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# **9A**

DATE: July 11, 2011

## COUNCIL COMMUNICATION

**INITIATED BY:** Durham Town Council

**AGENDA ITEM:** UPDATE ON THE RESULTS OF THE SUPPLEMENTARY CONCRETE INVESTIGATION OF THE OYSTER RIVER DAM AND PROVIDE RECOMMENDATIONS FOR FUTURE ACTION

**PREPARED BY:** David Cedarholm, Town Engineer

**PRESENTED BY:** Todd Selig, Administrator  
David Cedarholm, Town Engineer

**AGENDA DESCRIPTION:**

Town Engineer David Cedarholm will provide an update on the Oyster River Dam and an overview of the supplementary investigation on the Oyster River Dam's spillway performed by Dr. David Gress, and provide recommendations for future action. Attached is Dr. Gress's report entitled Predicting Future Expansion of the Oyster River Durham Falls Dam. The results of the investigation and recommendations for next steps will also be discussed. This investigation is a follow-up on an engineering study on the dam's concrete which performed in 2009 by a team of Dr. Gress and Stephen's Associates Consulting Engineers, Inc. The results of the 2009 engineering study was compiled in their report from March 2010.

To satisfy some immediate concerns by the New Hampshire Department of Environmental Services (NHDES) Dam Bureau, additional work was also performed in December 2010 at the dam's right (looking downstream) soil embankment to protect it from the threat of erosion during flooding. This work consisted of constructing a engineered rock apron adjacent to the right abutment where erosion occurred during recent flooding. The rock apron is a temporary measure and essentially buys the Town some time to figure out how best to address the numerous other somewhat more serious deficiencies with the dam. The right soil embankment is not actually owned by the Town, however NHDES considers it part of the dam since it is integral with the right concrete abutment. This makes both the landowner and the Town responsible for the erosion issues, and as such the cost to install the rock apron work was shared by the landowner and the Town.

## **Background**

It has been about 13 months since the last update on the Oyster River Dam's deficiencies, so the below background information is provided to help the Town Councilors better understand how we got to where we are today.

As the Oyster River Dam approaches its centennial anniversary, it is clearly showing signs of serious deterioration. The floods of '06 and '07 made some of these problems more apparent and brought to light some new problems. The deficiencies identified by NHDES and further noted by Stephens Associates in their inspection of the Oyster River Dam in September of 2008 are mostly due to the advanced age of the structure. The needed repairs were estimated by SA in their March 2009 report to range between \$500,000 and \$1,200,000.

In addition to the structural problems associated with the dam, the Oyster River has water quality issues related to stagnant water conditions in the Mill Pond and as a result the Oyster River is listed as impaired for low dissolved oxygen on NHDES's Section 303(d) Clean Water Act priority list of impaired water bodies. New Hampshire Surface Water Quality Regulations (Env-Wq 1700) require that corrective measures be to implement address impairments to listed water bodies.

The combination of the structural deficiencies with the dam, the water quality issues in the Mill Pond, and desire by some to restore the submerged river to its original tidal salt marsh habitat inspired consideration of dam removal as an alternative to continued dam repairs and to solve the water quality problems. More background information and a chronology of the project is provided following the discussion of the recent studies.

The two studies performed in 2009 focused obtaining more detailed information to help provide a higher level of confidence in determining whether it is reasonably feasible to repair the dam and to preliminary investigate some key questions associated with possible dam removal/river restoration.

### Concrete & Bathymetric/Topographic Survey and Sediment Investigations:

The concrete investigation involved conducting physical tests and observations on the exterior of the dam, and analyzing about a dozen 4 and 6 inch diameter concrete cores that were extracted from the dam to assess the interior of the dam. The concrete cores were extracted from various locations on the dam by UNH Civil Engineering Professor Dr. David Gress. Dr. Gress, who is leading authority on concrete deterioration, analyzed the concrete cores for microscopic cracking, signs of irreversible chemical deterioration, and conducted tests to measure the concrete's compressive and tensile strengths. Stephens Associates assisted Dr. Gress in collecting the cores while conducting acoustic tests on the exterior of the dam in search of evidence of near surface deterioration. Stephens Associates prepared the attached Final Report dated

March 31, 2010 which contains a detailed description of the tests, a summary of the results, and recommendations regarding the concrete issues.

The bathymetric/topographic survey and sediment investigation involved performing bathymetric survey of the surface of the Mill Pond sediments to topographic map of Mill Ponds bottom. A ground survey was conducted to create a seamless topographic map between the Mill Pond and the surrounding upland. The topographic maps were then used to estimate where the tidal water would inundate the Oyster River in the event the dam was removed. The Mill Pond's bottom sediments were probed to estimate the thickness of the pond sediments and samples were collected and analyzed for possible contamination.

A detailed discussion of the results and recommendations for further steps were provided by the Town Engineer during a presentation to the Town Council on June 7, 2010.

Historical records indicate that the Oyster River Mill Pond Dam was constructed in 1913 by local contractor Daniel Chesley and was apparently gifted to the Town by the daughter of Hamilton Smith, Edith Onderdonk. The design of the dam is very similar to a patented design developed by the Ambursen Hydraulic Company. The Ambursen dams were innovative for their day and constructed of steel reinforced concrete walls, which are not much thicker than an average house foundation, with hollow chambers to economize on concrete. The chambers are open on the downstream face of the dam beneath the spillway. The dam spillway is approximately 140 feet wide and about 10 feet tall.

The dam is considered a "head of tide" dam, meaning the dam structure blocks the incoming (ebb) tide from the tidal portion of the Oyster River. This is significant from an ecological standpoint in that a tidal brackish habitat formerly extended into the area currently occupied by the Mill Pond. It is difficult to say how much of the Mill Pond area was inundated with tidal water prior to construction of the first Dam, but it likely that a salt marsh historically extended well up into Mill Pond area. Because the dam's chambers (also called cells) are open on downstream face, the tidal waters are free to wash up against the inside of the chambers during high tide.

After more than 60 years of use, the dam underwent an extensive renovation in the mid 1970s to repair major deterioration of the spillway and incorporate a fish ladder. The renovation was extensively debated by a succession of Boards of Selectmen as it was a costly endeavor. The dam's structure had been seriously eroded prior to this renovation by years of water flowing over the spillway and brackish water lapping against it downstream face. The repairs were made possible by a combination of Town funds and the New Hampshire Department of Fish and Game who funded the design and installation of the denil fish ladder.

Although the problems that have been identified recently are considered serious and need to be addressed very soon, they are not nearly as extensive as what the Town dealt with in the 1970's renovation.

The Department of Public Work monitors the condition of the dam on a regular basis and is involved in annual communication with the New Hampshire Department of Environmental Services (DES) regarding the condition assessments, inspections reports, deficiencies, etc. DES performs dam inspections about every five years and provides inspection reports outlining deficiencies that range from minor issues such as a tree branch hung up on the spillway to more serious structural problems.

The following is a chronology of correspondence and information regarding the Mill Pond/ Oyster River Dam, which was provided in response to a request by the Town Council in March of 2009.

Project Chronology:

- ✓ 1974 - Town of Durham letter to NHFG requesting fish ladder installation.
- ✓ 5/15/1980 - DES inspects the dam- dam classified as low hazard.
- ✓ 4/15/1982 - DES inspects dam.
- ✓ 4/23/1982 - DES- Ken Sterns issues memo to Chief Engineer- recommend Class B due to damage to Route 108.
- ✓ 2/17/1983 - DES issues inspection report from 4/15/1982 inspection- Class B questionable. Detailed analysis needed to verify hazard classifications.
- ✓ 4/12/1988 - DES inspects dam.
- ✓ 2/19/1997 - Miscellaneous correspondence RE: Emergency Action Plan.
- ✓ 3/26/1997 - Miscellaneous correspondence RE: Emergency Action Plan.
- ✓ 3/31/1997 - Miscellaneous correspondence RE: Emergency Action Plan.
- ✓ 1/05/1998 - Miscellaneous correspondence RE: Emergency Action Plan.
- ✓ 3/16/1998 - Miscellaneous correspondence RE: Emergency Action Plan.
- ✓ 6/6/1993 - DES inspects dam.
- ✓ 7/29/1998 - DES inspects dam.
- ✓ 4/24/2000 - DES letter to Town approving Operation and Maintenance Plan.
- ✓ 9/19/2000 - GZA Engineering- Issues a Dam Inspection Report.
- ✓ 10/09/2002 - DES conducts a dam safety inspection.
- ✓ 12/10/2002 - DES issues LOD
- ✓ 12/12/2002 - Town sends DES Intent to Complete Repairs.
- ✓ 12/20/2002 - Town sends letter to DES- Repairs made by 11/01/03.
- ✓ 1/1/2003 - Town approves \$22,500 for minor repairs (not fully expended).

- ✓ 3/19/2003 - Town demonstrates partial compliance with LOD.
- ✓ 7/15/2003 - Town conducts independent concrete patch type trial tests on cracked and deteriorated areas.
- ✓ 5/24/2004 - Trial patch repairs inspected - both trial tests fail within 10 months.
- ✓ 9/10/2004 - Town inspects dam with masonry contractor, minor repairs will not work due to degree of deteriorated concrete.
- ✓ 3/23/2005 - Town issues and RFQ for consulting services to help Town address the Oyster River Dam's outstanding deficiencies.
- ✓ 6/08/2005 - Town selects Stephens Associates as the Town's dam engineer.
- ✓ 10/31/2005 - DES conducts flood inspection.
- ✓ 11/14/2005 - DES sends Town letter regarding flood and outstanding deficiencies.
- ✓ 11/17/2005 - Town completes DES 2005 storm survey.
- ✓ 5/24/2006 - DES conducts flood inspection.
- ✓ 6/08/2006 - Town completes DES 2006 flood survey.
- ✓ 1/1/2007 - Town approves \$37,000 for possible flood related damages and collects information for FEMA (not expended).
- ✓ 4/18/2007 - DES conducts flood inspection.
- ✓ 5/08/2007 - Town completes DES 2007 flood survey.
- ~~✓ 8/9/2007 - Town completes Project Worksheet Report with FEMA Officials due to possible damage from April 2007 flood.~~
- ✓ 9/18/2007 - DES conducts dam safety inspection.
- ✓ 9/28/2007 - DES completes a trip report from inspection.
- ✓ 1/1/2008 - Town approves \$88,000 for dam related engineering services.
- ✓ 3/10/2008 - Stephens Associates completes cost estimate of stability analysis.
- ✓ 4/08/2008 - DES issues report and recommends Administrative Order.
- ✓ 5/19/2008 - The Town Council awards engineering contract to Stephens Associates as unanimous consent item without discussion.
- ✓ 8/25/2008 - DES provides Draft Administrative Order for review by the Town requiring repairs to the Dam according to a specified schedule.
- ✓ 8/26/2008 - Town holds public informational meeting to inform the public about the upcoming dewatered inspection.
- ✓ 9/18-23/2008 - Town and Stephens Associates conducts a dewatered inspection of the Oyster River Dam.
- ✓ 12/12/2008 - Stephens Associates provides a draft of preliminary estimates of repair costs/options.

- ✓ 03/03/2009 - Stephens Associates provides a summary of results from the Draft Final Report (see below table).

As noted above, the Oyster River Dam has experienced many years of use and was identified to be in need of repairs by NHDES. The first letter of deficiency issued by DES in December 2002. The Town demonstrated partial compliance in 2003 and began to develop plans to address the remaining more serious issues. In 2003 the Town conducted a series of independent trial tests to determine if simple surficial patch type repairs might inexpensively solve the deteriorated concrete problems. The results were not encouraging and it was determined that concrete repair would likely involve a solution of reforming at least some portions of the dam to address the areas where deterioration has penetrated deep into concrete structure. Reforming requires removing all deteriorated concrete, building custom wooden concrete forms around the problem area, and pouring new concrete into the form. Based on this determination, it was decided to delay the repairs until a consulting engineer specializing in dam repairs could be hired to assist the Town in developing a more thorough solution.

In 2005, DPW advertized a Request for Qualifications based selection in which qualifications statements and proposals were submitted from eleven (11) firms, and the Stephens Associates Consulting Engineers, Inc. was hired. Table 1 summarizes Stephens Associates' physical observations made during the September 2008 dewatered inspection and general opinions of the dam's condition. The upstream face, crest and left abutment (looking downstream) are considered be good to fair conditions. The dam's downstream face, inside cells, gates, right abutment and right training walls are all significantly deteriorated and considered to be in poor condition. These areas will require extensive repair to ensure the long term health of the dam. The soil embankment behind the right abutment will require extensive work to prevent floodwater from overtopping and washing out the abutter's back yard. This will likely involve an archaeological investigation and some degree of historic mitigation due to the historic mill and industrial activities documented at the site.

<b>TABLE 1 - Summary of Dam Inspection Observations</b>	
Location	Observation
Upstream Face	Generally fair condition: gaps in some cold joints of about 0.5 in
Downstream Face	Generally poor condition: significant spalling, erosion, and exposed reinforcing steel on the downstream face of the ribs between cells; some footing undermining of rib between cells 8 and 9 (numbered 1-9 from R to L looking downstream). 1 in. gap at contact with right abutment.
Inside Cells	Generally poor condition: significant cracking, spalling and efflorescence, particularly at cold joints.

Crest	Generally good condition: some algae downstream of peak, some longitudinal cracking 6 to 7 ft. long. Cold joints at 35 and 71 ft. from right abutment have gaps of about 1 in. and 2 in., respectively.
Left Abutment	Generally good condition: fish ladder; previously repaired cracks observed.
Right Abutment	Generally poor condition: Spalling, erosion, and cracking on upstream face; spalling, erosion and exposed reinforcing steel on downstream face. Erosion at base of right abutment on downstream side by discharge pipe (see gates below). The Dam is also susceptible to erosion behind the right abutment (beginning at the right downstream training wall and migrating upstream) caused by overtopping, necessitating erosion protection, as evidenced by collapse of right downstream training walls and associated erosion in floods of May 2006 and April 2007.
Gates	Generally poor condition: The gates are functional and operation is fair to poor. Right gate discharges to ~12-in. diameter pipe. Significant deterioration and undermining of this pipe and surrounding concrete. Iron/steel supports/fasteners rusted and deteriorated - in need of replacement. Wood in fair condition, but should be replaced with metal components.
Right Training Walls	Generally poor condition: Walls are generally dry stone masonry. Right downstream training wall collapsed during floods of May 2006 and April 2007 and rebuilt by right abutter.

Rehabilitation vs. Decommissioning

Due the extensive repair determined following the September 2008 investigation, DPW requested that Stephens Associates preliminarily investigate the Town's options with respect to dam rehabilitation and dam decommissioning (removal) and provide an opinion of the range of probable costs. Stephens Associates provided a memorandum, dated December 12, 2008, which included a comparison of relative costs between dam rehabilitation and removal. The memorandum essentially showed that the range of costs between dam rehabilitation and removal are similar, although there may be more available outside funding for removal, dam removal is more complex and there are many unknowns associated with removal that were not considered (i.e. socioeconomic costs, success of river restoration). The complexities associated with dam removal as compared to repair are evident upon review of the below summary of guidelines, which is based on information provided by NHDES:

**Guidelines to Regulatory Requirement for Dam Repair Projects:**

Step One: Conduct Condition Assessment and Obtain Necessary Information

Step Two: Develop Repair Design Plans:

- Preliminary & Final Project Plans and Technical Specifications
- Historic Mitigation

Step Three: Prepare Permit Applications and Supporting Materials:

- NHDES Standard Dredge and Fill Permit Application
- NHDES Dam Bureau Dam Reconstruction Permit Application

Step Four: Permit Review and Issuance

**Guidelines to Regulatory Requirement for Dam Removal Projects:**

Step One: Obtain Necessary Information *and Involve the Public, Regulators and other stakeholders from the beginning!*

Step Two: Feasibility Assessment – Conduct Research on Key Technical Issues and Develop Preliminary/Conceptual Design Options while considering:

- Socioeconomic Issues
- Historical Resources
- Effects Habitat
- Water Quality & Ecology
- Hydrology & Hydraulics
- Sediment Issues
- Effects on Existing Infrastructure
- River Restoration & Streambank Stabilization
- **PUBLIC & STAKEHOLDER INVOLVEMENT**

Step Three: Develop Final Plans:

- Dam Removal Plan
- Historic Mitigation Plan
- River/Habitat Restoration Plan including Streambank Stabilization, Sediment Management, etc.
- **MORE PUBLIC & STAKEHOLDER INVOLVEMENT**

Step Four: Prepare Permit Applications and Supporting Materials

- NHDES Standard Dredge and Fill Permit Application
- Dam Removal Attachment
- Historic Mitigation Memorandum of Agreement (MOA)

Step Five: Permit Review and Issuance

On March 4, 2009 the DPW held a public informational meeting (PIM) to provide information to Durham residents on the issues associated with the dam, the available options, and to hear comments and questions from the public. The PIM included six (6) presentations:

- Technical Information (Dave Cedarholm - Town Engineer)
- History of the Dam & Mill Pond (Andrea Bodo - Newmarket Road Resident)
- Fisheries (Cheri Patterson - NH Fish & Game Dept.)
- Downstream Habitat (Ray Konisky - The Nature Conservancy)
- Hydropower (Steve Burns - Newmarket Road Resident & Jerry Whiteleather - Engineer)
- Mill Pond Drawdown Effects (Jerry Olson - Mill Pond Road Resident)
- Dam Removal/River Restoration & Feasibility Study (Deb Loiselle - NHDES, Dam Bureau)

The March 4<sup>th</sup> PIM lasted for four hours and was attended by approximately 82 residents and various individuals from the area that had many questions and comments regarding the options being considered. An overwhelming majority of attendees supported repairing and preserving the dam and/or incorporating some degree of hydropower into the structure. A handful of residents and regulators argued in favor of dam removal primarily for reasons having to do with habitat restoration or improving water quality.

At the March 16, 2009 Town Council meeting, Town Engineer David Cedarholm provided information relative to the physical condition of the Oyster River Dam, the structural problems identified, and the range of options to consider prior to developing plans to repair the dam. After a lengthy discussion regarding this matter, the Council voted to schedule a public hearing for Monday, May 4, 2009 to allow for a public discussion on the array of issues.

At its meeting on April 6, 2009, the Town Council further discussed the venue for the May 4<sup>th</sup> public hearing and decided to hold the hearing in the multipurpose room at the Oyster River High School. At the public hearing, Town Engineer Cedarholm presented a brief overview of the Oyster River Dam project. At the conclusion of his presentation, the public hearing was held. There were approximately 170+/- citizens who attended the hearing, many of whom provided input to the Council and Town staff relative to this matter. The Council also received written feedback concerning the dam from residents and concerned parties. During limited Council discussion at the end of the May 4<sup>th</sup> meeting, a number of Councilors expressed interest in gathering more information as part of a feasibility study surrounding questions that had been raised

regarding dam removal/river restoration. Questions also were raised concerning the short and long-term implications of dam repair.

As a follow up to the May 4<sup>th</sup> public hearing, the N.H. Department of Environmental Services offered a grant in the amount of \$40,000 to conduct a preliminary investigation (or pre-feasibility study) surrounding the topic of river restoration/dam removal. If after completing a pre-feasibility study the Town has interest in continuing to explore river restoration, the N.H. Coastal Program may be willing to work with the Town and contribute additional funding toward a full scale feasibility study.

On September 23, 2009 the Town of Durham was awarded a grant to "to assess principal questions associated with the potential repair or removal of the Oyster River Dam". The source of the funds for Part 1 below was from the National Oceanic and Atmospheric Administration. The consulting firms Vannasse Hangen Brustlin, Inc., and Hydroterra Environmental Services were selected to perform the Mill Pond bathymetric/ topographic survey and sediments investigation and prepared a report of the work and their findings. Their work consisted of the following Scope of Work:

#### **1. Sediment sampling and Bathymetric Survey**

Proceed with hiring a consultant to conduct a limited investigation of sediments that have accumulated in the Mill Pond to determine where the accumulation has occurred and explore the degree to which the sediments are contaminated.

- Conduct bathymetric survey of the impoundment area of up to 25 acres.
- Establish ground survey controls and layout up to 6 river transect surveys to tie in the bathymetric survey.
- Perform sediment core sampling using vibratory core methods. This task would include detailed descriptions of soil cores and screening for possible contamination from volatile organic compounds, petroleum products, or other suspect compounds.
- Perform analytical testing on suspected screened soil samples.

This information was intended to help the Town gain a better understanding of the condition of the Mill Pond and to what degree sediments may require remediation if sediments were dredged as part of a dam repair scenario or removed as part of a river restoration effort.

The source of funds for Part 2 below came from Town funds that were allocated for engineering services associated with the Oyster River Dam repairs.

#### **2. Phase II Dam Investigation**

Stephens Associates and Dr. Gress investigated the seriousness of the structural issues associated with the dam according to the following Scope of Work:

- Conduct an intrusive investigation of the dam's concrete which would involve concrete core sampling and strength testing.
- Update the cost estimate for short-term and long-term repairs. This cost estimate would not include complete replacement of the dam.
- Provide recommendations for immediate temporary measures to stabilize the right soil embankment.

The results from the Sediment Sampling and Bathymetric Survey described above were presented by the Town Engineer on June 7, 2010 and were summarized as follows:

- The thickness of sediments from 32 sediment probes ranged from 0.6 feet to 4 feet with an average of 1.9 feet. The thickest sediments were found south of the river channel;
- No VOCs, PCB, or pesticides were detected.
- Very low concentrations of metals (typical of atmospheric and naturally occurring sources) and PAHs (typical of urban developed areas) were detected.

The results of the Phase II Dam Investigation were also presented by the Town Engineer on June 7, 2010 and were summarized as follows:

- The right abutment is extremely deteriorated and needs complete replacement;
- A few voids in the concrete were identified near the top of the spillway;
- Strength testing of concrete cores revealed 50% lower than expected tensile strength;
- Petrographic analysis revealed extensive microcracking; and
- Alkali Silica Reaction (ASR) and issues related to freeze/thaw were suspected to be the primary cause of microcracking and ongoing concrete expansion.

The results from the Phase II Dam Investigation raised questions about the viability of performing long term repairs on the spillway due to the potential for ASR and freeze/thaw to cause continued volumetric expansion of the dam's concrete. In June 2010, it was recommended to conduct supplementary tests to determine to what degree ASR might cause the concrete to expand over time. The Town Council gave their support to conduct the supplemental investigation and the work was focused on the

spillway since the severe deterioration of right abutment requires it to be completely replaced in the not-too-distant future.

**LEGAL AUTHORITY:**

N/A

**LEGAL OPINION:**

N/A

**FINANCIAL DETAILS:**

See estimates listed above.

**SUGGESTED ACTION OR RECOMMENDATIONS:**

No formal action is required at this time. Receive the Town Engineer's presentation and recommendations to address the deficiencies of the Oyster River Dam.