QEA
Quantitative Environmental Analysis, LLC

305 West Grand Avenue
Suite 300
Montvale, NJ 07645
TEL (201) 930-9890
FAX (201) 930-9805

290 Elwood Davis Road
Suite 230
Liverpool, NY 13088
TEL (315) 453-9009
FAX (315) 453-9010

80 Glen Street
Suite 2
Glens Falls, NY 12801
TEL (518) 792-3709
FAX (518) 792-3719

800 Brazos Street
Suite 308
Austin, TX 78701
TEL (512) 707-0090
FAX (512) 275-0915

January 18, 2007

Dr. Russell Keenan
15 Franklin Street
Portland, Maine 04101

Dear Russ,

Quantitative Environmental Analysis, LLC (QEA) is pleased to submit a proposal to perform hydrodynamic analyses to support the feasibility study for the Centredale Manor dam removal remedial alternative. The primary objectives of the hydrodynamic analyses are:

- Evaluate various channel designs in the Allendale and Lyman Mill Pond areas after dam removal.
- Investigate hydrodynamics and extent of inundation in the floodplain (i.e., remnant deposit) areas in the Allendale and Lyman Mill Pond areas after dam removal.
- Analyze the effects of dam removal on the hydrodynamics and floodplain inundation in the Manton Pond area.
- Evaluate the impacts of dam removal on stage height and floodplain inundation during high-flow events in the region from Manton Dam to the confluence of the Woonasquatucket and Moshassuck Rivers.

The first three objectives will be addressed through application of a two-dimensional, depth-averaged hydrodynamic model to the Primary Study Area (PSA), which extends from the USGS gauging station at Centredale to Manton Dam (about 2.3 miles). The fourth objective will use a one-dimensional hydrodynamic model to simulate flood flow in the 4.7 mile reach from Manton Dam to the confluence. Descriptions of the technical approaches for both regions of the river are provided below.

Task1: Hydrodynamic Modeling Analysis in the Primary Study Area

The hydrodynamic model to be used in this analysis is EFDC, which is a well-tested hydrodynamic model that is supported by USEPA. This model was used during a sediment stability study of Allendale and Lyman Mill Ponds that was conducted by QEA for Battelle, USACE and USEPA. The model has the ability to simulate overbank flow and floodplain inundation during high-flow events.

For this application, the upstream boundary of the model will be at the USGS gauging station at Centredale and the downstream boundary will be at Manton Dam. We plan to use a high-resolution numerical grid, which utilizes 1-m square grid cells. This level of resolution will be adequate for channel design purposes in the two ponds after dam removal; approximately 200,000 to 300,000 grid cells will be used to delineate the PSA, including floodplain areas. Bathymetry and floodplain topography data for the Allendale and Lyman Mill Pond areas will be provided to QEA by AMEC/LEA. It will be necessary to collect additional bathymetry data from the Manton Pond area. We recommend that bathymetry data be collected along 15 cross-channel transects, spaced approximately 200 ft apart, between Lyman Mill and Manton Dams.

Uncertainty associated with the application of the model in a predictive mode will be addressed through the use of bounding calculations. Realistic upper and lower bounds on model parameters (e.g., bottom roughness) will be established. Predictive model simulations will be conducted using this range of input parameters, which will produce upper- and lower-bound results for each simulation. The level of uncertainty in the predictions will be reflected in these bounding simulations, with the 'real' answer somewhere between the upper and lower bounds.

The first application of the model will be focused on the Allendale and Lyman Mill Pond areas after dam removal. QEA will provide support to AMEC/LEA during the design of a new channel in the two pond areas after dam removal. AMEC/LEA personnel will provide a channel design to QEA (e.g., depth, width, location) and QEA will incorporate this channel design into the numerical grid of the PSA. For a particular channel design, four flow conditions will be simulated: low flow (e.g., 7Q10 discharge), average flow, 2-yr flood, and 100-yr flood. For each flow condition, upper- and lower-bound simulations will be conducted, resulting in eight simulations for a particular channel design. Based on our experience and professional judgment, an iterative design process will be necessary and four design iterations will be evaluated. Model results will be presented as graphical representations of: current velocity, bed shear stress, stage height, and extent of floodplain inundation. If requested, QEA can provide AMEC/LEA with files containing numerical values of model output at each grid cell location.

The second application of the model will evaluate the effects of dam removal on hydrodynamics and floodplain inundation in the area between Lyman Mill and Manton Dams. The focus of this analysis will be on the effects of high-flow events. Simulations of the 2-yr and 100-yr floods will be conducted with and without Allendale and Lyman Mill Dams in place, which will result in a total of eight simulations (i.e., upper and lower bounds for the four flow-dam combinations). Graphical comparisons of the with-dam and without-dam scenarios will be produced for: current velocity, bed shear stress, stage height, and extent of floodplain inundation. Note that the results of these simulations will be used as input to the 1-D hydrodynamic model applied to the downstream region (i.e., time history of flow rate at Manton Dam for a particular flow-dam combination), provided Optional Task 2B is conducted.

Task 2A: Hydrodynamic Modeling Analysis for Manton Dam to Confluence

Downstream of Manton Dam, three dams impound the free-flowing reach of the Woonasquatucket River: Atlantic Mills Dam (~1.9 miles downstream of Manton Dam); Paragon Pond Dam (~0.5 mile downstream of Atlantic Mills Dam); and Rising Sun Pond Dam (~0.2 mile downstream of Paragon Pond Dam). The river is tidally influenced between Rising Sun Pond Dam and the confluence with the Moshassuck River, which is a distance of about 2.1 miles. Note that the drainage area of the Woonasquatucket River increases by about 34% between the USGS gauging station at Centredale (38 mi^2) and the confluence (51 mi^2). Only one significant tributary flows into the river along the 7-mile reach between the gauging station and the confluence (i.e., Assapumpset Brook flows into Lyman Mill Pond).
Prior to construction of a hydrodynamic model for this reach, the predicted hydrographs for the 2-yr and 100-yr floods, with and without dams, at Manton Dam will be compared. This

comparison will provide an estimate of the potential effect of dam removal on flood flows in the river downstream of Manton Dam. It is possible that dam removal will have a minimal effect on the flood hydrograph in the lower portion of the river (i.e., downstream of Manton Dam). If the flood hydrograph comparison indicates minimal changes due to dam removal, it may not be necessary to conduct a hydrodynamic modeling analysis in this reach of the river.

Optional Task 2B: Hydrodynamic Modeling Analysis for Manton Dam to Confluence

If the flood hydrograph comparison conducted during Task 2A indicates that a modeling analysis is needed, then a 1-D hydrodynamic model (e.g., HEC-RAS) will be applied to the river from Manton Dam to the confluence. The objective of this analysis is to evaluate the impacts of dam removal on stage height and floodplain inundation in the region downstream of Manton Dam. Within the reach between Rising Sun Pond Dam and the confluence, tidal effects will be incorporated into the model. It will be necessary to collect bathymetry data between Manton Dam and the confluence. We recommend that bathymetry data be collected along 20 cross-channel transects, spaced approximately 0.25 mile apart, between Manton Dam and the confluence.

The model will be used to simulate flood flow in the river for the 2-yr and 100-yr floods, for the with-dam and without-dam scenarios. Graphical comparisons will be produced for model predictions of: stage height and floodplain inundation.

Task 3: Project Meetings with AMEC/LEA

It is assumed that QEA personnel will prepare for and attend two meetings with AMEC/LEA personnel at the LEA office in Plainville, CT.

Task 4: Report Preparation

A draft report that describes the modeling analyses and presents the results of the various simulations will be prepared and submitted to AMEC/LEA for review and comment. A revised draft report will be prepared for submission to USEPA (and other stakeholders) for review and comment. QEA will respond to USEPA/stakeholder comments and prepare a final report.

Optional Task 5: Dialog Meetings in Providence, RI

QEA personnel (Ziegler) will prepare for and attend Dialog meetings in Providence, RI as requested by AMEC/LEA.

Estimated Cost and Schedule

The total estimated cost for Tasks 1, 2A, 3 and 4 is $91,200, with $90,700 being allocated to labor costs and $500 for expenses. The cost of Optional Task 2B is $23,400 (total for labor and expenses). A summary of level-of-effort and estimated costs is provided in Table 1. Expenses for each task are provided in Table 2. For convenience, the estimated cost of preparation for and attendance at a Dialog meeting in Providence, RI (i.e., Optional Task 5) is provided on a per meeting basis. This cost is $3,400 per meeting, with the details provided in Tables 1 and 2. Hourly rates for QEA personnel are provided in Table 3.

It is anticipated that Task 1 can be completed within 12 weeks of approval to proceed. Note that it is assumed that the bathymetry data collected in Manton Pond will be provided to QEA no later than 2 weeks after approval to proceed. Task 2A will be started at the conclusion of Task 1, and it will take approximately 2 days to complete that work. The results of Task 2A will be discussed by QEA, AMEC and LEA personnel and a decision will be made about the necessity to conduct Optional Task 2B. If Optional Task 2B is conducted, that work will take approximately 4 weeks to complete once the necessary bathymetry data are provided to QEA. A draft report will be submitted to AMEC/LEA about 2 weeks after the completion of Task 2A (or 2B).

Table 1. Level of effort and labor costs for Tasks 1 through 5.

Task	Senior Managing Engineer (hours)	Senior Project Engineer (hours)	Project Engineer (hours)	Engineer (hours)	Labor Cost
1	40	72	224	240	
2A	1	0	0	4	
2B*	15	32	72	84	
3	20	0	0	4	
4	72	0	8	24	
5*	12	0	0	2	

*Optional Task

Table 2. Direct expenses for Tasks 1 through 5.

Task	Direct Expenses	Direct Expense Cost
1	Color copies, UPS shipping	$100
2B*	Color copies, UPS shipping	$100
3	Travel to Plainville, CT (2 meetings)	$200
4	Color copies, UPS shipping	$200
5*	Travel to Providence, RI. Assume overnight stay is required. Cost per meeting.	$400

*Optional Task

Table 3. Hourly labor rates.

Category	Hourly Labor Rate
Senior Managing Engineer	
Senior Project Engineer	
Project Engineer	
Engineer	

Please contact me if you have questions regarding this proposal.

Sincerely,

Quantitative Environmental Analysis, LLC

C. Kirk Ziegler

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Senior Vice President

CKZ:tm