Battelle
The Business of Innovation

Duxbury Operations
397 Washington Street
Duxbury, Massachusetts 02332
Telephone 781-934-0571
Fax: 781-934-2124

July 11, 2006
Ms. Beverly Lawrence
U.S. Army Corps of Engineers
New England District
696 Virginia Rd.
Concord, MA 01742-2751

CONTRACT NO. DACW33-01-D-0004
DELIVERY ORDER: 1
SUBMITTAL OF DELIVERABLE – Interim Final Letter Report, *October 2005 Storm Evaluation*, Centredale Manor Restoration Project Superfund Site

Dear Ms. Lawrence:

Enclosed please find four double-sided copies of the subject draft letter report for your review and comment. This draft report summarizes findings from the evaluation of the October 15, 2005 storm event at the Centredale Manor Restoration Project (CMRP) site located in North Providence, Rhode Island (Figure 1). Battelle's sub-contractor, Quantitative Environmental Analysis, LLC (QEA), analyzed the hydrograph of the October 2005 event, and compared that flood to historical high-flow events. In addition, results from a qualitative erosion assessment and interviews with local area residents regarding the October 2005 storm event are also documented.

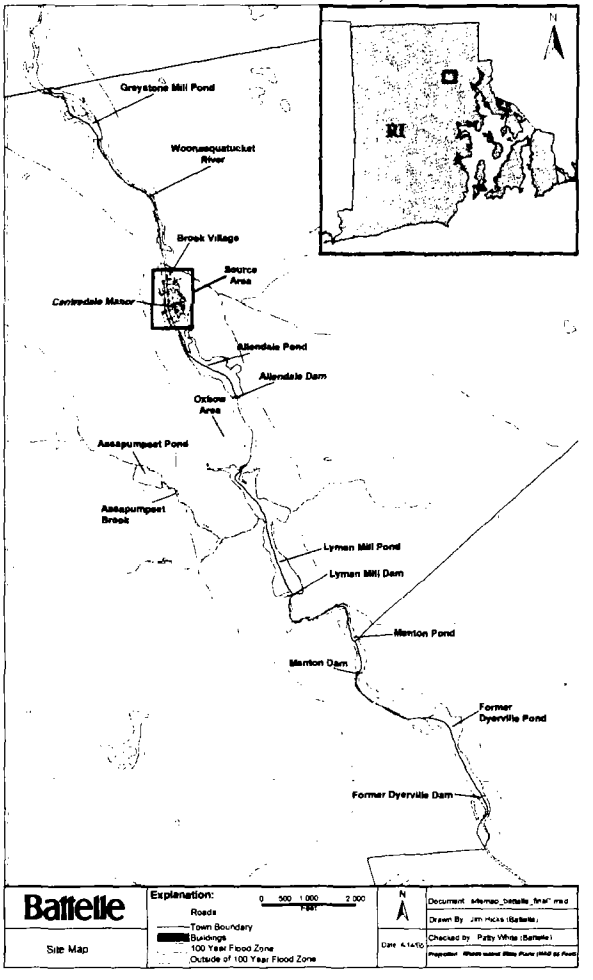

Figure 1. Site Locus Map

Evaluation of October 2005 Flood Hydrograph

A high-flow event occurred on the Woonasquatucket River on October 15, 2005. Discharge data initially reported by the U.S. Geological Survey (USGS) for the Woonasquatucket River Station (011145600) located at Centredale, RI (http://nwis.waterdata.usgs.gov/ri/nwis) showed a peak discharge of 2,020 cubic feet per second (cfs) on October 15, 2005. However, subsequent communications with the USGS revealed that the discharge data are considered *provisional,* that is the data are subject to change pending an evaluation of the field measured discharge data. According to the USGS, "the discharge measurements made during and after the October flooding resulted in the

establishment of a new rating. Shifts in the ratings have always been an issue at this site because the control is the natural streambed cobbles that are prone to movement during high flow events." (P. Zarriello, USGS, personal communication, May 3, 2006). The peak discharge computed from the old rating (i.e., 2,020 cfs) differs considerably from the flow measurements made on October 15, 2005. With the new rating (no. 44), the peak discharge value at the Woonasquatucket River Station on October 15, 2005 is 1,530 cfs, which agrees closely with field measurements made at that time using an Acoustic Doppler Current Profiler (ADCP). The discharge data from this event remains classified as *provisional data* by the USGS; discharge data are expected to be upgraded to *approved data* at the end of the water year, i.e., September 2006. At that time, the discharge data will be reviewed and approved as part of the preparation of USGS's annual report. Discharge data used in the evaluations below were provided by the USGS.

The October 15, 2005 flood was one of the largest high-flow events ever recorded at the USGS gauging station located at Centredale, RI, which has been in operation since October 1, 1942 (i.e., water year 1943). The hydrograph for the October 2005 flood, based on discharge data provided by the USGS (personal communication, Phillip J Zarriello, USGS, May 2006), is presented in Figure 2. The peak flow rate during the October 2005 flood, based on 15-minute discharge data, was 1,530 cfs. A flood frequency analysis was conducted by Maureen Corcoran of the U.S. Army Corps of Engineers (USACE) using historical data collected at the Centredale gauging station. The results of that analysis are presented in the sediment stability study (QEA, 2006), which evaluated the potential impacts of a range of floods (i.e., 5-, 10-, 25-, 50-, and 100-yr) on bed stability. Based on that flood frequency analysis, the peak flow rate during the October 2005 flood corresponds to a return period that ranges between 25 and 50 years (i.e., a probability that this flow rate will occur in a particular year that ranges between 2 and 4 percent).

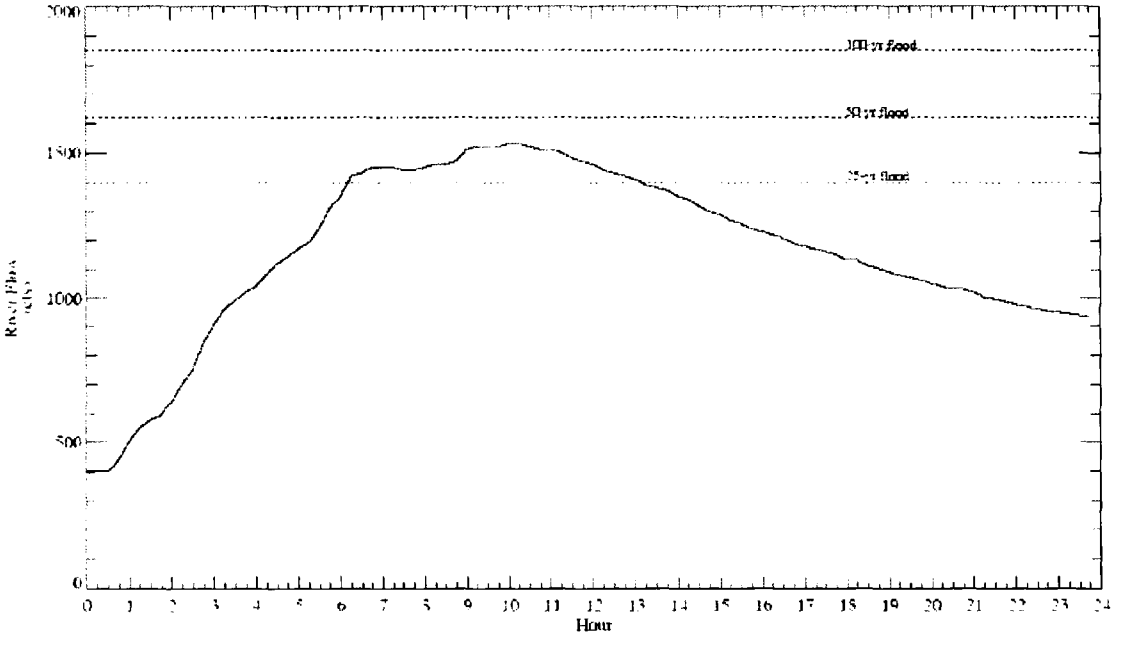

Figure 2. Hydrograph of the Woonasquatucket River at Centredale, RI on October 15, 2005.

The peak flow rate during the October 2005 flood, based on 15-minute discharge data, is the highest discharge value measured at the Centredale gauging station during the 62-year period of record. The October 2005 peak discharge value is compared to the three highest annual peak flow rates recorded during the 62-year period in Table 1. Note that a high-flow event in 1998, which occurred on a day when the daily-average flow rate was 831 cfs, had a peak discharge that was approximately equal to the October 2005 peak value (i.e., about 1 percent difference).

Table 1. Comparison of Historical Peak Flows to October 2005 Peak Discharge

Water Year	Annual Peak Flow Rate (cfs)	Comparison to October 2005 Peak Discharge (%)
1998	1,520	99
1968	1,440	94
1983	1,380	90

The daily-average flow rate for October 15, 2005 is 1,160 cfs, which is about 25 percent lower than the peak discharge during this high-flow event. The daily-average flow rate during the October 2005 high-flow event was equaled or exceeded on three dates during the 62-year period of record at the Centredale gauging station (Table 2).

Table 2. Comparison of Historical Daily-Average Flows to October 2005 Event

Date	Daily-Average Flow Rate (cfs)	Comparison to October 2005 Event (%)
March 18, 1968	1,250	108
March 19, 1968	1,230	106
January 25, 1979	1,160	100

Potential Effects of October 2005 High-Flow Event on Sediment Stability

The results discussed above indicate that the October 2005 high-flow event is one of the largest magnitude floods recorded at the Centredale gauging station since 1943. Comparable floods have occurred during the 62-year period of record, with high-flow events during 1968, 1979, 1983 and 1998 being within +10 percent of the October 2005 discharge, based on either peak discharge or daily-average flow rate. Thus, the October 2005 flood was a rare event (i.e., return period of 25 to 50 years) but four floods of similar magnitude have occurred during the previous 40 years.

A previous analysis of sediment stability in Allendale and Lyman Mill Ponds has been conducted (QEA 2006). That analysis evaluated the potential effects of high-flow events on bed scour in the two ponds, which included the prediction of potential bed scour for flood with return periods of 5, 10, 25, 50 and 100 years. The peak flow during the October 2005 event is within the range of flood discharges examined during the bed stability study. Thus, the results of that study, and associated conclusions, are applicable to the October 2005 high-flow event. Those modeling results indicate that scour depths of 1 cm or more occurred in about 1 percent of the bed area in Allendale Pond during the October 2005 event. For Lyman Mill Pond, it was predicted that about 4 percent or less of the pond bed area had scour depths of 1 cm or more during that high-flow event.

Thus, the results of the hydrograph analysis suggest that additional sampling and analysis to assess potential changes in sediment distributions is not necessary, because potentially significant bed scour (i.e.,

greater than 1 cm) caused by the October 2005 high-flow event is limited to relatively small portions of Allendale and Lyman Mill Ponds.

Qualitative Data Collection Activities

The remainder of this letter report summarizes qualitative data collected by Battelle, including: 1) qualitative erosion assessment; and 2) interviews with local residents. Findings from these qualitative data collection activities are described below.

Qualitative Erosion Assessment

A site visit was conducted on April 28, 2006 to collect anecdotal evidence of flooding and look for indications of erosion and scour in the areas, identified by QEA, that appear to be susceptible to potential scour during a flood event. Observations were noted and numerous photographs were taken for documentation. Findings from the April 2006 qualitative erosion assessment are not intended to signify a direct correspondence with the October 2005 high-flow event. Further, potential suspended sediment loads associated with high-flow events may not have been visually evident during the April 2006 site visit.

The site visit was conducted from north to south, beginning in the Cap Area 1, which is located at the southern end of the source area, and ending at Lyman Mill Dam (Figure 1). Evidence of a high-flow event was observed in the source area, but it was not extensive. For example, in some areas, the fence separating the parking lots from the cap area had grass and leaves trapped within the chain-link. In addition, many of the trees and shrubs along the Woonasquatucket River had debris in branches two to three feet above the normal water level. This debris may be associated with the October 2005 event, which resulted in over-bank flooding in some areas. The narrow, steep section of river channel adjacent to the source area was inspected for possible erosion. There was only one small area that showed any evidence of recent erosion, which was located on the west bank, approximately two-thirds of the way from Rt. 44 to the end of Cap Area 1. This spot was in a very sandy/gravelly area and appeared to be an area where a tree had previously grown and been blown over (Figure 3). There was little evidence of recent growth surrounding this area; however, the type of soil surrounding it does not appear to be conducive to supporting vegetation. Additionally, in most areas along the western bank of the Woonasquatucket River, a relatively thick, and undisturbed, mat of moss was present near the water line (Figure 3). It should be noted that the black mesh textile that was installed under the topsoil as part of the cap is exposed in many areas of the Cap Area 1.

Figure 3. View looking toward the western bank of the Woonasquatucket River, adjacent to the source area, April 18, 2006. Left – the disturbed area in the central portion of the photograph appears to be where a tree had been up-rooted. Right – evidence of abundant, thick moss growth.

Field staff walked down the sewer commission easement on the west side of Allendale Pond to obtain a closer view of the area of potential scour. From this vantage point, it did not appear that the flow patterns in the channel had shifted from site visits conducted prior to the October 2005 flood. The water level was lower than normal during this site inspection, due to a relatively dry spring, and the channel bottom could be observed in many areas. There was an abundance of vegetation along the bottom of the channel/pond, which appeared to be older, established growth (Figure 4). Areas absent in vegetation were not visually obvious. Due to the low water levels, the bottom of the rip-rap and cap liner was visible along the western edge of the source area.

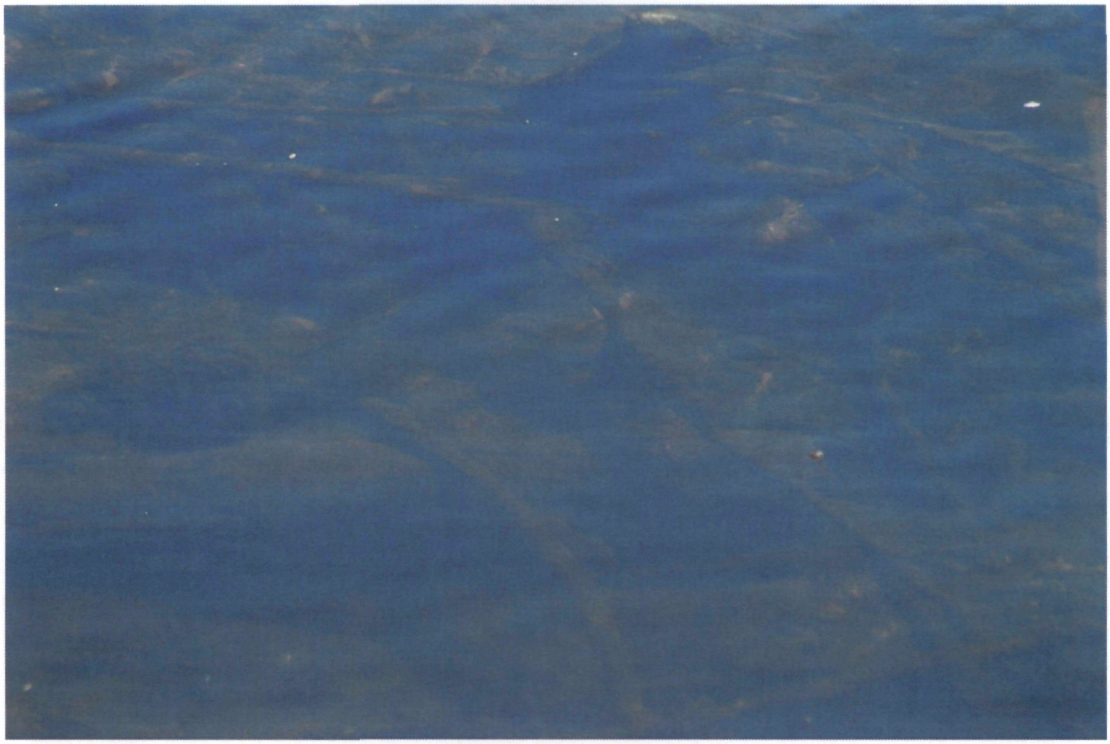

Figure 4. Photo of the river bottom at the upstream inlet to Allendale Pond, April 18, 2006.

Observations were made from the end of Stevens Street (located near the upstream region of Allendale Pond, on the east side) looking westward over Allendale Pond to better view the western bank of the Woonasquatucket River. No erosional surfaces, scarps, or sediment slumping were observed; evidence of street runoff in the form of rivulets of sand and silt, as well as an accumulation of debris (e.g., food wrappers, cigarette butts, and beverage bottles), was present at the end of Stevens Street.

A large amount of trash and debris was observed in the northern section of Allendale Pond. A soda machine was observed submerged on the western side of the pond, near the marshy area south of Cap Area 1, as well as an apparent steel fuel or oil tank (fuel tank shown in Figure 5). Additionally, two or three drums were noted (and photo documented) in the marshy area. Several old tires and other debris were scattered throughout the study area.

The area in the immediate vicinity of Allendale Dam was also visually assessed for signs of erosion; the only noticeable change from previous site visits was the slumping of bank material on the west side of the channel, immediately downstream from Allendale Dam (Figure 6).

Figure 5. Photograph taken from the western bank of the Woonasquatucket River on April 18, 2006. The object in the center of the image appears to be a steel fuel or oil storage tank.

Figure 6. Scarp immediately below Allendale Dam on the west side of the Woonasquatucket River, April 18, 2006.

As was observed at Allendale Pond, no obvious or substantial changes to the flow of water through the river channel near the upstream inlet of Lyman Mill Pond were observed. Evidence of erosion or scour was not visually obvious, and visible areas of the pond bottom were covered with well-established vegetation. Evidence of street runoff at the end of Warren Avenue was also noted; large amounts of household-type debris (e.g., food wrappers, beverage bottles) were observed in the reeds and vegetation surrounding the pond. A road-construction barrel was observed in the marshy area west of the upstream inlet to Lyman Mill Pond. Finally, there was also no obvious visible evidence (i.e., scouring or debris paths) of water having spilled over the earthen berm segment at Lyman Mill Dam.

Interviews with Local Residents

Interviews were conducted with representatives from the Brook Village and Centredale Manor apartment buildings; the Towns of North Providence and Johnston; Audubon Society; and the Woonasquatucket River Watershed Council (WRWC). The purpose of these interviews was to obtain anecdotal evidence related to the October 2005 high-flow event.

On April 24, 2006, Battelle visited the site to view 'as-built' plans for the Brook Village and Centredale Manor apartment buildings. During that visit, Battelle spoke with the building managers: Mr. David Briel, Senior Superintendent of Brook Village and Ms. Ann Vaccaro of Centredale Manor. Mr. Briel indicated that the water level nearly overtopped the riverbank immediately behind the Brook Village apartment building during the October 2005 storm event. Ms. Ann Vaccaro indicated that the flood waters did not reach the steps to the Centredale Manor, but that the southern parking lot was flooded and all the cars had to be moved to the northern parking lot at Centredale Manor. Ms. Vaccaro provided several pictures of the flooded parking lot and grounds (Figures 7 through 12). These photographs were not time-stamped, so the exact times of the images are not known; however, the photos still provide a useful visual reference. The flooding documented in the photographs was compared to photographs of the as-built plans to estimate flood water elevations. Assuming that the elevations listed on the as-built plans are accurate, flood waters from the October 2005 storm event approached the 98 ft in elevation near the Centredale Manor building. Further, a review of the flood inundation maps for the source area (USACE, 2000) show that the water levels documented in the photographs and the flow rates recorded by USGS are consistent with the evaluation of the October 2005 hydrograph (above) which indicates that the peak flow rate during the October 2005 flood corresponds to a return period that ranges between 25 and 50 years.

Mr. Alan Brodd, of the Town of Johnston Department of Public Works (DPW), was interviewed on April 28, 2006, when Battelle staff were at the site conducting the qualitative erosion assessment discussed above. Mr. Brodd stated that the water level in Lyman Mill Pond, which is located behind his office building, was approximately three feet higher than normal during the October 2005 event.

Phone interviews were conducted with Mr. Frank Bursie, the Assistant to the Mayor of North Providence and Mr. Dean Iacovone, Director of Sanitation for the town of North Providence.

Mr. Bursie indicated that he did not have any record of work orders (e.g., requests for assistance from residents who were attempting to deal with flooded basements or notifications that storm sewers were not functioning properly) for locations along the Woonasquatucket River during the October 2005 event. He did indicate, however, that if the water had been high enough to be flowing over the earthen berms of the dams, he would likely have been notified.

Mr. Iacovone stated that he had received several reports associated with sewer problems or basement flooding, but he had not received any reports related to water over-topping Allendale or Lyman Mill Dam. Additionally, Mr. Iacovone recalled receiving a call for a sewer problem in the vicinity of Allendale Dam;

he did not recall seeing water over-topping the earthen sections of the dam. Mr. Iacovone thought that he may have also checked Lyman Mill Dam, but could not say for certain.

Conversations with representatives from area environmental organizations generated additional leads and contacts which resulted in information presented in this report.

Summary and Conclusions

Analysis of the hydrograph shows that the October 2005 high-flow event is one of the largest magnitude floods recorded at the Centredale gauging station since 1943. Flood waters were evident in the vicinity of the Centredale Manor apartment building during the October 2005 high-flow event, especially in the southern parking lot which was flooded. While the October 2005 flood was a rare event (i.e., return period of 25 to 50 years), four floods of similar magnitude, based on either peak discharge or daily-average flow rate, have also occurred at the site during the previous 40 years. Findings and conclusions from the sediment stability study conducted for the site (QEA, 2006) are applicable to the October 2005 high-flow event, given that the peak flow during the October 2005 event is within the range of flood discharges examined (i.e., 5-, 10-, 25-, 50-, and 100-yr) during the sediment stability study (QEA, 2006). Those modeling results indicate that scour depths of 1 cm or more is expected to have occurred in about 1 percent of the bed area in Allendale Pond during the October 2005 event. For Lyman Mill Pond, it was predicted that about 4 percent or less of the pond bed area had scour depths of 1 cm or more during that high-flow event. Additional sampling and analysis to assess potential changes in sediment distributions does not appear to be necessary, because potentially significant bed scour caused by the October 2005 high-flow event is limited to relatively small portions of Allendale and Lyman Mill Ponds. Further, findings from the sediment stability study and remedial investigation (Battelle, 2005) do not suggest that potential bed scour preferentially occurs in areas of elevated contamination. Localized areas of higher contamination were found throughout both ponds, and were not restricted to the northern reaches where potential bed scour is expected to occur during a rare event.

References

Battelle, 2005. *Interim Final Remedial Investigation, Centredale Manor Restoration Project Superfund Site.* Prepared for USACE, New England District, June 2005.

Quantitative Environmental Analysis, 2006. *Interim Final Technical Memorandum. Sediment Stability Study, Phase II. Centredale Restoration Project Superfund Site.* Prepared for USACE, New England District, March 2006.

USACE, 2000. Centredale Manor Restoration Site Woonasquatucket River, North Providence and Johnston, Rhode Island. Inundation Mapping, 25 Year Flood Site B. 2000.

If you have any questions regarding this report, please contact Deirdre Dahlen at (781) 952-5253.

Sincerely,

Deirdre Dahlen
Project Manager

Lisa Lefkovitz
Program Manager

cc: A. Krasko, USEPA (5 copies)

Figure 7. Picture of Centredale Manor South Parking Lot on October 15, 2005 (looking toward Cap Area 1). According to the as-built plans, the central section of this parking log (center right of photo) has an elevation of 97 ft.

Figure 8. Entrance to Centredale Manor on October 15, 2005. Note that water did not reach the steps to the building; the elevation of the curb near the office sign is approximately 98 ft according to the building as-built plans.

Figure 9. Service drive on south side of Centredale Manor on October 15, 1005. The elevation of the flooded area of the driveway is approximately 97.5 ft according to the as-built plans.

Figure 10. Centredale Manor South Parking lot on October 15, 2005.

Figure 11. Centredale Manor South Parking lot on October 15, 2005. Cap Area 2 is visible in the right center section of the photo. According to the Centredale Manor building as-built plans, the elevation of the top of the curb in front of the bench is approximately 98 ft. Additionally, the curb elevation on the opposite side of the driveway in the right side of the photo is between 97.08 ft and 97.25 ft according to the as-built plans.

Figure 12. West side of Centredale Manor on October 15, 2005.