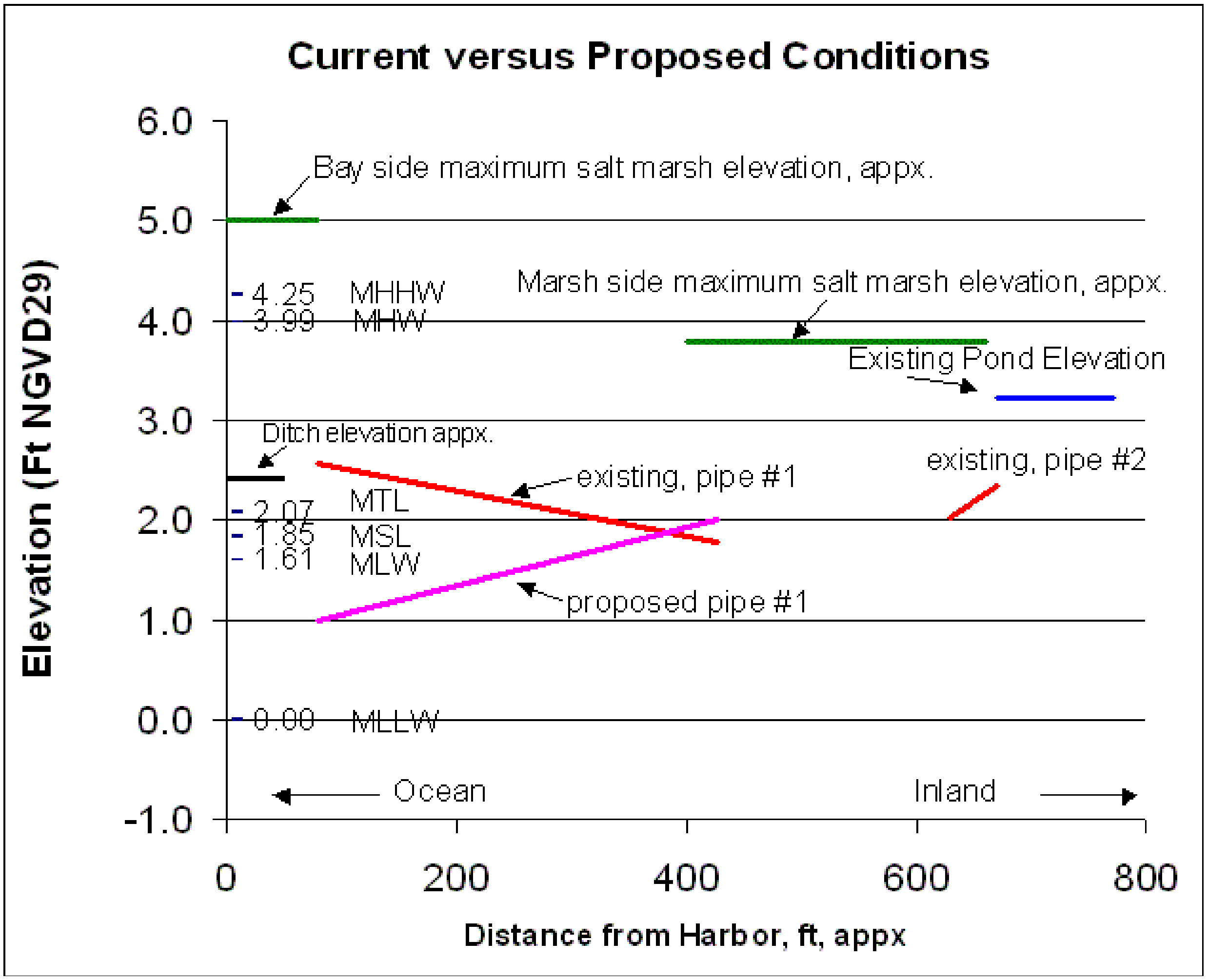

Figure 2. Summary of existing features and proposed new pipe elevation for the culvert replacement at Little Island Marsh.

To answer the question about increased tidal inundation resulting of larger pipe diameters and invert elevations, the Woods Group issued a supplemental report in May 2003[1] that considered a variety of pipe diameters and pipe invert elevations. In the report, they revised slightly the estimated tidal exchange for the existing pipe (if unobstructed) to 3,510 cubic feet during neap tides and 25,800 during spring tides. They also revised the predicted tidal exchange for the Warwick and Associates designs (1.0 foot harbor side invert elevation, 2.0 foot marsh side invert elevation, 1-foot diameter pipe) as 17,981 cubic feet during neap tides and 37,909 during spring

[1] Correspondence dated May 2, 2003, regarding “Summary of additional culvert design scenarios, Little Island Marsh, Falmouth, MA”, supplementing the report “restoration of Little Marsh” June 2002, Woods Hole Group 81 Technology Park Drive, East Falmouth, MA 02536.

tides. Based on the supplemental analysis, Woods Hole Group predicted the potential increases in pond elevations at the site with the different design scenarios, and used this data to recommend that the new pipe diameter not exceed 1.5 feet diameter.

However, the model used in the 2003 report generated wholly unrealistic increases in water elevations within the marsh (Table 2 of the report). The report stated "...increasing the [culvert] diameter from 1 ft to 2 ft. or greater greatly increases the volume of water flowing into the marsh (e.g. quadruples the volume flowing into the marsh and raises the water level in the pond by 4-12 feet)." This is of course an unrealistic conclusion because the water in the marsh would become more tidal with a larger opening, and the maximum tidal height in any case would never exceed the high water elevation on the open coast. Moreover, these statements could also cause concerns with abutters or the Conservation Commission when they review your permit application.

In response to our concerns about Table 2 and the statement in the report about increased water elevations, Kirk Bosma of Woods Hole Group clarified (email attached) that their box model did not include the topography or slope of the marsh. He noted that if the marsh had a 1/20 slope as an example, this "would mean a 5' water level increase in the "box" assumption, really is only an increase of 3 inches." This suggests that the reported 11.8-foot increase calculated in the model with installation of a three-foot diameter culvert is perhaps only a 7-inch increase in potential water elevation in the marsh during maximum tides.

If this project were funded with state or federal grant funds, a key management question would be resolving whether a 5-inch or 7-inch increase in water level during spring high tides would have any impact that justifies the recommendation of keeping the diameter to 1-foot or 1.5 feet diameter. That is, if a 1-foot diameter pipe will result in a 3-inch increase in maximum water elevation as noted in the Woods Hole Group 2002 report, would a 7-inch increase in maximum elevation from a three foot diameter pipe be that much more harmful? To answer this question, it is necessary to know the elevations of structures near the marsh that might be affected.

In a practical sense, irrespective of the results of the Woods Hole Group hydraulic box model or potential subsequent refinements to the model, with water exchange with the ocean, no matter how large the pipe, the water level in the marsh pond will not exceed sea level. The National Oceanic and Atmospheric Administration provides these tidal elevations for nearby Chappaquoit Point based on the NGVD29 datum as shown below (http://co-ops.nos.noaa.gov/benchmarks/8447685.html). All elevations are NGVD29.

Datum NGDV29	Meters	Feet
MEAN HIGHER HIGH WATER (MHHW)	1.295	4.25
MEAN HIGH WATER (MHW)	1.215	3.99
MEAN TIDE LEVEL (MTL)	0.632	2.07
MEAN SEA LEVEL (MSL)	0.563	1.85
MEAN LOW WATER (MLW)	0.490	1.61
MEAN LOWER LOW WATER (MLLW)	0.000	0.00

The elevation of the pond in the Warwick and Associates, Inc. plan is 3.22 feet NGVD29. With the installation of the new first culvert, the average water level in the first wetland will approach the mid-tide level of 2.07 feet. The pond level in the second marsh system would similarly drain, but it could drain no lower than the second pipe's invert elevation of 2.34 feet. Hypothetically, if there were no restriction to West Falmouth Harbor (e.g. if there were a natural channel into the marsh like at Sippewisset Marsh to the south), during mean high water, the water level in the first marsh system would be 8 inches higher than the existing pond level. During Mean Higher High Water, the water level in the first marsh system would average 12 inches higher than the existing pond level. These water levels would raise the water level in the second marsh component during high tides. Several high tides per month, water levels in West Falmouth Harbor may exceed 5.2 feet NGVD29, so in a completely unrestricted marsh system, water levels would be 2 feet higher than the existing pond elevation during the highest tides.

These tidal elevation predictions are consistent with salt marsh elevations shown on the Warwick and Associates, Inc. plans. On the West Falmouth Harbor side of the culvert, the salt marsh upper elevation is generally between 4.5 and 5.5 feet NGVD29. However, in the restricted side of the pipe, the salt marsh vegetation is less than 4.0 feet NGVD29. Thus, in a wholly unrestricted tidal regime, salt marsh elevations would likely rise somewhere between 0.5 to 1.5 feet in the restricted marsh.

In their 2003 report, Woods Hole Group correctly raised the issue of controlling storm surge during extreme events (e.g. hurricanes, nor'easters), and the Woods Hole Group recommends a self-regulating tide gate, even for a small diameter pipe. If a tide gate were installed, storm surge would no longer be a concern, even if a larger pipe were selected. The cost of a tide gate would again be a small fraction of the total project cost, but the expense would be unnecessary if homes behind the marsh were well above potential storm surge elevations.

We have been informed that there was debate about what vegetation existed at the site prior to the installation of the culvert. We have reviewed historic photographs, topographic maps, and other information. This site, like many along the west coast of Falmouth glacial moraine, may have once been a white cedar kettle hole swamp in past centuries that became a salt marsh as sea level rose. (Sea level has continued to rise since the last ice age 10,000 years ago, and the rise has been one foot per century for the past several hundred years). A 1941-dated USGS topographic chart (Figure 3) shows the site a wetland, consistent with today's salt marsh distribution. These older topographic maps typically do not show small tidal streams, so it is unknown what channel, if any, existed to the wetland. However, our earliest aerial photographs on file dated November, 1955 shows an inundated marsh with an apparent natural channel north of Little Island Road. Ironically, this is at the location of a structure, possibly a cottage, in the 1941 topographic map. Although shown on the 1941 map, features on topographic maps are not always current with their date of issue, and this structure may have been destroyed and the channel created by the 1938 hurricane, or a subsequent storm. This channel may have again been blocked by sand transport or hurricanes in the late 1950s, and by 1961 and 1962, photographs show the channel apparently again blocked or covered by south migrating sand dunes (Figure 3).

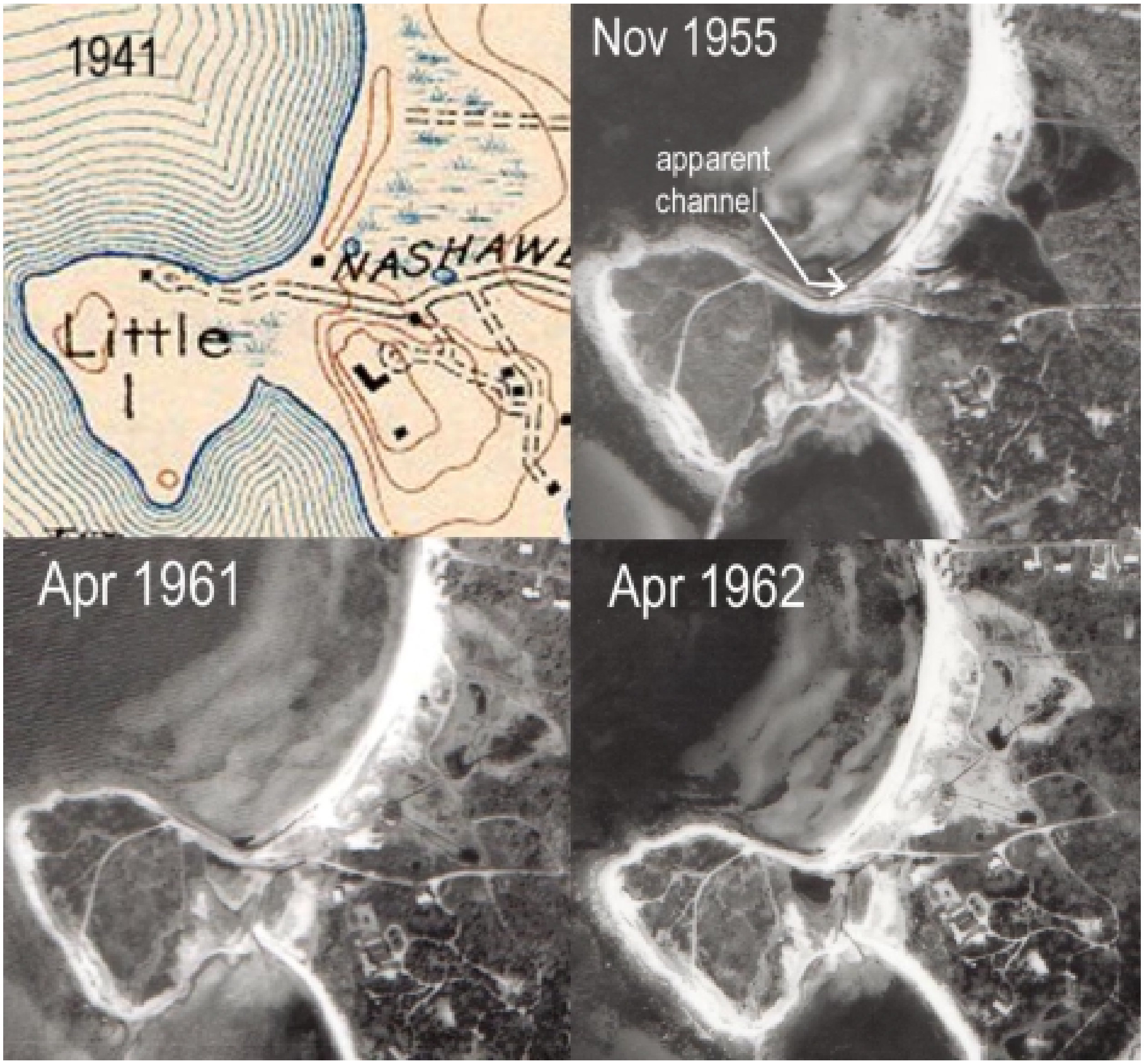

Figure 3. Little Island Marsh on four dates 1941 to 1962. The 1941 topographic map is likely based on surveys from the 1930s. The 1955 photograph suggests that a channel existed in the southwest corner of the marsh north of Little Island Road (broad darkened finger narrowing to a thin channel just visible in the photograph, terminating at the arrow). This channel appears to be filling in from dune and longshore sand transport to the southward. This channel might have been created during the 1938 hurricane or another subsequent storm.

If the existing culvert remains obstructed, the site will not revert to upland. Rather, the site will remain a brackish salt marsh until rising sea level or another storm eventually break through the beach and dunes. Currently this beach in front of the central portion of the marsh is eroding, and the vegetated dune crest has receded inland 12 feet during the period 1994 to 2002.

To obtain permits from the Conservation Commission and state and federal agencies for this design, we believe that a site survey with elevations of any structures potentially affected by tidal inundation around the marsh would be required. By keeping the pipe size to the same diameter, culvert replacement permitting is generally considerably easier, particularly in a wetland restoration project. However, because the proposed pipe inverts are being changed (the ocean side would be lowered from 2.57 feet to 1.0 feet, and the inner raised to 2.0 feet), this project would in fact drain the first marsh segment somewhat and change the hydrography of the marsh. This would require an U.S. Army Corps permit. Because the ocean invert was higher than the marsh invert, when the old culvert was operational, the water level in the marsh could never drop below 2.57 feet. With the new pipe elevations, the first segment would drain 2.0 feet, or a little over half a foot. The second marsh segment, however, could never drain below 2.34 feet, the invert of the second marsh segment culvert, which is not being replaced.

Draining the first marsh is actually not problematic from a salt marsh restoration point of view, because natural unrestricted salt marshes completely drained at low tide. For the Army Corps permit it is only necessary to demonstrate that the enough water can enter a one-foot diameter 346-foot long pipe to add enough salt water during high tides to ensure that fringing brackish wetlands are converted to salt marsh vegetation, and not upland. The Woods Hole Group analysis suggests more water will enter the marsh with the new culvert design, than the old design, and this report may be adequate for the purposes of that permit.

One additional issue must be considered with the proposed designs. The existing pipe elevation to the ditch entering West Falmouth Harbor is 2.57 feet. The proposed new invert elevation is 1.0 foot. However, the ditch base elevation appears to be around 2.5 feet MLW near the mouth of the culvert, and does not drop to 2.0 feet for at least 20 feet, and does not drop to 1.0 feet for at least 80 feet according to the plans. For the pipe not to be buried and to operate, the tidal ditch would need to be deepened to a 1-foot elevation. Because this ditch is within Massachusetts tidelands, this dredging would require a Chapter 91 permit, and considerable additional expense. Moreover, with the entrance of the pipe so far below the grade of the surrounding sediments, and the stability of sidewalls in a tidal environment questionable, and there would be serious questions as to whether the pipe opening would be buried. This might make obtaining a Chapter 91 dredging permit more difficult to obtain.

A simpler solution would be to raise the invert elevation on the bay side. A careful study of the Woods Hole Group May 2003 report shows that the ocean-side invert elevations are completely irrelevant in predicting tidal flushing. That is, for any pipe diameter and given salt marsh side pipe invert elevation, tidal flow is the same, no matter what the harbor invert elevation. In other words, Woods Hole Group concludes the slope of the pipe and lowest invert elevation have no effect on water exchange. Under closed conduit model, only the maximum invert elevation at either end of the pipe is relevant. That is why, even with an upwards sloping pipe in the existing conditions, unobstructed existing design flow matches flow in the May 2003 report for a marsh invert between 2.0 and 3.0 feet. A graphical representation of closed and open channel conditions is illustrated in Figure 4.

Thus, with closed conduit assumptions, the ocean side invert can be raised to the marsh side invert elevation (a level pipe), without affecting estimated tidal exchange. For that matter, both inverts can be kept the same to expedite permitting, but the existing harbor invert of 2.57 feet will then become the limiting factor controlling tidal exchange.

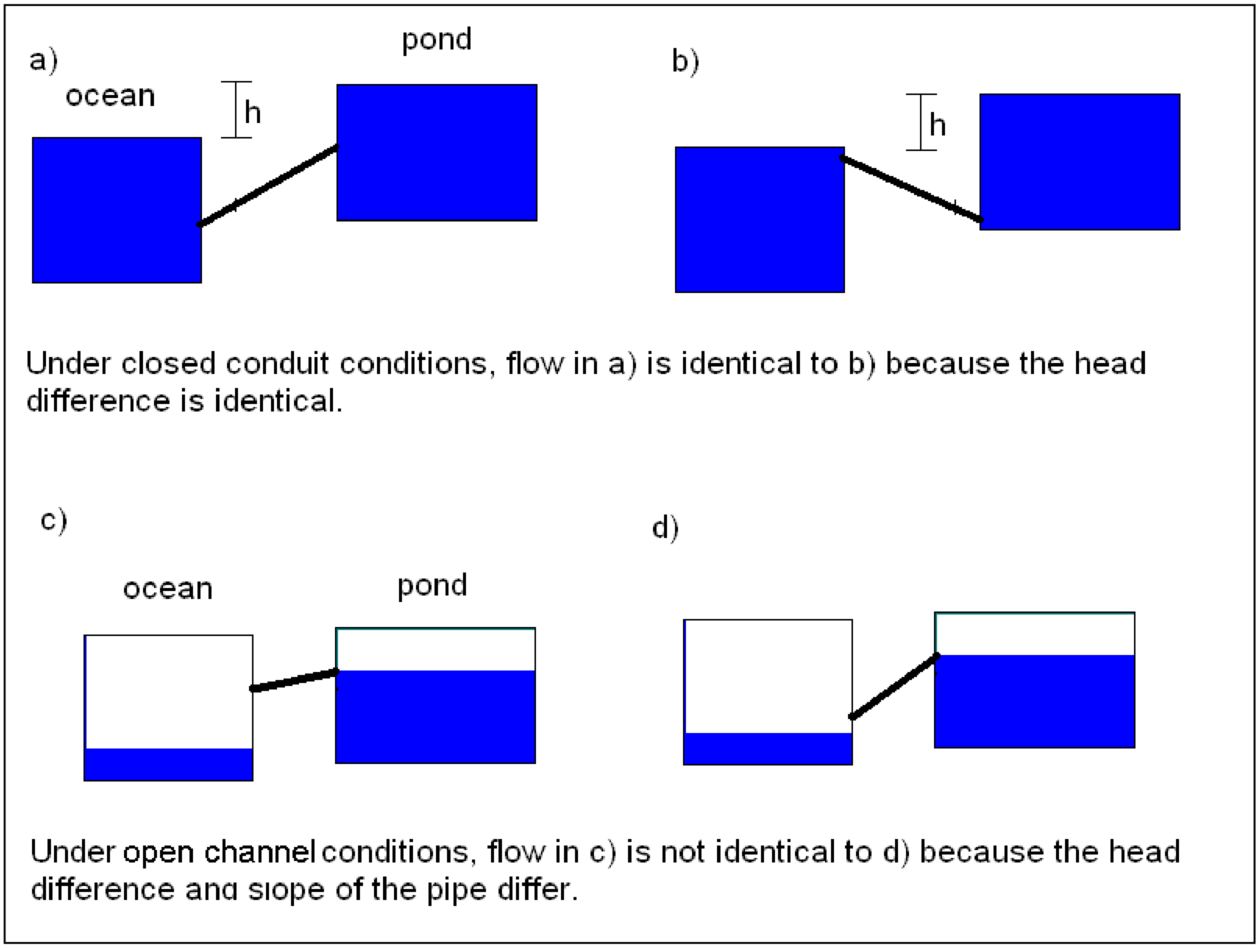

Figure 4. Comparison of open channel versus closed conduit conditions.

It appears that closed conduit conditions will not always be met because Woods Hole Group, in their May 2003 report, state that the marsh would be drained to the base of the pipe. By definition, the system will therefore not always behave like a closed conduit, and other factors like pipe slope will affect water movement. However, we do not know whether the duration of the “open channel” conditions will appreciably affect the conclusions of this study. Also, the 2002 report acknowledged that the presence of the second culvert affects the analysis, and the study treated the marsh system as a single unit. Clearly, the two-thirds of the marsh area beyond the second culvert will never drain below 2.34-foot level of the inner pipe invert.

The proposed new invert design has a maximum invert elevation (at either end) of 2.0 feet, whereas the existing maximum invert elevation (at either end of the pipe) is 2.57 feet. This reduction in maximum invert elevation is the basis of the calculation for the projected improvement in tidal flushing by the new designs. Specifically, a five-fold increase in tidal flushing is expected during neap tides, and 50 percent increase is expected during spring tides over the existing pipe if it were unobstructed because of this 0.57-foot decrease. Of course, installation of a new unobstructed pipe, even at existing invert elevations, would be a considerable improvement over the nearly completely blocked pipe conditions that now exist, and are adversely affecting the salt marsh.

In conclusion, if you and your neighbors were to fund this project, the Buzzards Bay Project would endorse your effort to restore the marsh by replacing the existing obstructed 1-foot diameter pipe with a new 1-foot diameter pipe. You may however wish to reconsider the proposed 1.0-foot pipe invert elevation to West Falmouth Harbor to avoid additional dredging and permit costs, and the likelihood the culvert entrance will become buried. Keeping the pipe size and invert elevations identical to current conditions will result in less permitting requirements. Changing invert elevations and increasing pipe size will require additional permitting (e.g. Army Corps permits), but is achievable, and will provide more flushing benefits to the salt marsh.

If you and your neighbors were to seek state or federal wetland restoration grants for this project, we would likely explore installing a larger pipe diameter to maximize benefits to the salt marsh. A larger pipe diameter would be easier to maintain and clear, particularly given the length of the pipe. It is also relatively easy to install flow control structures and tide gates to prevent tidal inundation of low-lying structures if that were a concern. This decision would also require a site survey with elevations of structures potentially affected by tidal inundation around the marsh. We might be able to obtain free technical assistance from federal agencies to complete the final survey, but this would be possible only if all abutters were in consensus and gave access for the survey.

I hope the information in this letter further guides your efforts. Please do not hesitate to call me if you have any questions (508-291-3625 x19).

Sincerely

Joseph E. Costa, PhD
Executive Director

cc.