White Paper: Dam Removal Practices and Implications for Dams on the Housatonic River

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1.0 Introduction

This paper provides an overview of dam removal and the potential implications to be considered during the remediation of polychlorinated biphenyl (PCB) contamination in Reaches 7 and 8, between Woods Pond Dam and Rising Pond Dam, (study reach) of the Housatonic River Rest of River in Berkshire County, Massachusetts. The objectives of this white paper are to present:

1. Decision-making processes considered during dam removal;
2. Sediment management as part of dam removal; and
3. Aquatic resource restoration opportunities associated with dam removal.

Information presented in this paper is based on professional experience and expertise with dam removal projects, and integrates scientific knowledge in engineering, fluvial geomorphology and hydraulics, sediment transport, biology, and ecology. The preparers' experience with dam removal includes design and permitting work for 13 completed dam removals and more than 60 dam removal studies in the United States and Canada, including preparation of approximately 45 preliminary dam removal planning studies in Massachusetts. The purpose of this paper is to provide an overview of constraints and opportunities associated with dam removal and how this information may relate to remediation of the Housatonic River.

2.0 Overview of Dams along the Study Reach of the Housatonic River

Dams were historically constructed along the study reach of the Housatonic River for multiple purposes, including water supply and production of mechanical and hydroelectric power.

2.1 EXISTING DAMS

There are five existing dams downstream from Woods Pond Dam in the study reach of the Housatonic River in Massachusetts, including:

1. Columbia Mill Dam, Lee (Reach 7);
2. Eagle Mill Dam, Lee (Reach 7);
3. Willow Mill Dam, South Lee (Reach 7);
4. Glendale Dam , Stockbridge (Reach 7); and
5. Rising Pond Dam, Great Barrington (Reach 8).

The subject dams are operated as run-of-river systems, have little storage capacity, and are not capable of substantially attenuating high flows (i.e., floods). During normal flows, however, the subject impoundments have identifiable impoundments.

There are no fish passage facilities at these dams and their presence has resulted in accumulation of sediment and associated PCBs in the impounded reaches of the Housatonic River upstream from each dam[1].

2.2 REMNANT DAMS

In addition to the five dams noted above, there are remnants of a timber crib dam in Lenox between the East Street Bridge and Columbia Mill Dam. Observable remnants of this dam are limited to a timber crib foundation that extends approximately 1 foot (ft) above the adjacent streambed during periods of low flow. There is little apparent accumulation of sediment upstream from this dam and it does not appear to substantially affect upstream movement of aquatic organisms.

Note that unidentified remnant dams may be present in the study reach.

2.3 DAM SAFETY REGULATIONS

Jurisdictional dams in Massachusetts are regulated by the Massachusetts Department of Conservation and Recreation (DCR) Office of Dam Safety (ODS) unless the dams are regulated by a superseding authority, such as the U.S. Army Corps of Engineers and the Federal Energy Regulatory Commission. Owners of jurisdictional dams are responsible for compliance with relevant dam safety regulations.

3.0 Dam Effects on Riverine Systems

3.1 HYDROLOGY

The primary effect of dams on riverine hydrology is alteration of the hydraulic regime in the impounded reach of the river, including increased depths of water and reduced flow speeds.

3.2 SEDIMENT TRANSPORT

Dam impoundments can function as “sinks” for sediment due to lower flow speeds relative to undammed conditions. The sizes and volume of sediment that may accumulate vary spatially and temporally in a given impoundment, and substantial accumulation of sediment over time can reduce the capacity of an impoundment to capture sediment. In the extreme, sediment can accumulate up to the spillway of a dam, which can largely eliminate additional trapping of sediment.

Capture of sediment in dam impoundments reduces downstream sediment transport. Typically, larger size fractions of sediments are captured while smaller size particles are transported through the impoundment during high-flow events. Patterns of sediment accumulation in impoundments can be generalized as 1) formation of a delta comprised of relatively coarse (e.g., gravel, cobble) material towards the upstream end of the impoundment, 2) formation of foreset deposits downstream from the delta, and 3) deposition of finer material between the foreset deposits and the dam and/or transport of finer

[1] Eagle Mill Dam is partially breached; however, the dam still holds back accumulated sediment.

material through the impoundment and downstream. The process of sediment accumulation can result, over time, in stratified bedding of sediment sizes comprised of layers of relatively coarse sediment overlying finer material. These processes can result in formation of apparent armor layers comprised of coarser material overlying finer material.

Physical characteristics of sediment (e.g., sediment sizes) vary spatially in rivers, and sediment sizes in channels are typically larger relative to sediment sizes in adjacent floodplain areas. Dam impoundments can result in changes to typical spatial variations in sediment sizes, such as accumulation of foreset deposits in impoundments, increased floodplain extents, and resulting deposition of finer sediments in areas that may extend beyond the pre-dam floodplain.

3.3 ECOLOGICAL EFFECTS

Ecological effects of the subject dams include 1) alteration of habitat in the dam impoundments, 2) alteration of fluvial processes upstream and downstream from each dam, and 3) impeding and/or preventing movement of aquatic fauna.

Alteration of aquatic habitat associated with dam impoundments results from backwater effects from the downstream dam and can be generally characterized as a shift from lotic to lentic habitat. The physical extent of aquatic habitat alternation may be characterized as the area that is backwatered by the dam, and may extend upstream above the elevation of the spillway. A consequence of the shift from lotic to lentic habitat is that conditions in an impoundment may be favorable for species that are not well adapted to riverine habitats, including invasive flora and fauna.

Altered fluvial processes affect aquatic habitat in the dam impoundment and can affect habitat downstream. A primary effect on aquatic habitat in and upstream from the dam impoundment is accumulation of sediment, and includes accumulation of coarse sediment at the upstream limit of the impoundment and deposition of finer material downstream to the dam. These changes can affect benthic habitat and suitable habitat for spawning and rearing of aquatic organisms. In addition, slower-moving water in an impoundment may favor growth of rooted aquatic vegetation that would not typically be found in a riverine (lotic) system. Additional impacts to water quality may also occur, such as increased water temperatures.

Alteration of fluvial processes can have ecological effects downstream from a dam due to reduced transport of some sediment sizes through an impoundment. A typical manifestation of this effect is coarsening of substrates in the downstream reach of the river due to lack of replenishment of some sediment sizes from upstream.

Dams prevent upstream movement of aquatic fauna and can impede downstream movement of aquatic fauna under some conditions. The five subject dams lack upstream fish passage facilities and are therefore complete barriers to upstream fish passage. In addition, dams and adjacent infrastructure can impede upstream and downstream movement of fauna in the adjacent riparian corridor.

4.0 Drivers for Dam Removal

There are multiple drivers for dam removal, including elimination of liabilities associated with dam ownership, decommission of legacy infrastructure, and ecological restoration, including restoration of continuity of aquatic and riparian habitat. Currently, Columbia Mill and Eagle Mill Dams have been the subject of preliminary dam removal discussions and activities.

4.1 ELIMINATION OF DAM OWNER LIABILITY

Dam removal is a means to eliminate costs associated with dam maintenance and operations and liability associated with dam failure. Owners of jurisdictional dams that are not in compliance with ODS regulations may receive Dam Safety Orders from ODS that proscribe required actions for compliance; these orders typically include a statement that removal of a dam is a means to achieve compliance with the regulations.

4.2 DECOMMISSIONING OF LEGACY INFRASTRUCTURE

Dam removal provides a means to decommission and eliminate infrastructure (i.e., dams) that no longer serve their intended purpose; dam removal is a means to eliminate ongoing costs associated with dam operations and maintenance. This driver for dam removal varies from the previously noted driver related to dam owner liability (Section 4.1), as it encompasses dams that may be in good condition.

4.3 ECOLOGICAL RESTORATION

Dam removal provides a means to restore lotic habitat in an impounded reach of a river, continuity of aquatic habitat (including volitional upstream and downstream movement of aquatic organisms), and continuity of habitat in the adjacent riparian corridor.

Relative values of implementing active habitat restoration measures in an impoundment following dam removal may be compared with values associated with restoration of volitional passage for aquatic organisms associated with dam removal. In some cases, it may be determined that costs for restoration of a previously impounded reach are too high to warrant detailed restoration if it is determined that restoration of volitional passage for aquatic organisms through dam removal meets project objectives for restored access between upstream and downstream habitats.

4.4 SEDIMENT MANAGEMENT

Management of accumulated sediment in a dam impoundment is not a typical direct driver for dam removal but can provide an opportunity to coordinate dam removal with contaminated sediment removal as part of remediation actions. Sediment management as part of dam removal should be considered on a case-by-case basis. The quality of impounded sediment varies between impoundments and opportunities for sediment management are dependent on site-specific variables. The presence of contaminated sediments may result in costs in excess of what would otherwise be necessary for dam removal absent the presence of contaminated sediment and can complicate dam removal planning, design, and permitting.

Concerns regarding liability for a dam owner and liability associated with contaminated sediment should be evaluated in consideration of how to manage sediments in a dam impoundment. Sediment management associated with dam removal can allow for focused removal or remediation actions, whereas intentional or accidental downstream release of sediment, such as what could occur as a result of dam failure, would likely result in uncontrolled dispersal of potentially contaminated material over a larger area.

Minimization or mitigation of risk associated with contaminated sediment may therefore represent an opportunistic driver for dam removal, whereas management of impounded sediment, including contaminated material if present, may otherwise represent a significant constraint to dam removal.

5.0 Dam Removal Planning

Dam removal planning must be addressed on a site-specific basis, including the potential need for integration of various components of a given project, including construction access and egress, water and sediment management during construction, remediation of contaminants, impacts to natural resources, and potential post-construction effects.

The Commonwealth of Massachusetts has published guidance documents addressing planning and design of dam removal projects in Massachusetts, including:

1. Dam Removal in Massachusetts: A Basic Guide for Project Proponents (Massachusetts Executive Office and Energy and Environmental Affairs [EOEEA] 2007) (Appendix A); and

2. Dam Removal and the Wetland Regulations (Massachusetts Department of Environmental Protection [MassDEP] 2007) (Appendix B).

These documents provide an overview of the dam removal process, including a summary of the common components of dam removal planning, design and implementation, and may be relevant to informing an approach to dam removal in the study reach.

5.1 OVERVIEW OF DAM REMOVAL PLANNING AND IMPLEMENTATION

As described in EOEEA (2007), there are general planning, design, and implementation components and considerations that are common to many dam removal projects. While each dam removal project is unique and subject to numerous site-specific considerations, the components summarized below may be considered as a generic “check-list” when evaluating a specific dam removal project:

1. Initial Reconnaissance and Preliminary Planning

    a. Determine ownership, current uses, and legal rights associated with project elements.
    b. Identify potential project impacts to infrastructure and sensitive resources.
    c. Preliminarily assess potential sediment quantity, quality, and mobility.
    d. Assess potential stakeholder interests and concerns.
    e. Identify primary project opportunities and constraints.
    f. Identify potential funding sources.

2. Site-Specific Studies / Feasibility Study

   a. Collect and review existing applicable data.
   b. Conduct surveys and prepare base map.
   c. Quantitatively assess sediment quantity, quality, and mobility.
   d. Conduct hydrology and hydraulics assessments.
   e. Assess potential impacts to infrastructure and sensitive resources.
   f. Conduct site-specific studies and pre-project monitoring.
   g. Develop design alternatives, including dam removal, water and sediment management, and site restoration.
   h. Identify and quantify project impacts.
   i. Identify required federal, state, and local regulatory coordination and permits.
   j. Develop conceptual drawings of project alternative(s).
   k. Develop preliminary opinion of probable costs.

3. Stakeholder Outreach and Coordination

4. Preliminary Design Development

   a. Develop design plans to level of detail appropriate for stakeholder and regulatory review.

5. Regulatory Coordination and Permitting

   a. Coordinate with local, state, and federal regulators as required by applicable regulations.
   b. Submit applications for required approvals and permits.

6. Final Engineering Design Development

   a. Develop engineering design plans for project construction.
   b. Develop technical specifications for project construction.
   c. Develop an Engineer's Cost Estimate for construction.

7. Project Implementation and Construction

   a. Select and contract with construction contractor(s).
   b. Remove dam and conduct site restoration.
   c. Conduct post-construction monitoring and reporting.

EOEEA (2007) provides a detailed discussion of the above-described general components that are typical of planning, design and implementation for dam removal projects in Massachusetts.

The following sections of this document address in more detail topics related to project planning and design components of water management, sediment management, natural resource management, and existing infrastructure management.

5.2 WATER MANAGEMENT

Water management during construction is a requirement of dam removal. Water management includes management of water levels to allow for safe and effective dam removal construction and diversion of flows to maintain instream flows downstream from the dam during construction. Water management and sediment management as part of dam removal may be managed as a single component of work or as distinct components of construction.

Management of water levels in an impoundment during dam removal is typically accomplished by drawing down the impoundment using a low-level outlet. If a low-level outlet is not present or non-functioning, alternative means may be appropriate to draw down an impoundment, or a "live-breach" (i.e., drawing down the impoundment during dam removal) may be appropriate. If a low-level outlet is present, but in a closed position and not functioning, it may be appropriate to remove the control mechanism (e.g., valve closure) to allow for dewatering of an impoundment. Note that opening or removal of a low-level outlet may not be reversible (i.e., it may not be possible to close it).

Low-level outlets on most dams are typically sized to have limited hydraulic capacity and may only pass low or normal flows, and occurrences of high-flow events may result in refilling of an impoundment even if the low-level outlet is open. Lack of high-flow hydraulic conveyance can be advantageous for sediment management, as refilling of the impoundment will result in reduced shear stress and reduced sediment remobilization in the event of a high-flow event during dam removal and/or sediment management construction.

Diversion of instream flows to the downstream reach of a river is a typical requirement during dam removal construction. A component of this requirement is that turbidity be minimized in the diverted flow. If accumulated sediment is relatively coarse (e.g., gravel size material or larger), dedicated measures to divert flow may not be required except in areas of direct disturbance, such as areas where dam removal construction or sediment excavation is being performed. If relatively fine sediments are present, or if elevated concentrations of contaminants are present, dedicated measures for diversion of flow may be required.

Dedicated measures for diversion of flows to reduce entrainment of fine sediment and/or contaminants may include temporary coffer dams, diversion conduits, and/or constructed channels. Sizing of water diversion systems must be evaluated on a case-by-case basis with consideration of risks associated with insufficient hydraulic capacity if flows exceed the conveyance capacity of the diversion system during construction. The basis for selection of an appropriate flow is largely based on risk associated with insufficient hydraulic capacity ("failure"), and therefore relates to both the composition (e.g., presence of environmental contaminants) and the amount of material that could potentially be released in the event of failure of the water diversion system. Necessarily, decisions regarding the sizing of a water diversion system must consider the expected duration and seasonal timing of construction. Minimization of costs associated with a water diversion system may be accomplished by scheduling construction during periods of seasonal low flows (e.g., late summer/early fall) and minimizing the duration of construction.

5.3 SEDIMENT MANAGEMENT

Sediment management as part of dam removal is evaluated on a case-by-case basis, and may be considered as having two distinct components, including 1) minimizing turbidity of diverted instream flows during project construction, and 2) management of accumulated sediment, such as mechanical excavation. An additional factor that bears consideration as part of dam removal is potential spatial differences (e.g., in a river channel, in floodplains) of sediment characteristics and mobility before and after dam removal.

Minimizing turbidity of diverted instream flows is discussed in the previous section, and is largely based on segregating diverted flow from work areas. Where substantial accumulations of fine sediment and/or contaminants are not a concern, dam removal may be pursued without dedicated sediment/turbidity management systems.

The need for and approach to management of accumulated sediments is largely dependent on the composition (i.e., physical and chemical characteristics) and volume of accumulated material. Removal of accumulated sediment may also be appropriate if contaminants are present in the sediment and/or if there are relatively large volumes of fine grained sediment. Similarly, remobilization of relatively large volumes of clean, coarse sediment may be desirable for some projects, but not for others.

The concept of a relative volume of sediment is an important consideration, as it should be related to the assimilative capacity of the downstream reach of the river and the expected duration over which a volume of accumulated sediment could be remobilized.

Dam removal can result in changes in the hydraulic regime in a river channel and in the adjacent floodplains. Typical changes include increased flow speed and shear stress in areas of a former impoundment, including the channel and previously inundated floodplains, increased flow speed and shear stress in some former floodplain areas, and reduced incidence of flooding in areas that are above the restored floodplain. Because of the varying spatial effects of dam removal on flow speed and shear stress, sediment management planning for dam removal must address varying spatial effects. Where contaminants may be present, planning and design must also address potential changes in exposure pathways, such as use of persistently exposed land following dam removal.

The Commonwealth of Massachusetts has published guidance documents addressing sediment management as a part of dam removal projects in Massachusetts, including:

1. Dam Removal and the Wetland Regulations (MassDEP 2007) (Appendix B); and
2. Impounded Sediment and Dam Removal in Massachusetts: A Decision-Making Framework Regarding Dam Removal and Sediment Management (Massachusetts Riverways Program 2003) (Appendix C).

These documents provide a detailed overview of sediment management considerations for dam removal projects in Massachusetts, including sediment analysis and characterization, sediment management alternatives and regulatory requirements, and development of project-specific sediment management plans.

Section 6 of this document provides more detailed discussion of four specific sediment management strategies commonly implemented as a part of dam removal.

5.4 NATURAL RESOURCE MANAGEMENT

Natural resource management needs as part of dam removal must be evaluated on a case-by-case basis. The need for natural resource management as part of dam removal is typically identified and defined as part of local, state, and federal natural resource permit requirements. Typical requirements of the natural resource permitting processes include identification of regulated natural resources, including wetland and endangered species, and avoidance, minimization, and mitigation of impacts to these resources. Management of listed species can require specific measures as part of dam removal construction, including time-of-year restrictions on construction, dedicated design measures for exclusion of species from work areas, and/or oversight of work by appropriately qualified professionals.

Dam removal projects in Massachusetts are typically considered to be "self-mitigating" with regard to potential impacts to regulated natural resources such as wetlands, resulting in habitat conversion intended to more closely approximate pre-construction habitat conditions.

5.5 EXISTING INFRASTRUCTURE

Dam removal can potentially result in adverse impacts to existing infrastructure, such as bridges, roadway/railway embankments, underground utilities, surface water withdrawals, and shallow groundwater wells in close proximity to an impoundment. The potential for impacts to adjacent infrastructure must be evaluated on a case-by-case basis.

6.0 Sediment Management Strategies

Following here are descriptions of four general approaches to sediment management as part of dam removal.

6.1 INSTREAM SEDIMENT MANAGEMENT

Instream sediment management allows for natural remobilization and distribution of sediment following dam removal. This approach may be appropriate when there is relatively little accumulated sediment and/or when a dam has restricted replenishment of sediment in the watercourse downstream from a dam and remobilization of accumulated sediment would be beneficial to the downstream watercourse. This approach is typically used when most of the accumulated material is relatively coarse-grained (e.g., sand-size and larger sediment), but may also be appropriate when finer-grained sediments are present but substantial adverse impacts to remobilization are not identified.

The presence of large volumes of fine-grained (e.g., silt-size) sediment can represent a constraint to instream sediment management, and may require detailed assessment of potential impacts.

Instream sediment management is typically not appropriate when concentrations of contaminants in sediment that would likely be mobilized as a result of dam removal exceed screening benchmarks and "background levels" of contaminants downstream from the dam.

Note that naturally formed armor layers in and upstream from a dam impoundment may not be stable following dam removal, and dam removal may result in incision of a new channel through armor layers that may have formed prior to dam removal. Incision of a channel through these armor layers can be rapid, and may expose intermediate layers of finer material that is readily remobilized.

6.2 SEDIMENT REPOSITIONING

Sediment repositioning is a sediment management approach that includes removal of sediment from the expected post-action watercourse and placement of the material onsite, including in areas that may be intermittently wetted. This approach may include placement of material in areas that may not be wetted during seasonal high-flow events but may be inundated during flood events and/or placement in adjacent uplands.

In the absence of large volumes of fine sediment and/or presence of contaminants, sediment repositioning may include construction of a "starter channel" through accumulated sediment with repositioning of material removed from the starter channel immediately adjacent to the starter channel. This approach may be appropriate if it is determined that repositioning of sediment would reduce the storm event-specific loading of sediment to the downstream watercourse.

6.3 SEDIMENT REMOVAL

Sediment removal is a sediment management approach where removal of sediment from the watercourse is desired or required as a result of project-specific factors. Drivers for sediment removal include excessive volumes of accumulated sediment and/or presence of elevated concentrations of contaminants. Sediment removal as part of dam removal is inherently similar to sediment removal from undammed reaches of a river, and typically requires dedicated water and sediment management systems during construction.

6.4 SEDIMENT CAPPING

Sediment capping is a sediment management approach that may be implemented as part of a partial removal action (e.g., in concert with sediment repositioning or sediment removal). The basis of this approach is construction of an armored cap (e.g., riprap) over sediments. Design of sediment capping systems is considered to be a risk-based design, and there is therefore potential for failure of the system and release of capped materials if design criteria are exceeded, such as occurrence of an extreme high-flow event (e.g., flows similar to those that occurred during Tropical Storm Irene in August 2011).

Sediment capping over existing sediment in an impoundment that has steep foreset deposits of accumulated sediment could result in a barrier to upstream movement of aquatic fauna.

6.5 FATE OF CONTAMINANTS AND DAM REMOVAL

Dam removal can have multiple effects on sediment and contaminants, and the fate of contaminants must therefore be addressed on a site-specific basis as part of dam removal. Dam removal can result in increased erosion of sediments and associated contaminants and downstream transport of these materials, exposure of areas that may not have been readily accessible prior to dam removal, and changes in contaminant exposure pathways. The fate of contaminants must therefore be evaluated on a case-by-case basis as part of dam removal along with consideration of area-specific changes to remobilization and/or exposure pathways.

7.0 Dam Removal Design and Construction

This section addresses specific components of dam removal design and construction, including water and sediment management, and resource conversion, and identifies considerations specific to development of design standards applicable to dam removal in the study reach. The Commonwealth of Massachusetts guidance documents provided in Appendices A, B, and C of this document provide further overview of these and other components of dam removal design and construction.

7.1 CONSTRUCTION-PHASE WATER AND SEDIMENT MANAGEMENT FOR DAM REMOVAL

Water and sediment management as part of dam removal are addressed separately above. Integration of water and sediment management may, however, be necessary for dam removal construction.

The need for integration of water and sediment management during dam removal construction may follow on multiple factors, including the potential for remobilization of sediment during and/or following drawdown of a dam impoundment prior to or following dam removal. Integration of water and sediment management as part of dam removal can be realized operationally using separate but coordinated systems and may include approaches that are intended to provide for sediment removal in-the-wet and/or in-the-dry following drawdown of an impoundment.

Examples of operational approaches to water and sediment management where removal of potentially contaminated sediment is a project objective include:

- Use of turbidity curtains to segregate areas in an impoundment for removal of sediment with dredging (in-the-wet): This approach is appropriate where dam removal follows initiation, and possibly completion, of sediment removal and remediation work. A potential advantage of this approach is that work may be performed in a relatively low-energy environment that may not be conducive to downstream transport of sediment. Disadvantages of this approach include difficulties associated with performing submerged work and resuspension of fine sediment during construction.

- Diversion of water through a conduit or lined channel for removal of exposed sediment using mechanical excavators: This approach may be implemented with an impoundment drawn down or following dam removal. Implementation of this approach prior to dam removal requires a suitable means for drawing down the impoundment and allows for refilling of the impoundment if a high-flow event during construction results in flow that exceeds the capacity of the water diversion system. Implementation of this approach following dam removal must consider risk associated with the potential occurrence of high-flow events during construction that exceed the capacity of the water diversion system, which could result in remobilization and downstream transport of sediment.

Selection of an appropriate approach(es) for water and sediment management must consider site-specific conditions and risks associated with potential failure of the system components. Potential risk factors may include delays in construction, cost for rebuilding failed systems, and/or release of sediment and contaminants.

Typical terrestrial erosion and sedimentation controls must be integrated into water and sediment management controls, which may also serve a dual purpose as wildlife barriers.

7.2 SEDIMENT CAPPING AS PART OF DAM REMOVAL

Sediment capping may provide a means to limit the potential for remobilization of sediment from a former impoundment as part of dam removal. Design of a sediment capping system should address potential adverse and beneficial impacts to aquatic ecology following dam removal and risk associated with failure of a capping system and remobilization of sediment and contaminants.

Design standards for capping should be risk-based and consider impacts that could result from failure of a cap and resulting release of sediment and contaminants. Recommendations for deterministic criteria, such as stability of a cap system during a given return-interval flow (e.g., 100-year storm), are not provided here as development of appropriate criteria are beyond the scope of this paper.

7.3 SEDIMENT MANAGEMENT AND AQUATIC RESOURCE RESTORATION

Dam removal and associated sediment management needs may be considered in context of aquatic resource restoration. The four sediment management approaches described in Section 6 of this paper present varying and different opportunities to restore and/or enhance aquatic resources. The applicability of a given sediment management approach or group of approaches must be evaluated on a case-by-case basis, and may include consideration of project-specific goals and objectives. Potential benefits and impacts to aquatic resources may be defined based on restoration opportunities in the impounded reach upstream from a dam, in the potentially affected reach downstream from a dam, and the potential to restore volitional upstream and downstream passage for aquatic organisms.

The potential to restore lotic aquatic habitat in an impoundment may be of lower value relative to the potential to restore continuity of aquatic habitat and restoration of volitional upstream and downstream passage for aquatic organisms if the reconnected reach of the river are substantially larger than the reach that is impounded. Potential impacts to the downstream reach of the river are largely a function of current use of the downstream reach by aquatic organisms and impacts that would result from the selected sediment management approach. For example, remobilization of a large volume of sediment into a high-value water downstream from a dam as part of implementation of instream sediment management could result in undesirable impacts; a potential consideration of this approach would be whether impacts to habitat downstream from a dam would be offset by restored access to upstream habitats.

Conversely, a mix of sediment removal and sediment capping where contaminated sediment is left in place may limit remobilization of contaminated sediment, but retains risk associated with failure of the cap system during extreme high-flow events or other conditions that may not have been included in the design. It may therefore be appropriate to consider uncertainty in evaluating risk associated with actions that could result in future exposure of capped material, such as uncertainty related to future climate conditions (e.g., increased peak flows).

Design standards relevant to aquatic resource restoration may include criteria that address aquatic habitat in the reach of river through a former impoundment and passage of aquatic fauna through this reach. Primary design objectives can be that habitat conditions are suitable to support listed and indigenous species and instream fauna passage enables use of these areas during normal seasonal flows.

7.4 RESOURCE CONVERSION

Dam removal will eliminate the associated impoundment, can result in conversion of habitat, and will likely result in impacts to impoundment-dependent resources. Resource types that may be impacted include areas persistently inundated (e.g., palustrine unconsolidated bottom) prior to dam removal, persistent exposure of fringe areas that may have supported emergent aquatic vegetation and/or where seasonally inundated along the former impoundment, and “offline” areas where the impoundment may have contributed to formation of resources (e.g., culverted road or rail embankment along an impoundment resulting in persistent or perennial inundation that foster wetland resources). The elimination of an impoundment associated with dam removal will foster conversion from current impounded conditions to a condition more resembling historic riverine and riparian conditions (e.g., potential increase in the availability and distribution of the riverine floodplain, free-flowing waterway).

Conversion of existing natural resources that may result from dam removal must be addressed on a case-by-case basis. Design standards associated with resource conversion must similarly be addressed on a case-by-case basis. Where resource conversion may or will occur in an area where contaminants are or may be present, design standards should address changes in exposure pathways.

8.0 References

Massachusetts Department of Environmental Protection (MassDEP). 2007. Dam Removal and the Wetland Regulations. Boston, Massachusetts.

Massachusetts Executive Office of Energy and Environmental Affairs (EOEEA). 2007. Dam Removal in Massachusetts: A Basic Guide for Project Proponents. Boston, Massachusetts.

Massachusetts Riverways Program. 2003. Impounded Sediment and Dam Removal in Massachusetts: A Decision-Making Framework Regarding Dam Removal and Sediment Management. Department of Wildlife, Fisheries, and Law Enforcement. Boston, Massachusetts

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DAM REMOVAL in MASSACHUSETTS

A Basic Guide for Project Proponents



Executive Office of Energy and Environmental Affairs

December 2007

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Dear Friends of the Environment,

I am very excited to release a document that renews the Executive Office of Energy and Environmental Affairs' commitment to restoring riverine flows and aquatic habitat in the Commonwealth of Massachusetts.

Massachusetts has over 3,000 dams; the Blackstone watershed has the highest density of dams in the country. Our State is also blessed with rich natural resources and many species of plants and fish that are unique to our rivers and streams. While many of the dams provide important benefits in the form of water supply, flood control, and hydropower, many other dams are no longer serving the purpose for which they were built, but remain as decaying relics of our industrial past. They create ecological and hydrological hurdles. Dams that have served their life and are no longer functional need to be removed. That removal can be a win for everyone. It can restore rivers and streams to the vibrant, robust, complex habitats they once were; help revive fisheries that, because of dams, have been cut off from their historical spawning grounds; eliminate public safety hazards; and relieve owners of unwanted liability.

This guidance document will help dam removal proponents maneuver through the initial conceptualization of the project, the feasibility studies, the permitting process and the funding avenues with greater ease and clarity.

Sincerely,

Ian A. Bowles
Secretary

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David Mendelsohn, Federal Emergency Management Agency
Deerin Babb-Brott, Massachusetts Environmental Policy Act
Deirdre Desmond, Department of Environmental Protection
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Gerard Kennedy, Department of Agricultural Resources
Hunt Durey, Coastal Zone Management
Jack Buckley, Department of Fish and Game
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Preamble

The Executive Office of Energy and Environmental Affairs (EOEEA) is committed to restoring natural river ecology, re-establishing river continuity, and maintaining public safety, while avoiding inadvertent or adverse impacts to important natural and cultural resources. EOEEA considers the removal of out-dated dams – dams whose negative impacts outweigh their benefits – to be a critical mechanism in achieving these goals. EOEEA, through its agencies, aims to make the dam removal process predictable and easy to understand. It is the intent of this document to provide guidance for the removal of dams that are dilapidated and no longer functional. For the most part, these would be smaller dams or run-of-river dams that impede the flow of water and obstruct habitat, and no longer provide significant benefits. This guidebook informs the public of what the removal of a dam entails, the process, parameters to be considered, permits required, funding available, and constituents involved. The guidebook also distills some of the national and local experience in dam removal to help achieve projects that restore the environment and protect infrastructure.

Dam Removal in Massachusetts

Dams, in many forms, have been a part of our communities for centuries. By 1880, the six New England states had one third of the nation's water power, even though New England represents only two percent of the nation's land area. In Massachusetts, more than 3,000 dams dot the landscape, some of them originally built in the 17th to the 19th centuries to provide mechanical power for mills. Some dams represent significant achievements in the history of technology and engineering, or are important character-defining elements of historic areas. Yet, today, many of these dams no longer serve their originally intended purpose. Power is no longer generated from the majority of these small facilities, and most of the water-powered mills were abandoned or modified to use more modern power sources. Many dams are in varying stages of disrepair and in need of significant repair and maintenance to meet modern dam safety standards. Other dams are so dilapidated or have been so heavily modified or repeatedly replaced that they no longer retain their historical characteristics. While some dams continue to provide important societal benefits, such as hydropower, flood control, water supply, infrastructure support, or historical value, many others no longer provide the service for which they were constructed, but nevertheless remain in our rivers and streams. The placement, maintenance, and replacement of dams affect river flows, fish passage, and transportation upstream and down.

Dams also have had a tremendous impact on the ecology of our state's rivers and streams. Dams, big or small, generally impede the flow of water and obstruct the continuity of a riverine system. They also decrease oxygen levels in the water, obstruct the downstream movement of silt and nutrients, change river bottom characteristics, and alter the timing and quantity of river flow. Dams can cause river flow to slow down, allowing water temperatures to increase. This, in turn, can alter the fish populations living in streams or rivers. Also, many of the dams that are in a dilapidated condition and in need of repair are an economic burden on their owners. Dams can also be public safety hazards, causing sudden release of water to flow downstream thus causing flooding, bank erosion, property loss, and serious injury, and death. More and more dam owners are deciding that the cost and liability of owning an aging structure outweighs the benefits and are considering removing their structures. If managed well, removing a dam can benefit multiple interests by restoring ecosystem health, improving public safety, providing new recreational opportunities, and relieving a dam owner's economic burden.

However, evaluating infrastructure concerns, completing the best project for the environment, and navigating through the regulatory process, can make completing a dam removal project a daunting task for most project proponents. The Executive Office of Energy and Environmental Affairs (EOEEA), the Riverways Program in the Department of Fish & Game, and a multi-stakeholder task group of state and federal regulatory agencies, non-governmental organizations, and other river restoration practitioners, have collaborated in preparing this guidebook for dam removal project proponents to help organize and explain the process that goes into considering and implementing a dam removal project.

General Steps for Dam Removal

The following lists the general steps in a dam removal project. These steps are intended to be very general because every dam removal process will have site-specific engineering, environmental, and community issues that may cause the process to differ. In some cases, not all of these steps will be necessary. Evaluate each step presented here to determine if it is necessary for your project. Also, these steps do not always conform to a set order. For example, stakeholder and pre-permitting meetings may need to be held earlier in some cases.

Prior to considering removal of a dam, there are certain things that one must consider. Does the dam currently serve any purpose or provide any benefits, such as:

- Power generation;
- Flood control;
- Recreation from the impoundment such as fishing, boating, swimming, etc.;
- Water supply or irrigation;
- Road, rail, or other utility crossing;
- A significant historic structure with integrity of materials, important design or technology elements, or which contributes importantly to the historical setting and character of the site or the area.

If the answer to the above is no and the dam no longer performs its originally intended purpose then it may be ripe for removal. Conversely, if the owner of a dam is interested in removal of the structure or if maintenance of the dam in perpetuity for these purposes is expensive, the structure could be ripe for removal.

While different projects have different timeframes, in general, expect projects to take two-and-a-half to three years from conception to completion: Year one for planning, feasibility, and pre-permitting; Year two for engineering design and permitting; Year three for implementation.

The following are steps that would be required in a typical dam removal project.

1) Initial Reconnaissance – determine breadth and scope of project

- Determine approximate dam age and history of modifications
- Determine dam owner and point of contact
- Determine current uses and legal rights associated with the dam and impoundment
- Assess land ownership around the impoundment and the dam structure
- Identify potential infrastructure impacts: utilities, roads, bridges, etc.
- Determine if the dam, impoundment, or adjacent land are in rare species habitat based on Natural Heritage and Endangered Species Program maps
- Determine potential "hooks" for funding possibilities – particularly, will the dam removal restore passage and habitat for anadromous species or for sportfish
- Assess historical land use to gauge sediment quality
- Assess community interests/concerns associated with potential impacts to water supply, flooding, recreation, historic, habitat

2) Site Visit and Planning Meeting

- Conduct a site visit with project proponent, dam owner, local, state, and federal agencies to plan next steps

3) Fundraising (See Appendix A for details)

- Develop a fundraising strategy and a list of potential grant sources
- Gather letters of support
- Apply for funding

4) Feasibility Study – assess scientific and engineering challenges and conceptual approaches

- Collect existing data
- Survey and map the site to prepare scaled plans and elevation drawings showing existing conditions
- Assess sediment quantity, quality, and mobility
- Assess hydrology and hydraulics
- Develop conceptual plans for:
    - Removal or modification of structures
    - sediment management
    - channel and riparian habitat restoration
- Analyze other site-specific issues such as utilities, infrastructure, wetland impacts, rare or endangered species, known historic or archaeological sites
    - Determine if the dam, impoundment, or adjacent land includes properties in the Inventory of Historic and Archaeological Assets of the Commonwealth by conducting research at the office of the Massachusetts Historical Commission (MHC)
    - Consult with the local historical commission (and local historic district commission if the project is within a local historic district) for information about properties in the proposed project area that may be historic but not yet included in the MHC's Inventory, and to begin to consider any local historical values. [Note: Almost every town government in Massachusetts has a local historical commission; the local commission is not the same as the local historical society (which is usually a private, non-profit organization).]
- Determine which federal, state, and local permits will be required and complete calculations necessary for those permits
- Pre-project monitoring
    - Gather and measure pre-project information on water quality, geomorphology, and ecology
    - Photograph the site extensively
- Develop cost estimates
- Develop conceptual drawings of proposed project approaches

5) Working with the Community

- Stakeholder/community meeting(s)
    - Meet with abutters and other stakeholders to review alternatives and seek to obtain local support for a preferred alternative
    - Community visioning and planning
- Pre-permitting meeting(s)
    - Contact and if possible, meet with local, state, and federal planners and environmental regulators, dam safety officials, and local historical commission and local historic district commission to clarify and confirm regulatory review requirements if necessary, and any additional information requirements needed by the agencies.

6) Final Engineering Design

- Develop engineering design plans for the preferred alternative, which may propose modification, or dam removal and stream restoration
- Develop Project Specifications that specify necessary construction equipment, material specifications and quantities, project sequencing, staging areas, and site access
- Provide an Engineer's Cost Estimate for construction

7) Permitting

- File all regulatory permits
- Attend public hearings
- Address public and regulatory agency comments and permitting conditions

8) Project Implementation and Construction

- Hire contractors
- Drawdown impoundment
- Address impoundment sediments as necessary
- Remove dam structure
- Stream channel restoration
- Impoundment revegetation

The following pages describe many of the above steps in more detail.

Initial Reconnaissance

The initial reconnaissance phase is intended to determine the overall breadth of the project and the likely project challenges. At this phase, determine whether the project is simple and straightforward; or very complex, requiring such things as extensive community outreach, contaminated sediment remediation, and comprehensive environmental impact studies. Consider how each of the issues below will affect the cost and scale of the project.

Dam and Land Ownership

- Determine the date of construction and history of repairs and modifications of the dam through research and consultation with a civil engineer and other expert consultants. Sometimes historical engineering drawings can be located which can provide important information for project planning and design.
- If the dam owner is not the project proponent, determine the dam owner and, if necessary, a point of contact for the dam owner. This may sound like a simple step, but in some cases dams have been abandoned for decades or land owners do not realize that they own dams. If the dam owner does not express an interest in or objects to removal, or is not under a dam safety order to repair or remove the dam, then the project will be challenging or even impossible to complete. Many dam owners will express interest in dam removal due to economic, liability, or even environmental reasons. Some simply no longer want the long-term responsibility of repairing and maintaining their structure.
- Preliminarily assess land ownership around the impoundment and the dam structure. Dam impoundments with abutting residential backyards, public beaches, and motorboats will be much more challenging community outreach efforts than dam impoundments entirely under the ownership of one entity that is interested in removal.

Dam Uses

- Determine if the dam and impoundment are currently serving any purpose that will necessitate replacement of the use. Most dams in Massachusetts no longer serve the purpose for which they were designed, but many do provide important functions. Dams that provide water supply, hydropower, flood control, road, rail, or other utility crossing, are much less viable dam removal projects than those structures that do not provide these services. In some cases, these purposes can be replaced by other means. If the dam is a historically significant structure (for its important design or technology, or which contributes to the historical setting of the site or the area, but has not been so severely altered as to have lost its historical integrity), sensitive in-kind repair of the structure, or modifications that do not adversely affect its historical characteristics may be a feasible alternative to dam removal or replacement.

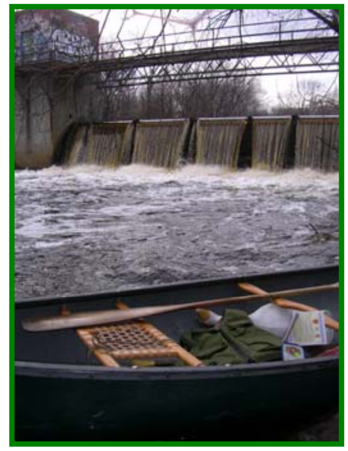
Infrastructure

- Identify any potential infrastructure that could be impacted by dam removal. For example, if bridges cross any portion of the impoundment or downstream of the dam, an assessment will need to be made of potential scour during the feasibility study. In some places, water and sewer pipes or telecommunication cables cross through dams or through the impoundment and alternatives will need to be assessed for protecting or moving them. Some dams are attached to mill buildings or retaining walls, requiring a stability assessment during the feasibility phase.

Rare Species

- Determine if the dam, impoundment, or adjacent land are in priority or estimated habitat for state listed species, based on maps published by the Natural Heritage & Endangered Species Program. If these habitats are present, projects can only proceed through close consultation with state and federal biologists.

Sediment Quality



- Preliminarily assess the potential for contaminants trapped behind the dam by considering current and past upstream land uses such as industrial activity and road density. Information on water and sediment quality in the river may also be available from past environmental studies. Analyzing a sediment sample may even be useful at this reconnaissance phase, to understand the breadth of the project if other assessments are insufficient to determine the probability of contamination. The sample should be taken from the fine-grained portion of the impounded sediment and analyzed at a lab for heavy metals and organic constituents. Sediment screening standards are available from the Department of Environmental Protection. The need for contaminant cleanup can significantly increase project complexity and cost.

Community Concerns

- Preliminarily assess potential community interests and concerns. Is the impoundment currently used for recreation? Is there an opportunity for a park or canoe access following dam removal? Is the dam structure an important historic resource for the site, neighborhood, or town? Have other parties expressed an interest in contributing to the long-term maintenance and liability of the dam structure?

Funding Possibilities

- Determine potential “hooks” for funding possibilities. Foundations and agencies that provide grants for river restoration and dam removal have different interests. Some provide funds for projects that help anadromous fish such as herring or salmon or for other sportfish such as trout. Others will provide funds for private landowners working to improve habitat on their land. Based on these “hooks” some projects can be almost entirely funded by outside sources, while others will receive very little outside funding. With overall project costs typically in the hundred thousands, this is a critical first step.

The Riverways Program at the Department of Fish and Game can help provide technical assistance for evaluating site-specific reconnaissance issues.

Feasibility Study

The feasibility study provides concept-level plans and quantitative information on environmental and engineering feasibility necessary to make final decisions on the project approach. The feasibility study can be extensive or minimal depending on the breadth of work identified during initial reconnaissance. In some cases, the feasibility study can be part of the final engineering design. In most cases, it is done separately to allow for changes that may be necessary after consulting with regulators.

In Massachusetts, feasibility studies have cost between $15,000 and $145,000. In the simplest cases, projects have proceeded directly to engineering design without a separate feasibility study. However, in most cases, local, state, and federal agencies will require a good-faith effort to consider project alternatives that would avoid, minimize, or mitigate environmental impacts, including a no-action alternative.

Selecting Effective Consultants

Typically feasibility studies are conducted by environmental consultants, and the choice of the consulting team is critical to project success. Because dams are in dynamic riverine environments and multidisciplinary issues such as sediment management, habitat restoration, and infrastructure protection must be addressed, a multidisciplinary consulting team is needed. There is always much more to a dam removal project than just removing a concrete structure. At a minimum, the consulting team must have expertise in engineering, environmental permitting, ecology, and fluvial geomorphology. This combination of skills is very rare in traditional environmental consulting and engineering firms. *Therefore, traditional engineering firms that lack some of these skills should expect to subconsult with a firm with specific river restoration experience or other required technical expertise*. An effective consulting team can greatly smooth the process, as regulators expect to see an understanding of all of these multidisciplinary issues in the analysis and design.

Scoping the Feasibility Study

The feasibility study typically includes analyses necessary to develop alternatives for removing the structure, protecting infrastructure, restoring instream and riparian habitat, and managing sediment. While every case is site-specific, below are some general items that are frequently included in the feasibility study scope of work. Note that not every step is necessary for every project and a site-specific evaluation must be completed:

1) **Data Collection.** Collect and synthesize all available existing data on the dam, the river, and the surrounding landscape. These could include archival records of local, state, and federal agencies for existing maps and plans, past dam inspection reports, FEMA flood mapping, air photos, historic maps and photographs, fisheries data, planning department reports, and utilities mapping.

2) **Survey and Base Mapping.** A site survey by a professional is necessary to create a scaled topographic base map showing existing conditions to provide information necessary to assess engineering conditions and deficiencies, hydraulics and sediment management. In order to completely survey the site, the surveying team must get in the water! The surveying should include:
    a. topographic plans and cross section drawings of the river and adjacent land, cultural (the dam, roadways, buildings, utilities, etc.) and geographic features in the impoundment, downstream and upstream,
    b. a survey of the deepest part of the stream through the impoundment, downstream, and upstream (longitudinal profile),
    c. a survey of the impoundment bottom and the depth of soft sediment throughout the impoundment (bathymetry and depth to refusal),

   d. a delineation and survey of the resource areas that will be affected as required in the Wetlands Protection Act and Army Corps of Engineers regulations, including: Land Under Water, Bordering Vegetated Wetland, Riverfront Area, Mean Annual High Water Line (or Ordinary High Water Line), and Bordering Land Subject to Flooding.

3) **Sediment Management Plan.** Quantitatively assess sediment quality and quantity. Develop a conceptual plan to manage sediment movement. Fundamental to this analysis is determining what portion of the sediment will transport downstream as a result of different management approaches. The consulting team must know how to complete this type of analysis and it is integral in the decision of who to hire for the work.

4) **Hydrology and Hydraulics Assessment**. Hydrology involves assessing the volume and frequency of flows in the river. Hydraulics involves assessing the velocity, scour potential, and depths of these flows. Assessing both is critical to determining how effectively the dam removal will allow for aquatic species passage; to assess potential flood impacts; and to assess potential impacts to surrounding infrastructure.

5) **Channel and Riparian Restoration Plan**. Assess alternatives for the structure and habitat within the stream channel and on exposed land in the former impoundment. This may include assessing whether the site will provide fish passage and should provide alternatives for habitat improvements.

6) **Fisheries**. Consult Division of Marine Fisheries when the dam removal involves an anadromous or catadromous fish run. Additionally, consult Mass Wildlife (Division of Fisheries and Wildlife**)** when the dam removal involves a coldwater fisheries resource or waterfowl breeding or feeding habitat; and in the Merrimack and Connecticut watersheds, when dam removal involves anadromous or catadromous fish runs.

7) **Preliminary Structure Removal Plan**. The final approach for removing the structure will be completed during the engineering design, but several issues should be considered during the feasibility phase as they can have a significant effect on the scope of the design. These include:

   a. assess the condition of the dam structure to determine safety concerns, potential demolition approaches, and whether there are usable gates or removable boards that can be used during the dam removal,
   b. assess access to the site and staging areas for construction equipment,
   c. assess site limitations, such as utilities or topographic constraints, and
   d. assess locations suitable for the disposal of dam rubble, as well as sediment removed from the site, if necessary.

8) **Pre-Project Monitoring.** The analysis done during the feasibility study should provide the baseline for future project monitoring. See the section on 'project monitoring' for more information.

9) **Site-Specific Conditions.** There are many additional site-specific conditions that may need to be evaluated during the feasibility study on a case-by-case basis. These could include:
   a. fish and wildlife habitat studies and wetland impact assessment,
   b. infrastructure protection plan – consider potential effects on utilities, bridges, culverts, retaining walls, wells, withdrawal pipes, etc.,
   c. assessment of replacing the current uses of the dam and impoundment,
   d. historic/archaeological assessment of the dam and surrounding area that may be affected by the project (use the MHC's Project Notification Form),

e. develop photo renderings of project alternatives as a tool if desired for community work (see section on community issues), and
f. develop recreation plan for parks, river walks, boating/fishing access.

10) **Permit Identification.** Determine which federal, state, and local permits will be required by assessing whether the project approach will exceed permitting thresholds. Complete the calculations and data collection necessary to fill out those permits.

11) **Technical Memorandum**. The Technical Memorandum should describe the above analysis. It should describe project alternatives to remove the dam, protect surrounding infrastructure, protect and restore wetland, riverine, and riparian habitat, and provide a recommended alternative.

12) **Conceptual Drawings**. Develop concept-level drawings of design alternatives for repairing, replacing, or removing structures and restoring the site. These concept-level drawings are often referred to as 10% design drawings.

13) **Cost Estimate.** Develop cost estimates to bring the recommended approach to completion, including costs of final design, permitting, construction and construction oversight. At this point in the process until the engineering design has been finalized, the cost estimate will be considered a 'probable cost' based on the consulting team's best judgment and past experience.

The Riverways Program at the Department of Fish and Game can provide sample scopes of work for dam removal feasibility studies and can assist with identifying issues to assess in your feasibility study.

Working with the Community

With more than 3,000 structures in Massachusetts, dams are a central part of many Massachusetts communities. Some are historic and scenic structures, and decisions surrounding dams often raise strong feelings about preserving a sense of place, and tangible connections to local history and the landscape. Many impoundments are used for recreation or simply provide a pleasing view for adjacent landowners. In some cases, communities will strongly oppose the notion of dam removal. In other cases, the community will have no interest in the dam at all. In still other cases, the surrounding community may support improved water quality and the return of fish runs and riverine recreational opportunities. Whatever the case, the importance of working with the local community should not be underestimated.

Community interest in the site should be assessed in the early stages of project conception. Based on this initial assessment, project proponents should develop a plan for community presentations and participation.

Public Participation

There are two primary ways to involve the community in dam removal projects: through mandatory regulatory hearings and through proactive public participation. If the community has an interest in the dam, then proactive approaches are critical to help the community understand and evaluate the changes that are proposed in the landscape. Having community members as active proponents of a dam removal will help ease the fear of change, will help create new community norms, and will smooth local decision making.

Even in cases where there is little community interest in a particular project, the local conservation commission will be involved as the first step in the regulatory process. Some conservation commissions do not often evaluate ecosystem restoration projects like dam removals, and therefore, may not have experience with permitting projects that restore the natural capacity of the ecosystem. Therefore project proponents should expect to present the ways that a well-managed dam removal can restore ecosystem health. The Riverways Program has realized success by involving conservation commissioners directly in project planning meetings. By inviting conservation commissioners to planning meetings, they have a stronger understanding of the project, the options that were considered, and the factors that comprise various project decisions.

Stream Teams. Forming a Stream Team around any local river issue is a great way to help community members gain a better understanding of river ecosystems and their needs. In turn, these new river advocates will lend a voice to river restoration. By looking at the river system as a whole, the Stream Team can help the community start a discussion about a vision for the stream and plan a long term strategy for restoration. The Riverways Program's Adopt-A-Stream Program can provide assistance with developing a Stream Team for your local stream.

Public Visioning

A sense of loss is inherent in the notion of dam removal - an object is being removed. But dam removal projects can also bring a great deal of gain in terms of new recreation opportunities, restored ecosystem health, and a renewed connection to a free-flowing river. With some creative community visioning, the fear of loss can be turned into a sense of gain.

Renderings. Renderings can take the form of drawings or digitally-altered photographs showing "before" and "after" images of the site. They can help the community gain a better vision for how the restored river will look when a dam is removed. Renderings have been successfully used in situations where there is apprehension about the "look" of the restored river or where different removal options are being considered.

Framing Effective Messages. While many river advocates care deeply about the river, the fish and the wildlife it supports, for others these are small concerns. The perception of an idea such as dam removal is more important than the actual science that backs it up. It is important to think about the perceived benefits of dam removal for your audience. For many communities, public safety and the financial burden of failing infrastructure present a strong economic argument for dam removal, while in other places historical, cultural, social, practical, or recreational interests may weigh in the decision of dam removal. It is also important that community visioning is led by someone from the community and not by state or federal agency staff who will be perceived as an outsider. Agency partners can provide valuable scientific backup and support, including producing renderings and talking about alternatives, but local decisions should be made by those who will be affected by the outcome.

A good initial exercise in planning a community outreach strategy is to write down perceived benefits and barriers as viewed by the community so that they can be adequately addressed. Barriers might include the perceived loss of property values, the loss of a pond and recreational amenity, or simply a fear of change. With every loss, there can be a real or perceived gain, such as increased fishing opportunities or increased recreational opportunities in the form of a new walking trail through the old impoundment. Using examples and case studies from other Massachusetts communities or from other states can also help create a sense that dam removal is becoming a community norm.

Below are some good resources to use when planning community outreach:

1. *Taking a Second Look: Communities and Dam Removal* – video produced by Trout Unlimited, American Rivers, River Alliance of Wisconsin, Natural Resources Council of Maine, and Atlantic Salmon Federation, in cooperation with the National Park Service, Rivers, Trails and Conservation Assistance Program.
2. *Relics and Rivers: Dismantling Dams in. New England* – video produced by the National Oceanic and Atmospheric Administration.
3. *Dam Removal: A Citizen's Guide to Restoring Rivers*, River Alliance of Wisconsin and Trout Unlimited.
4. *Dam Removal Success Stories: Restoring Rivers Through Selective Removal of Dams that Don't Make Sense*, 1999, American Rivers, Friends of the Earth and Trout Unlimited.

Final Engineering Design

The final design plans are the culmination of the feasibility analysis, project approach decision-making, stakeholder input, and regulator input. Engineering design plans and specifications should be completed in sufficient detail that a contractor can take the plans and complete the work. While that is the goal in terms of the level of detail, the designer should also be present on-site during construction to oversee the process. Just as with the feasibility study, the design team must be interdisciplinary to appropriately design all aspects of the project (see discussion in the feasibility study section on selecting effective consultants).

The design typically includes a set of drawings (the design plan), a set of detailed specifications, and a technical memorandum describing the analysis and approach.

Final engineering design has cost between $10,000 and $100,000 for Massachusetts projects.

Engineering Design Plan. The design drawings should show both dam removal and stream restoration plans. Plan sheets typically include base maps and drawings of:

- Existing site conditions
- Staging and access
- Removal plan
- Dewatering plan (sometimes completed by the contractor)
- Delineations of resource areas and resource protection treatments
- Proposed plan view
- Proposed cross sections
- Proposed longitudinal profile
- Erosion and sediment control treatments
- Infrastructure replacement/protection
- Habitat feature schematics

Project Specifications. The project specifications detail the construction work that will be completed. Typically specifications detail:

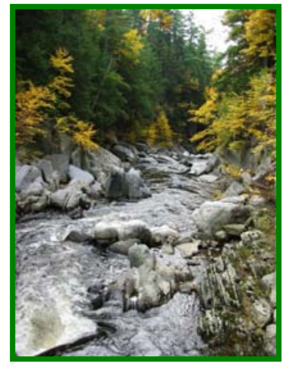
- Construction equipment needs
- Material specifications and quantities
- Project sequencing
- Staging area treatment
- Site access
- Dewatering
- Other site-specific details such as planting plans, traffic control, resource and infrastructure protection, etc.

Both the design plan and specifications should be stamped by a licensed Professional Engineer.

Technical Memorandum. The technical memorandum describes the analysis that goes into the design and details the rationale behind the project approach. If a technical memorandum is completed during the feasibility, this document may be nearly identical with revisions that were completed in the final design.

Cost Estimate. The design team should develop an itemized cost estimate based on the design and specifications. At this stage, the cost estimate is considered an Engineer's Opinion of Probable Cost based on the project specifications, until contractors bid on the project.

Permitting Dam Removal



Local, state, and federal agencies have authority over dams, including dam removal, and ecological restoration. Depending on the nature of the dam and the site-specific conditions, multiple permit applications may be required to remove a dam. Timing for each permit varies and some permits, once the application is submitted, can take up to 90 days for the agency to review. The more thoroughly prepared the feasibility analysis and permit application, the less time it takes to receive approval. Note that in some cases, regulators may require additional information during the permitting review process. It is advisable when submitting information for environmental review to send it by certified mail, return receipt requested, so that you know when it was received and by when to expect a response based on that agency's regulatory timeline for review and response.

Costs to prepare permits can vary widely depending on project complexity. If the work is entirely completed by consultants (including completing paperwork, filing forms, and attending hearings, meetings, and site visits) permitting can cost between a few thousand and a hundred thousand dollars depending on site-specific permit requirements. Many of the filings and hearings can be completed by the proponent at significant cost savings if so inclined. Most permit applications require payment of fees, although some of these fees can be waived if the applicant is a municipality or state agency.

Some general recommendations:

- Consult with and work cooperatively with regulatory agencies.
- Invite agency personnel to the site prior to beginning the permitting process.
- Maintain communication with permitting agencies and respond completely and accurately to their questions or comments.
- Plan sufficient time to complete all the necessary consultations and regulatory processes.

Permit Sequence

These are some general guidelines on the most likely steps that a proponent can follow to acquire all the permits required to remove a dam. This sequence is based on past experience. Detailed descriptions on each of the permits are outlined further below in the order they are listed here.

After completing the feasibility study and working through any issues with the local community, but prior to completing the final engineering, the following three determinations and filings should be made:

- Jurisdictional determination through a request letter to the Office of Dam Safety (ODS) at the Department of Conservation and Recreation (DCR)
- Project Notification Form (PNF) with the Massachusetts Historic Commission (MHC)
- Massachusetts Environmental Policy Act (MEPA) filing with an Environmental Notification Form – this would be necessary only if the ODS has deemed the dam to be jurisdictional or if other MEPA thresholds are triggered

Once the final engineering designs are complete, and the above determinations have been made, one or multiple of the following permits will be required. ***Note that not all the listed permits may be required at all dam removals; permits required will depend on the site-specific conditions***. Depending upon the size of the dam and degree of environmental impacts, the following applications for permits or certificates may be required. Typically, federal permit agencies require that state and local permits are filed first or receive approval before the federal permits and approvals. We recommend filing a Notice Of Intent with the local conservation commission as a first step. Also, depending on the site specific conditions, permits indicated with an asterix below can be filed concurrently; many of these permits contain the same information and filing them at the same time will help streamline the process and provide greater ease for the proponent.

1. Notice Of Intent (NOI) – One of the key permits at the local level is with the local conservation commission(s) (if a dam is in two separate communities then permit applications will need to be sent to each community). A filing of a NOI with the conservation commission in turn also alerts the MassDEP to the project. MassDEP then responds to the proponent outlining which specific MassDEP permits will be required.
2. MEPA- Environmental Impact Report (if applicable)
3. Massachusetts Endangered Species Act (MESA) (if applicable)*
4. 401 Water Quality Certificate (WQC)*
5. United States Army Corps of Engineers (USACE) 404*
6. Chapter 91 (if a full license is required all permits must be received before the issuance of this license)
7. Federal Consistency Review
8. National Pollutant Discharge Elimination System (NPDES)
9. Local Building or other Permits
10. Beneficial Use of Solid Waste Permit

The following is a description of all the permits in the sequence that they are listed above,

Department of Conservation and Recreation (DCR), **Office of Dam Safety**
Jurisdictional Determination Chapter 253 Permit Application
http://www.mass.gov/dcr/pe/damSafety/
DCR regulates structures that meet the definition of "dams" in 302 CMR 10.03 and MGL c.253, s. 44. Any entity proposing to construct, repair, materially alter, breach or remove a dam, must file with the DCR Commissioner a notice for jurisdictional determination. If the structure qualifies as a dam, then an application for a permit to remove the dam must be submitted.

Any structure which is twenty-five (25) feet or more in height, or has a maximum impounding capacity of 50 acre feet or more, is considered a dam by DCR. The height of a dam is measured from the natural bed of the stream or watercourse measured at the downstream toe of the barrier, or from the lowest elevation of the outside limit of the barrier, up to the maximum water storage elevation. Structures smaller than this may also be considered a dam by DCR if the department determines that it needs to regulate the dam for public safety reasons. Any structure which is less than six (6) feet in height, or has a maximum storage capacity that is less than fifteen (15) acre-feet, will usually not be considered a dam by DCR. However, DCR may decide to regulate these structures if there are public safety reasons. In its determinations, DCR looks at factors such as: height, type of structure, condition of structure, volume of impoundment, and extent of downstream development.

Massachusetts Historical Commission (MHC) - Chapter 254/MEPA/Section 106 review
http://www.sec.state.ma.us/mhc/mhcrevcom/revcomidx.htm
The goal of MHC's review and consultation process is to encourage avoiding, minimizing, or mitigating adverse effects to significant historic and archaeological resources. If important cultural resources may be affected by the project, then a process to locate, identify, evaluate, and avoid or mitigate adverse project effects will be initiated. Projects that require a State or Federal permit, funding, license, or approval, require Massachusetts Historical Commission review ("Chapter 254" review under 950 CMR 71).

A Project Notification Form (PNF) (http://www.sec.state.ma.us/mhc/mhcform/formidx.htm) should be completed and submitted to the MHC. The PNF submittal should include a USGS locus map with the boundaries of the project area of potential effect clearly indicated, scaled project plans and drawings showing existing and proposed conditions, and current photographs keyed to the plans. For projects that require an Environmental Notification Form (ENF), MEPA requires that a copy of the ENF be sent to the MHC. The USACE also requires that a copy of their permit application be mailed to MHC for review. MHC may require supplemental information, and will only comment in writing, by regular mail.

Massachusetts Environmental Policy Act (MEPA)
http://www.mass.gov/envir/mepa/
MEPA review is required for projects that exceed the regulatory thresholds listed at 301 CMR 11.03 (http://www.mass.gov/envir/mepa/thirdlevelpages/meparegulations/meparegulations.htm). If the dam to be removed is jurisdictional (i.e. as determined by DCR-Office of Dam Safety - an applicant is recommend to file a jurisdictional determination permit application under Office of Dam Safety Chapter 253 to determine MEPA eligibility; alter one or more acres of salt marsh or bordering vegetated wetlands (bvw); ***or*** would endanger property or safety if they fail) and if structural alteration of the dam causes any decrease in impoundment capacity it would require an Environmental Notification Form and an Environmental Impact Report (EIR). (Note that other thresholds related to dams may also apply, depending on the specific activity proposed.) The requirement to prepare an EIR may be waived by the Secretary on the grounds that: 1) preparation of an EIR would result in an undue hardship for the proponent; 2) preparation of an EIR would not serve to avoid or minimize damage to the environment; 3) the project is not likely to cause damage to the environment; and 4) existing infrastructure exists to support the project. Proponents for dam removal projects should consult with the MEPA office early in the planning process to determine whether MEPA review is required, and if so, how the filing can be used to coordinate overall state agency review of the proposed activity, including any waiver request.

Notice of Intent with local Conservation Commission - Wetlands Protection Act
http://www.mass.gov/dep/water/approvals/wwforms.htm
The Wetlands Protection Act is administered by the local conservation commission with support from the Massachusetts Department of Environmental Protection (MassDEP). All dam removal applicants should file a Notice of Intent (NOI) under the Wetlands Protection Act with their local Conservation Commissions. Filing a NOI requires abutter notification, a posting in the local paper, payment of a fee and an appearance at one or multiple public hearing(s). All resource areas must be clearly demarcated on the plan and wetlands flagged in the field. The plan must also include calculations of area impacts to resource areas. Dam removals are often considered limited projects under 310 CMR, 10.53(4) and therefore are a permissible activity under the Wetlands Protection Act. Please refer to the guidance document prepared by DEP to assist local conservation commission in interpretation of this limited project provision.

A proponent may also need to comply with a local wetland protection bylaw (town) or ordinance (city). Check with your local conservation commission to determine if a local wetland law exists, what application forms are required, and what the process is for receiving a permit or approval.

Massachusetts Endangered Species Act (MESA) - Natural Heritage and Endangered Species Program (NHESP) http://www.mass.gov/dfwele/dfw/nhesp/nhenvmesa.htm
The Massachusetts Endangered Species Act (MESA) M.G.L. c.131A and regulations 321 CMR 10.00 protect state listed species and their habitats by prohibiting the "Take" of any plant or animal species listed as Endangered, Threatened, or of Special Concern by the MA Division of Fisheries & Wildlife. A "Take" includes protection of state listed species habitat, and is defined as, "in references to animals to harass, harm, pursue, hunt, shoot, hound, kill, trap, capture, collect, process, disrupt the nesting, breeding, feeding or migratory activity or attempt to engage in any such conduct, or to assist such conduct; and in reference to plants, it means to collect, pick, kill, transplant, cut or process or attempt to engage or to assist in any such conduct. Disruption of nesting, breeding, feeding or migratory activity may result from, but is not limited to, the modification, degradation or destruction of Habitat." Permits for taking state listed species in priority or estimated habitats for scientific, educational, conservation, or management purposes are subject to review.

Note: If a project falls within Priority Habitat of Rare Species and does not meet the MESA filing exemptions, proponents must file with the NHESP. Priority Habitat is defined as "the geographic extent of Habitat for state-listed species" as delineated by the Division pursuant to 321 CMR 10.12. There are three types of filings under MESA - MESA Information Request for rare species information, MESA Project Review, and the Application for a Conservation and Management Permit.

401 Water Quality Certificate - Massachusetts Department of Environmental Protection
http://www.mass.gov/dep/water/approvals/wwforms.htm
This Certificate is applicable for projects which involve filling or dredging of areas covered by the Clean Water Act, including Land Under Water and Wetlands. Most dam removal or breaching projects will involve these activities. Any project which must obtain a Section 404 permit from the Army Corps of Engineers (USACE) must also obtain a 401 Water Quality Certification. The Notice of Intent under the Wetland Protection Act serves to notify the state and MassDEP will indicate through this process if a 401 is required.

Note: The permit requires plans and information on dredge amounts and impacts. A 401 Water Quality Certificate (WQC) for dredging (BRP WW 07,08 Dredging) is classified into major and minor project based on whether or not the project will dredge more or less than 5,000 cubic yards. Projects that dredge less than 100 cubic yards may not require a certificate. Sediment quality testing is required if a certain percentage of excavated sediments is fine grain material (see MassDEP guidance for further details). The WQC has a 21-day comment period. Along with the WQC application package an applicant can publish the Chapter 91 notice (Chapter 91 Waterways License - see below). Additionally, the Chapter 91 permit plans can be used for the WQC application - specifications of both permit applications are similar (water levels, dredge elevations, cross-sections, etc.).

US Army Corps of Engineers - Section 404 of the Clean Water Act and Section 10 of Rivers and Harbors Act of 1899
Any discharge of dredged or fill material into waters of the United States requires a permit from USACE. Any work conducted in navigable waters comes under Section 10 jurisdiction and hence requires USACE approval. A USACE permit review includes consultation with the State Historic Preservation Officer, and Federally recognized Native American Tribes, CZM Federal consistency concurrence (see below), and MassDEP Section 401 Water Quality Certification (see above) in addition to coordination with federal resource agencies.

Note: The USACE application form and plan requirements, and the Programmatic General Permit (for expedited review of minimal impact projects) are available on the USACE website at http://www.nae.usace.army.mil/reg. Typically the USACE requires permit plans to be 8 ½" x 11" but for projects which can be authorized through the Programmatic General Permit a copy of the Chapter 91 or Water Quality Certification application is acceptable if the plans show the federal jurisdictional limits such as wetlands, and ordinary high water or high tide line and mean high water in tidally influenced areas.

Chapter 91 Waterways License - MassDEP
http://www.mass.gov/dep/water/approvals/wwforms.htm
Chapter 91 regulates activities in navigable waterways of the Commonwealth, and approval from this program is required if dredging is involved, even if the dredging will ultimately benefit navigation. Most perennial rivers and streams in the state are considered navigable.

For the most part dam removal does not need a Chapter 91 license [310 CMR 9.05(3)(m) and 310 CMR 9.22(1)] if no dredging is proposed. Proponents will simply be required to notify and seek a written approval, from MassDEP, of the dam removal. This should be done through a letter that includes the following information,
- geographical context of the dam
- the name of the river and municipality where it is located
- the precise location of the structure
- whether it is an authorized structure
- whether there are docks/piers or boat ramps in the upstream impoundment that could be affected
- description of the dam/previously authorized structure, i.e. size, height
- description of proposed removal

If dredging is involved in the removal of the dam, a Chapter 91 dredging permit is required. Dredging work can be completed under a simplified application with local planning board and building inspector notification. An applicant can publish the Chapter 91 notice along with the Water Quality Certification application package (401 permit - see above). Additionally, the Chapter 91 permit plans can be used for the WQC application - specifications of both permit applications are similar (water levels, dredge elevations, cross-sections, etc.). The Chapter 91 dredge permit has a 15- day comment period. Municipal sign off in the form of an Order of Conditions is required.

Federal Consistency Review - Massachusetts Coastal Zone Management (MCZM)
http://www.mass.gov/czm/fcr.htm
In projects where the removal of a dam is proposed in the Massachusetts coastal zone, federal consistency review from the Office of Coastal Zone Management (CZM) is required. Federal consistency review is the process required under the national Coastal Zone Management Act and federal regulations (15 CFR 930), that allows states with federally–approved Coastal Program Plans to review federal actions, licenses and permits (and other specific activities such as Outer Continental Shelf leases) to ensure that these actions, licenses and permits are consistent with state enforceable policies. For those proposals found to be within the Massachusetts Coastal Zone or affecting the Coastal Zone, the next consideration is whether any federal permits are required. If so, then federal consistency review by the CZM office is necessary. See Appendix D for a full description of this process.

National Pollutant Discharge Elimination System (NPDES) - Environmental Protection Agency
http://cfpub.epa.gov/npdes/stateinfo.cfm?&view=region&region_id=1
A NPDES Permit is required for discharges from large-scale construction sites, including clearing, grading, and excavation activities.

Local Building and Other Permits
A building permit application is often available at the city, town hall, or municipal website. Otherwise, an applicant should contact the municipality's building inspector to obtain an application and inquire as to whether a building permit is required. Other local permits may be required such as a site plan review permit from the planning board, or a Certificate of Appropriateness from the local historic district commission if the project is in a local historic district. The local building inspector usually serves as the zoning code enforcement officer and should be consulted for other applicable municipal permits.

Beneficial Use of Solid Waste Permit - MassDEP
Materials from a dam can be reused for bank stabilization or for on-site use. If the materials consist of uncontaminated earthen material only, rock and soil, they can be reused without any solid waste permit approvals. Be aware that other requirements may apply to the reuse of soil materials such as the Massachusetts Contingency Plan, 310 CMR 40.000. Reuse of materials from dams made of concrete, bricks or other masonry materials are subject to regulation under 310 CMR 16.05(3)(e) "Asphalt, Brick and Concrete Recycling Operations" (http://www.mass.gov/dep/recycle/laws/regulati.htm#sw) and the policy "Guide to Regulations for Using or Processing Asphalt, Brick & Concrete Rubble**"** (http://www.mass.gov/dep/recycle/laws/abc.htm). The regulation provides an exemption from solid waste permitting if the reuse is in accordance with the conditions of the exemption. However, if these conditions cannot be met a Beneficial Use Determination (BUD) permit will be required for the intended reuse.

Some key conditions of the exemption include:
- The concrete must be "clean", i.e. it cannot be painted or otherwise coated or contaminated.
- Concrete must be reduced to 6 inch size or less.
- Rebar must be removed.
- MassDEP must be notified 30 days before the concrete crushing begins.

Project Implementation and Construction

Construction is most commonly bid out to qualified contractors. In some cases, town departments of public works or partnering corporations have qualified personnel and the appropriate equipment to complete some or all of the work. Regardless of who is driving the construction equipment, project construction should be overseen by the same team that designs the project. There is a small, but growing, number of contractors that have experience with habitat restoration projects and many of the nuances of infrastructure protection and habitat construction must be relayed on-site during construction. The specific permitting conditions must be adhered to rigorously as there are significant penalties for violation of local, state, and federal permits.

Construction has cost between $35,000 and $290,000 for Massachusetts projects.

While this document is not intended to guide the scientific and engineering aspects of dam removal, some key points to consider during the design and construction phase of projects include:

- The entire vertical extent of the dam structure should be removed from the stream. Rivers are dynamic systems and any solid concrete structure that is left in the bed of a river can eventually become a barrier again as river flows cause scour on the downstream side over time. In some cases, side abutments are left in place. In these cases, the hydraulics should be carefully modeled to ensure that the remaining abutments do not create a constriction and ultimately scour and cause high flow velocities.
- To effectively restore habitat, simulate natural portions of the surrounding stream or other nearby healthy streams to the extent possible. For example, if the stream channel upstream of the impoundment has a slight slope and the channel downstream of the dam has a slight slope, then as a general rule, the restored channel through the removed dam should not have a steep slope. However, this needs to be specifically evaluated on a case by case basis, as some dams are built on steep sections that differ from the surrounding stream, but simulating the surrounding stream is a good general rule as a starting point. Simulating the surrounding stream will allow whatever species that make use of the more natural sections of the stream to also make use of the restored sections.
- Remember, good habitat is diverse! Aquatic species need a range of complex habitats at different times in the season and for different life stages. Depending on the site, these habitats are provided by extensive streamside vegetation and complex instream features such as large wood and stream bed variation.
- Slowly draining the impoundment during dam removal:
    - Reduces the release of sediment downstream
    - Allows the bed of the impoundment and stream to drain and stabilize
    - Prevents a sudden release of water which could unnecessarily damage downstream infrastructure and/or habitat

  This can be accomplished by gradually removing boards from the control structure; slowly opening a low-level outlet if one exists; or by cutting incremental breaches into the dam structure and letting the water level lower after each increment.

- Carefully consider the need to proactively revegetate land that is exposed by the dam removal. While the Massachusetts environment is extremely effective at growing vegetation, often the first species that take root in exposed land are non-native or invasive.
- Project evaluation should initially be completed by the contractor and construction manager immediately following project completion. However, the project proponent should also complete regular project walk-throughs of the site. The proponent can develop a checklist of issues to visually inspect with the assistance of the project design team. The checklist might include a visual assessment of vegetation growth, erosion, and scour around infrastructure, such as pipes, retaining walls, and abutments.

Appendix A: Frequently Asked Questions

What will the restored river look like?
The river channel that re-forms or is actively restored after a dam is removed will be a similar size and shape as the river upstream and downstream of the former impoundment. Sometimes the general shape of the old river channel can be seen in underwater patterns if you look at an aerial photograph of the impoundment. Some dams were built to increase the water level in a natural lake or pond and that natural lake will be restored after dam removal. Changes to the landscape will be more or less dramatic depending on the size of the structure, its purpose and the size and shape of the impoundment. Riverways has worked with citizen groups and engineers to create renderings of what the restored river channel will look like under different removal scenarios. These renderings can help the community to understand the process and make decisions about removal options.

Will there be an increase in flooding?
Only a small percentage of dams provide flood control benefits and those dams were expressly built for that purpose. Most dams do not significantly affect or control downstream flooding and therefore their removal will not cause a significant change in flooding downstream. In some cases, dam removal can actually decrease flooding upstream of the dam, and can eliminate a downstream hazard by removing the potential for a catastrophic breach of the structure.

How long will it take the impoundment to revegetate?
Depending on the time of year, revegetation of the sediment behind a dam begins within weeks of exposure to sunlight. It is important to keep an eye on invasive plants such as purple loosestrife during the first growing season, so that native plants can grow and out-compete unwanted species. A management plan may need to be developed in case on invasive species. Riverways has several before and after photos of dam removal sites that give a good indication of the rate of plant growth in impoundments.

What happens to the fish and wildlife that were in the impoundment?
Dams create artificial habitat by impounding water and altering river function. Impoundments trap sediment and create stagnant conditions with warmer water than the rest of the river system. Generally, much of the wildlife that uses an impoundment such as birds and turtles will quickly adapt to restored river conditions. Rivers typically provide more habitat variety and conditions for native species. Fish will be able to move upstream and make use of the full river for their life cycle. The restored river may also help bring back cold water fisheries such as trout, and will allow anadromous fish such as Atlantic salmon, smelt and river herring to use the river for spawning. While the fishery will certainly change, a greater variety of fish and fishing opportunities is likely to result.

What about all the sediment behind the dam?
One of the first steps for assessing dam removal feasibility is to assess the quality and amount of sediment behind a dam. If the sediment is contaminated, precautions will be necessary for removal and disposal or in-situ capping. Dredging of sediment is not always necessary during a dam removal and not all sediment that was trapped by the dam will flush downstream during removal. Typically a combined approach is taken of removing some sediment and stabilizing the rest through active revegetation and bioengineering. Sediment impacts below the dam are generally temporary and the river quickly readjusts to its new configuration. Bioengineering and stream channel reconstruction can help stabilize sediments in the former impoundment.

Will there be wetland impacts?
The wetland habitat behind a dam will change when the dam is removed. Depending on the surrounding topography, deep water marsh may become shallow marsh or wet meadow. Habitats such as red maple swamp may return. Rivers are also wetlands, and riparian areas have important habitat functions. While the total wetland area may change, the function of the natural ecosystem will be improved. Usually wetlands

above a dam are not self-sustaining (they are sustained by a human-made structure that must be maintained) and will gradually fill with sediment over time.

What if the owner just breaches the dam?

A dam owner may be required by the Office of Dam Safety to open their gates, breach or lower their dam for safety reasons. This action removes the pressure from impounded water on the dam structure to prevent a catastrophic failure. Many dam owners may not have the financial means to fully remove a structure and will leave the structure in the stream. Open gates can clog with debris and water can re-impound behind the structure creating an unstable habitat and safety concerns.

Breached structures can also continue to be passage barriers to fish, especially at low flows, and do not allow for full channel recovery above the dam. A better option is to fully remove the vertical extent of the structure and fully restore the channel and its banks as a natural system. Citizens should encourage dam owners to proactively deal with their dams before emergency situations arise so that the community has a chance to participate in the decision process.

Who will own the exposed land?

Because many dams were constructed by mill owners centuries ago, sorting out property ownership is not an easy task. A mill owner may have owned a dam and/or mill pond miles from the mill itself, and deeds for the dam may not always be attached to surrounding properties. Deeds and titles for the specific dam and/or legislative acts that provide for creating reservoirs will often show who owns the impoundment and the land under the water, and often this might be the municipality, especially if it is a municipally owned dam. Whether or not abutters have rights to the newly exposed land is something that would have to be sorted out on a case by case basis.

What about property values?

While the loss of one type of recreational and scenic resource may decrease value to some, to others, the restored river, improved water quality, and added open space increases the value of the site. Preliminary studies are showing that property values in some cases may actually increase long-term following dam removal, but every case is site-specific.

Will removal of the dam affect important historic or archaeological resources?

Some dams and their associated historic or archaeological resources (such as water-powered mills with stone-lined raceways and waterwheel pits etc.) are historically significant examples of colonial and early industrial development, have innovative technology or engineering, or were built as part of designed cultural landscapes (such as parks). Sometimes ancient Native American sites or early historic sites are present in a dam removal project area, and could be inadvertently affected by the activities and consequences of these projects. . If a dam proposed for removal is historically significant, alternatives to removal should be considered, such as repair of deteriorated elements, or modifications to the structure that are sensitive to the original construction. Some historic dams are so dilapidated or so heavily modified as to no longer retain their historical appearance or original design and function. Removal of dams that have lost their "historical integrity" is less problematic (and may be less controversial in the local community) than projects that adversely affect important cultural resources. Nevertheless, when there is no prudent and feasible alternative to removal, the history of historic dams can be appreciated thorough documentary and archaeological research, the preparation of archival documentation, and conveyed through interpretive signage, interpretive publications prepared for the general public, or other "mitigation" strategies that benefits the interested public.

Is there money available to help remove the dam?

There are several sources of federal and other funding available for dam removal, depending on the amount and type of habitat being restored. Rivers are seen as a public resource and especially where at-risk species such as Atlantic salmon are concerned, there are many parties interested in seeing habitat restoration.

Appendix B: Funding Sources for Dam Removal

Dam removal projects often require a combination of different funding sources to piece together all of the necessary funding. Funders are more likely to fund projects with multiple partners, strong state support, and effectively completed initial assessments. Each funding source has different interests and project proponents need to determine which funding sources best fits your project's goals. Also, project proponents should carefully consider funding deadlines relative to the project schedule, as many funders have a time limit on using their funds.

Project proponents should not enter into a project with the expectation that the project will be free to them through the available funding sources. Most funders require matching contributions and are more likely to fund projects with a contributing owner. To date, dam removal projects in Massachusetts have ranged from $50,000 to $400,000 in total costs. The Riverways Program can provide assistance with determining which funding possibilities may apply to your project.

National Sources

Open Rivers Initiative (NOAA)
http://conservationconference.noaa.gov/case/open_river.html
http://www.fedgrants.gov/Applicants/DOC/NOAA/GMC/NMFS-HCPO-2006-2000405/Grant.html
NOAA oversees a competitive grant program focused on community-driven, small dam and river barrier removals in coastal states to help repair vital riverine ecosystems, to benefit communities, and to enhance populations of key trust species. Funding range: $50,000-$250,000.

Gulf of Maine Council/ NOAA Partnership Habitat Restoration Grants
http://restoration.gulfofmaine.org/
The Gulf of Maine Council for the Marine Environment partners with NOAA to fund marine and anadromous fish habitat restoration projects around the Gulf of Maine. Typical Funding Range: $25,000-$75,000.

NOAA Community-Based Habitat Restoration Project Grants
http://www.nmfs.noaa.gov/habitat/restoration/projects_programs/crp/partners_funding/callforprojects.html
The program invites the public to submit proposals for available funding to implement grass-roots habitat restoration projects that will benefit living marine resources, including diadromous fish, under the NOAA Community-based Restoration Program. Funding range: $50,000-$200,000, October deadline. Funded Silk Mill dam removal in Becket.

NOAA/Ocean Trust/National Fisheries Institute
http://www.nmfs.noaa.gov/habitat/restoration/projects_programs/crp/partners/otnfi.html
NOAA partners with Ocean Trust to fund habitat restoration projects that enhance living marine resources around the coastal U.S. The applicant must be an individual, association or company in the fish and seafood industry. Funding range: $5,000-$20,000.

The Nature Conservancy/NOAA Habitat Restoration Partnership
http://nature.org/initiatives/marine/strategies/art9023.html
NOAA partners with The Nature Conservancy (TNC) to fund marine and anadromous fish habitat restoration projects around the coastal U.S. The applicant must be a TNC local chapter. Organizations that have project ideas should contact their local TNC chapter to discuss forming a partnership to apply for project funds under this request for proposals. Funding Range: $25,000-$85,000.

Trout Unlimited/NOAA Partnership
http://www.nmfs.noaa.gov/habitat/restoration/projects_programs/crp/partners/troutunlimited.html

Provides matching grants that require 1:1 match from a non-federal source or sources. Typical awards are from $10,000 to $100,000, and can cover any aspect of a habitat restoration project, including construction, engineering, planning, or outreach. There is no formal application process. Project must be sponsored by a TU chapter or State Council, or by TU staff.

American Rivers/NOAA Community-Based Restoration
http://www.nmfs.noaa.gov/habitat/restoration/projects_programs/crp/partners/americanrivers.html
NOAA partners with American Rivers to fund voluntary dam removal and fish passage projects. Funding range: $5,000-$25,000. Funded Robbins Dam removal in Plymouth/Wareham.

FishAmerica Foundation/NOAA
http://www.fishamerica.org/faf/projects/noaa.html
FishAmerica, in partnership with the NOAA Restoration Center provides funding for on-the-ground, community-based projects to restore habitat for marine and diadromous fish in the United States. Funding Range: $5,000-$50,000. Funded Billington Street dam removal in Plymouth

National Fish Passage Program (U.S. Fish and Wildlife Service)
http://www.fws.gov/fisheries/FWSMA/FishPassage/fpprgs/GetInvolved.htm
The U.S. Fish and Wildlife Service's National Fish Passage Program is a non-regulatory program that provides funding and technical assistance toward removing or bypassing barriers to fish movement. Contact: Region 5 – Northeast Dave Perkins 413/253-8405, David_Perkins@fws.gov

U.S. Fish and Wildlife Service Partners
http://www.fws.gov/partners/
The U.S. Fish and Wildlife Service's Partners for Fish and Wildlife program offers technical and financial assistance to private (non-federal) landowners to voluntarily restore wetlands and other fish and wildlife habitats on their land. Restoration projects include reestablishing fish passage for migratory fish by removing barriers (dams) to movement. Funded Silk Mill dam removal in Becket

National Fish Habitat Initiative Brook Trout Habitat Restoration Program
www.fishhabitat.org
NFHI is a nationwide strategy that harnesses the energies, expertise and existing partnerships of state and federal agencies and conservation organizations. The goal is to focus national attention and resources on common priorities to improve aquatic habitat health.

General Matching Grant Program (National Fish and Wildlife Foundation)
http://www.nfwf.org/guidelines.cfm
The National Fish and Wildlife Foundation operates a conservation grants program that awards matching grants to projects that: address priority actions promoting fish and wildlife conservation and the habitats on which they depend; work proactively to involve other conservation and community interests; leverage available funding; and evaluate project outcomes. Funding Range: $10,000-$150,000.
Funded Billington Street dam removal in Plymouth, and Silk Mill dam removal in Becket

Conservation Law Foundation/ NOAA Partnership
http://www.clf.org/programs/cases.asp?id=531
CLF launched this program to distribute funds for estuary restoration projects to communities in the Gulf of Maine. Typical Funding levels between $10,000.00 – 50,000.00

Wildlife Habitat Improvement Program (Natural Resources Conservation Service)
http://www.nrcs.usda.gov/programs/whip/
Funding awarded to projects that work to establish and improve fish and wildlife habitat. Contact local USDA Service Center for more information. Funded Billington Street dam removal in Plymouth

Corporate Wetlands Restoration Partnership (CWRP)
http://www.coastalamerica.gov/text/cwrp.html
CWRP leverages the collective resources, skills and processes of the private and public sectors through dam removal and river projects such as fill removal, channel clearing and enlarging, fish passage construction, and replanting. Funding pending Ballou dam removal in Becket.

U.S. Army Corps of Engineers
http://www.nae.usace.army.mil/pservices/206.htm
Aquatic Ecosystem Restoration – Section 206, Water Resources Development Act of 1996. Funds from this program can be utilized to remove lowhead dams as a way to improve water quality and fish and wildlife habitat. This funding source is listed under the Continuing Authorities Program.

Wildlife Restoration Act (Pittman-Robertson Act) Dept. of Interior-Fish and Wildlife Service
http://federalasst.fws.gov/wr/fawr.html
The purpose of this Act was to provide funding for the selection, restoration, rehabilitation and improvement of wildlife habitat, wildlife management research, and the distribution of information produced by the projects. Contact: The Division of Federal Assistance, FederalAid@fws.gov

National Trust for Historic Preservation Northeast Office
Provides several grant programs for maintenance and preservation of significant historic properties.
Brent_Leggs@nthp.org

State Sources

Funding for dam removal in Massachusetts is determined on a case by case basis. Interested proponents should consult with the Riverways Program's River Restore.
http://www.mass.gov/dfwele/river/programs/riverrestore/riverrestore.htm

Local Sources

Funding for fish passage and dam removal on municipal owned land may be funded through the Community Preservation Act (CPA). Check with your local planning department or Conservation Commission, or contact the Community Preservation Coalition.
http://www.communitypreservation.org

Private Sources

Some private sources, such as family foundations or corporate foundations, have funded dam removals in other parts of the country and may have an interest in funding habitat restoration projects.

Additional References

American Rivers' Paying for Dam Removal: A Guide to Selected Funding Sources
http://www.americanrivers.org/site/DocServer/pdr-color.pdf?docID=727

EPA Catalog of Funding Sources for Watershed Protection
http://www.epa.gov/owow/funding.html

River Alliance of Wisconsin's list of resources (scroll down to view Private funders):
http://www.wisconsinrivers.org/index.php?page=content&mode=view&id=8

River Network list of Funding Sources
http://www.rivernetwork.org/library/index.cfm?doc_id=114

Appendix C: Finding Additional Assistance

For more information, contact the Riverways Program at 617-626-1540.

Through a competitive application process, the Riverways Program will provide more extensive technical assistance and in some cases funding for some projects based on habitat restoration priorities. For more information, see Riverways Priority Projects at http://www.mass.gov/dfwele/river/programs/stream/index.htm.

Other partners who provide on-the-ground assistance with dam removals in Massachusetts include:

1. NOAA Restoration Center, http://www.nmfs.noaa.gov/habitat/restoration/
2. US Fish & Wildlife Service Partners for Fish & Wildlife, http://ecos.fws.gov/partners/viewContent.do?viewPage=home
3. American Rivers, http://www.americanrivers.org/site/PageServer?pagename=AMR_Dam_Removal

In addition, the national Dam Removal Clearinghouse provides a wealth of additional information and project examples from around the country: http://www.lib.berkeley.edu/WRCA/damremoval/index.html

Appendix D: Federal Consistency Review

In projects where the removal of a dam is proposed in the Massachusetts coastal zone, the following considerations should be taken into account relative to the Office of Coastal Zone Management (CZM) federal consistency review. Federal consistency review is the process required under the national Coastal Zone Management Act and federal regulations (15 CFR 930), that allows states with federally–approved Coastal Program Plans to review federal actions, licenses and permits (and other specific other activities such as Outer Continental Shelf leases) to ensure that these actions, licenses and permits are consistent with state enforceable policies. The Massachusetts enforceable policies can be found at: http://www.mass.gov/czm/policies.htm.

Coastal Zone Boundary

An applicant should first determine whether a proposal is located within the defined Massachusetts Coastal Zone. While the entirety of the twenty-three communities on Cape Cod, Martha's Vineyard, Nantucket and the Elizabeth Islands are included within the boundary, in most cases only portions of the remaining coastal towns are. A written description of this boundary can be found at 301 CMR 21.99, or in the Massachusetts GIS files. Interested parties are also encouraged to contact the CZM Project Review Coordinator by telephone or at the address below for further assistance in making this initial determination.

Federal License or Permit In or Affecting the Mass Coastal Zone

For those proposals found to be within the Massachusetts Coastal Zone or affecting the Coastal Zone, the next consideration is whether any of the permits listed below are required. If so, then federal consistency review by the CZM office is required.

Listed Permits:

1. Army Corps of Engineers:
   - Federal Water Pollution Control Act section 404 permit for the discharge of dredged or fill materials in navigable waters
   - River and Harbor Act section 10 permit for obstruction or alteration of navigable waters, or section 11 permit for establishment of harbor lines
   - Outer Continental Shelf Lands Act section 4(f) permit for artificial islands, installations or other devices permanently or temporarily attached to the seabed of the OCS
   - Marine Protection, Research and Sanctuaries Act section 103 permit for transportation of dredged material for the purposes of dumping in ocean waters

2. Department of Commerce:
   - Marine Protection, Research and Sanctuaries Act section 304(b) approval of activities affecting marine sanctuaries

3. Department of Interior:
   - Outer Continental Shelf Lands Act section 5(e) granting rights of way for oil and gas pipelines in the OCS
   - Endangered Species Act section 10 permits

4. Department of Transportation:
   - Deep Water Ports Act section 4 license
   - River and Harbor Act section 9 permit for construction or modification of bridge structures across navigable waters
   - Regattas and Marine Parade permits

5. Environmental Protection Agency:
   - Federal Water Pollution Control Act sections 402 NPDES; 404 ocean dumping authorizations; and, 102 and 104 ocean dumping permits issued in conjunction with the ACOE

6. Nuclear Regulatory Commission:
   - Energy Reorganization Act section 102 license for construction and operation of nuclear power plants

Unlisted Activities:
In addition to those licenses or permits listed above, activities that CZM believes will likely affect the land or water uses or resources of the Mass Coastal Zone may also be subject to review with approval from NOAA.

Review Procedures

For projects subject to review an applicant must provide CZM with:

- a federal consistency certification that includes:
    - a brief of that statement in light of each of our program policies
    - a copy of the federal permit application or, in the case of an NPDES permit application, a copy of the draft permit
    - a copy of the final Secretarial Certificate if MEPA has jurisdiction
- and, any additional information specified in the Program Plan or program policies as necessary for the evaluation of the proposed activity

Following receipt of the consistency certification by CZM:

- The review period begins immediately upon conclusion of a completeness determination by CZM
- CZM concurrence with the certification may be presumed if CZM does not issue or request an extension within 6 months from the beginning of the review
- There is a required 21 day public comment period during the review period
- At three months into the review period CZM must inform the applicant of the status of the review if it is not yet complete
- Prior to the six month deadline the review may be extended to a date-certain by mutual agreement with the applicant

Note: CZM may not issue a concurrence until all required state licenses permits or certifications are received.

Objections to Consistency Certifications

CZM may object to a federal consistency certification if applicable state authorizations are not received by the close of the six-month review period (unless extended by agreement), or the proposed activity is deemed to be inconsistent with the program policies. In these cases CZM must notify the applicant, the relevant federal permitting agency(ies) and the Director of NOAA’s Office of Ocean and Coastal Resource Management of its objection. Such notification must include a description of how the project is inconsistent with the specific enforceable policies, and may describe alternative measures (if they exist) which, if adopted by the applicant may permit the proposed activity to be conducted in a manner consistent with the policies. If CZM proposes alternatives within the objection letter they must be described in sufficient detail to allow the applicant to determine whether to adopt it, abandon the proposal, or file an appeal.

Following receipt of notification of CZM objection, the federal agency may not issue the federal license or permit (except following appeal).

Appeal of CZM Objection to a Consistency Certification

An appeal of a CZM objection may only be brought by the project applicant, and such objection may be over-ridden by the Secretary of Commerce only in cases where the activity is found to be consistent with the objectives of the Act (Coastal Zone Management Act of 1972, as amended), or is necessary in the interest of national security.

A finding of consistency with the Act is made if:
- The activity furthers the national interest as articulated in sections 302 and 303 of the Act in a significant or substantial manner
- The national interest furthered by the activity outweighs the activity's adverse coastal effects, when those effects are considered separately or cumulatively, and
- There is no reasonable alternative which would permit the activity to be conducted in a manner consistent with the enforceable policies of the management program

An activity is necessary in the interest of national security if:
- a national defense or other national security interest would be significantly impaired were the activity not permitted to go forward as proposed

Contact Information

Massachusetts Office of Coastal Zone Management
Project Review Coordinator
251 Causeway Street, Suite 800
Boston, MA 02114
Ph: 617-626-1219
Fax: 617-626-1240

Appendix B

Dam Removal and the Wetland Regulations

Massachusetts Department of Environmental Protection
Bureau of Resource Protection
Wetlands/Waterways Program
1 Winter Street, 5th floor
Boston, MA 02108

December 2007

I. Preface

This guidance is intended to encourage environmental improvements to rivers and streams anticipated to result from dam removal. The document provides guidance for conservation commissions and the Department of Environmental Protection, as the permitting authorities, in the application of the Massachusetts Wetlands Protection Act and its regulations. This guidance provides commissions with an overview of permitting issues and review considerations associated with dam removal projects. The Executive Office of Energy and Environmental Affairs (EOEEA), Riverways Program document entitled *Dam Removal in Massachusetts – A Basic Guide for Project Proponents*[1] contains a comprehensive review of other regulatory requirements associated with dam removal.

Many thanks to the following individuals for their insightful input and review:

Liz Callahan, MassDEP, Bureau of Waste Site Cleanup
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Michael Stroman, MassDEP Wetlands Program

Layout & Design: Sandy Rabb, MassDEP

Photo credits: Many thanks to the Riverways Program for the photos of the Town Brook Dam Removal in Plymouth, MA and the Ballou Dam Removal in Becket, MA; to Eric Hutchins of NOAA for the photos of the Town Brook Dam Removal; and to George Zoto, MassDEP.

[1] For more information regarding this document, contact the Riverways Program at 617/626-1540 or go to their website: www.mass.gov/dfwele/river/index.htm.

Table of Contents

II. Dam Removal and the Wetlands Protection Act

There are thousands of dams in Massachusetts, most originally constructed many years ago for a variety of reasons including mechanical milling, hydropower generation and flood control. Today, many of these dams are aging, no longer serving their original purpose, and have exceeded their expected lifespan, causing multiple concerns – most importantly, loss of life, property and environmental degradation.

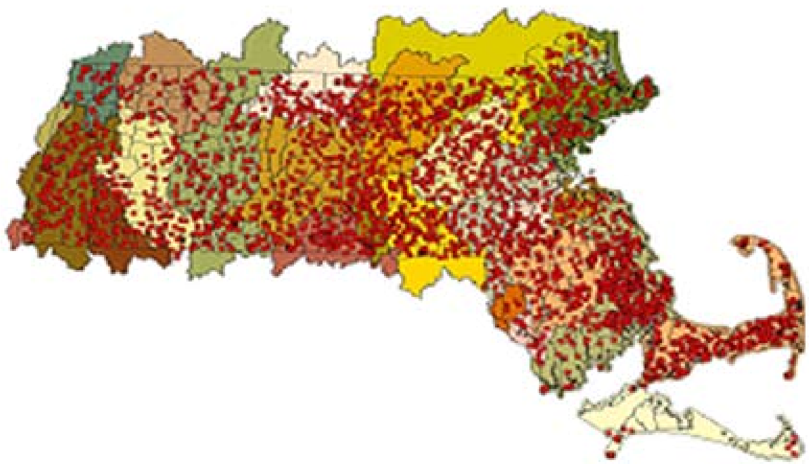


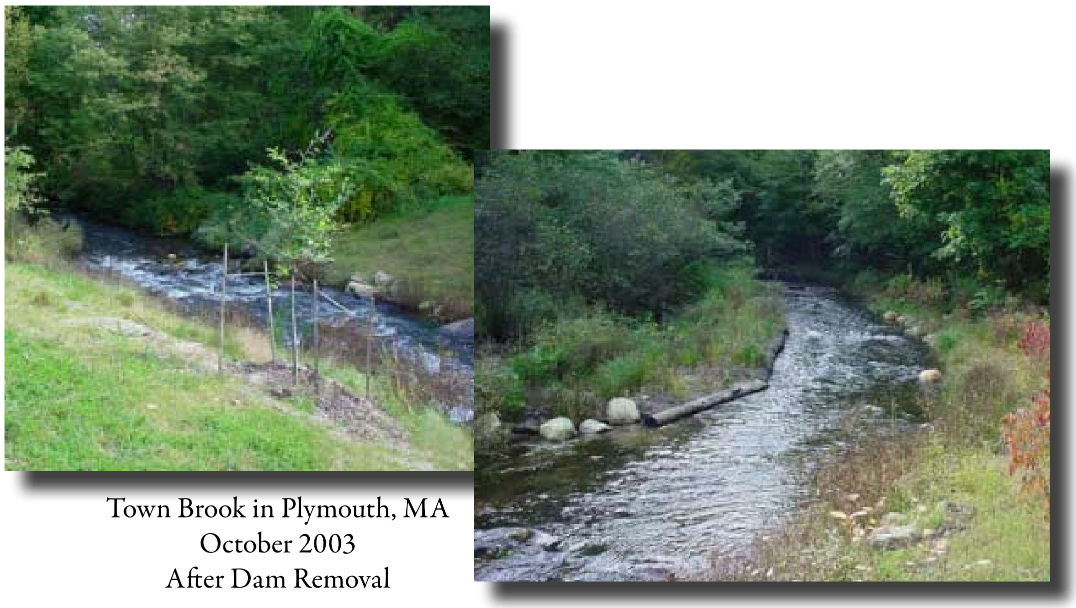
Figure 1: Over 3,000 Dams in Massachusetts in all 28 Watersheds

The Wetlands Protection Act (WPA), M.G.L. c. 131, s. 40, and the associated wetland regulations (310 CMR 10.00) acknowledge the importance of dam safety. The wetland regulations, (310 CMR 10.53 (3)(i)), provide for work on dams involving maintenance, repair and improvement (but not substantial enlargement). The WPA regulations also acknowledge the role of lake drawdown projects for the purposes of dam safety, but not if they involve breaching a dam and only if water levels are ultimately restored.

Across Massachusetts, decisions are being made on a regular basis as to how to best address dams that are in need of substantial repair. Along with the traditional options of repair, replacement or redesign, dam removal has become a viable option as a means to restore healthy wetland and riverine ecosystems. Ecosystem fragmentation caused by dams has been linked to declines in biodiversity. Dams act as barriers to fish movement by interrupting the migration of diadromous fish and the movement of resident aquatic species to habitat for spawning, nursery or refuge. Dams also transform free-flowing rivers to slow-moving water bodies by creating impoundments that can become sinks for contaminated sediment. Dams can also impact water quality by increasing summer water temperatures and reducing dissolved oxygen resulting in eutrophication and warming.

Third Herring Brook
Norwell & Hanover
3 Months after drawdown

While many dam removal projects are initiated to prevent damage to human life and property resulting from dam failure, other dam projects may serve to restore the ecology of riverine systems. Although a handful of dam removal projects have been accomplished in Massachusetts, hundreds have been successfully completed nationwide. Dam removal projects can contribute to the restoration of aquatic habitats upstream and downstream by restoring the natural movement of water and sediment, and by reestablishing more natural temperatures and oxygen levels. Dam removal projects can also improve flood management, storm damage prevention, and prevention of pollution in cases where the dam is otherwise in disrepair and represents a hazard. Since these projects can serve to improve the natural capacity of a river to protect the many interests of the WPA, they may be (and have been) permitted under 310 CMR 10.53(4). During permitting review of dam removal projects under the Wetlands Regulations, it is recommended that the following guidance be incorporated.



Town Brook in Plymouth, MA
October 2003
After Dam Removal

III. Assessment

A Notice of Intent proposing a dam removal project should include assessments of the existing dam structure, sediment deposition and composition, and upstream and downstream river morphology. In general, assessment levels should depend upon site conditions and the scale of the project. Small dams with little sediment accumulation, no infrastructure risk, and no endangered species concerns require less analysis, whereas more complex projects should require more in-depth analysis. Initial assessment should determine if the dam, impoundment, adjacent land, and downstream stream reach are in rare species habitat based on the Natural Heritage and Endangered Species Program, Massachusetts Natural Heritage Atlas (12th or more recent Edition).[2]

The existing dam structure must first be evaluated, including the structure's materials and integrity. This is important as an aging, structurally unsound dam may fail during removal causing flooding and other damage downstream. Usable gates and low-flow outlets should be identified for possible use in a staged release (i.e. a controlled draw down that is done in phases). Historic records and photos can be helpful in identifying structural materials and methods that were used in the original construction. Also, removal of a dam, especially in developed areas, can affect nearby infrastructure such as bridges, sewers, and culverts. All utilities, structures and other infrastructure in the project area (as well as those upstream and downstream) that could be impacted by scour, sedimentation, or changes in flow velocity should be identified.

[2] http://www.mass.gov/dfwele/dfw/nhesp/nhenvmesa.htm

Initial assessment should also include a survey of impoundment bathymetry, and upstream and downstream channel characteristics. Data collection should provide, at a minimum, information on upstream and downstream channel features (including dimensions, streambed patterns, riffles, runs, and pools) as well as a longitudinal profile through the impoundment and downstream reach.[3]

Management of sediment accumulations behind a dam is often a significant component of a dam removal proposal, as the impoundment behind a dam can trap up to 95 percent of the sediment that enters from upstream. The need for sediment management must be specifically evaluated at each site because all dams behave differently. Some dams have very little sediment behind them and some have a lot. Differences also exist in the chemical quality of the sediment. Therefore, sediment deposition must be evaluated.

IV. Sediment Management and Transport

Sediment management is an important component of any dam removal proposal. The remobilization of sediment impounded behind dams can have physical (increased turbidity) and toxicological (exposure to contamination) effects. As such, methods of sediment management are contingent upon the physical and chemical composition of sediments.

There are three primary sediment management alternatives to be considered when dam removal is proposed: Sediment removal and disposal; In-stream management (sediment repositioning within the waterway); and in highly contaminated cases, capping or in situ remediation. Considerations for each alternative are described below, and plans should be developed in consultation with local, state and federal agencies and stakeholders. The Massachusetts Riverways Program document entitled *Impounded Sediment and Dam Removal in Massachusetts, A Decision-Making Framework Regarding Dam Removal and Sediment Management Options* (i.e. Impounded Sediment Document) dated June 2003 should be consulted.[4]

A. Sediment Removal and Disposal greater than 100 cy

Submission of the 401 Water Quality Certification Dredge Permit Form[5] is required for projects involving sediment removal and disposal of quantities greater than 100 cubic yards (cy). Sampling and disposal requirements are detailed in the 401 Water Quality Certification regulations.[6] Section 314 CMR 9.07 (2) requires two steps to determine whether further sediment analysis is required:

1. Due Diligence Review: Applicants must perform a "due diligence" review of past and present land use practices in the watershed, upstream of the dam, to determine the potential for the sediment contamination by concentrations of oil or hazardous materials, as defined in the Massachusetts Contingency Plan (MCP).[7] Such a review may include, but is not limited to, an analysis of records of the local Board of Health, Fire Department, and/or Department of Public Works, the Department's Bureau of Waste Site Cleanup, knowledge of historic land uses, information on prior dredging projects and discharges of pollutants in the project area watershed. Table 1 should be consulted for information on the due diligence review.
2. Sieve Analysis: An analysis must be conducted to determine if the sediment to be dredged contains less than 10% by weight of particles passing the No. 200 U.S. Standard Series Testing Sieve (nominal opening 0.0029 inches). Fine-grained sediments (i.e. those passing the #200

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[3] To develop a longitudinal profile, a record of the downstream changes in elevation (i.e., slope), along the riverbed must be recorded at regular intervals.

[4] The document published by the MA Department of Fish & Game, Riverways Program, River Restore, in cooperation with MassDEP and others entitled *"Impounded Sediment and Dam Removal in MA - A Decision-Making Framework Regarding Dam Removal and Sediment Management Options"* dated June 2003, contains detailed guidance on handling sediments for dam removal projects. www.mass.gov/dfwele/river/pdf/damremoval_impounded_sediment.pdf

[5] BRP WW 07, 08 Dredging - www.mass.gov/dep/water/approvals/ww0789ap.doc

[6] 401 Water Quality Regulations - www.mass.gov/dep/service/regulations/314cmr09.pdf

[7] *See the MA Contingency Plan, 310 CMR 40.0000 - www.mass.gov/dep/cleanup/laws/mcptoc.htm*

sieve) have a higher potential for having chemical contaminant adsorpsion. Fine-grained sediments, whether or not contaminated, are also more likely to be transported as the river sediment load to distant points downstream and ultimately to the ocean. Since due diligence review does not always identify all potential sources of watershed contamination, the sieve analysis is required as a second test of potential contamination and to provide important information about the physical characteristics of the proposed dredge sediment (i.e. evenly or poorly graded sandy gravel, or highly silty material). The sieve analysis also helps to determine the suitability of sediment for reuse, dewatering specifications, and whether the downstream sediment transport is likely to result in turbidity that could be harmful to benthic or other aquatic organisms.

Table 1: Due Diligence Review Sources of Information

'Due Diligence Review' for Potential Contaminants –
Possible Sources of Information

- Existing and historic industrial use at the dam and impoundment
  - review Sanborn Fire Insurance Maps [http://sanborn.umi.com/] for industrial history of site
  - review local Historical Society information
- Existing and past land use in watershed and at site (e.g. urban areas, agricultural areas, etc.)
- Existing and past industry within the watershed and near the site
  - MA DEP - Source Water Assessment Program (SWAP): Land Use/Associated Contaminants Matrix (DRAFT February 1999) for reference
- Review of environmental databases in watershed with added focus within 1 mile of the site

  Federal Environmental Databases (See http://www.rtk.net/rtkdata.html)
  - Comprehensive Environmental Response, Compensation and Liability Information Services (CERCLIS) or Superfund Sites
  - Resource Conservation and Recovery Information System (RCRIS)
  - Toxic Release Inventory (TRI)
  - Emergency Response Notification System (ERNS) Database (e.g. toxic spills)
  - National Pollutant Discharge Elimination System (NPDES) permits

  Massachusetts Environmental Databases (available at regional DEP offices)
  - 21E Sites (MA Contingency Plan (MCP) – Hazardous Waste sites)
  - Underground Storage Tanks
  - State Landfill and/or Solid Waste Disposal Sites
  - SPILLS Database
  - DEP Regional Files Review

  Local-Municipal Files
  - Board of Health
  - Department of Public Works

Source: ***See page 15, Box 2** Impounded Sediment and Dam Removal in Massachusetts – A Decision-Making Framework Regarding Dam Removal and Sediment Management Options* dated June 2003. See footnote 4.

3. Findings of Due Diligence and Sieve Analyses: Once the Due Diligence and Sieve Analyses are completed, no chemical testing is required if the sediment to be dredged contains less than 10% by weight of particles passing the No. 200 U.S. Standard Series Testing Sieve (nominal opening 0.0029 inches), and if the "due diligence" review demonstrates, to the Department's satisfaction, that the area is unlikely to contain anthropogenic concentrations of oil or hazardous materials. If, however, due diligence review demonstrates that the area is likely to contain anthropogenic concentrations of oil or hazardous materials, or if sediment contains greater than 10% by weight of particles passing the No. 200 U.S. Standard Series Testing Sieve then chemical and physical testing must be conducted in accordance with 310 CMR 9.07 (2)(b) and performance standards and disposal requirements in 310 CMR 9.07 must be met.

B. Sediment Removal and Disposal Less than 100 cy [8]

Sediment removal and disposal of less than 100 cubic yards does not require the submittal of a 401 application, provided a Final Order of Conditions has been issued by the local Conservation Commission or MassDEP. In such cases, the proposed work must qualify for a USACOE Category One Programmatic General Permit (PGP). Nevertheless, this guidance document endeavors to promote consistent approvals of sediment management methods among the review authorities. Project proponents must demonstrate (and it is recommended that Conservation Commissions require evidence) that disposal of dredged sediment is managed in accordance with 314 CMR 9.07 (9), (10) and (11).

C. In-Stream Management (i.e. Sediment Repositioning)

In-stream management simply means allowing the river to naturally redistribute the impounded sediment downstream while forming its own channel through the former impoundment or while flowing through a newly constructed channel. In such cases, full dam removal can result in a large one-time sediment release depending on the quantity and mobility of trapped sediment. [9]

1. 401 Contaminant Screening: Because in-stream management involves sediment repositioning, it is considered 'dredging' under MassDEP's 401 Water Quality Certification Regulations (314 CMR 9.00) and project proponents should follow the guidelines above for sampling greater than 100 cy. These guidelines should be followed even if the amount of sediment estimated to be repositioned is less than 100 cy since the sediment will typically be released to downstream areas, and considerations pertaining to this management technique must include protection of downstream ecological and human resources that may contact the exposed sediment. If the due diligence or sieve analysis indicate further physical and chemical testing is needed, then testing should be completed by an environmental professional such as a Licensed Site Professional (LSP) with experience in site assessment prior to taking actions that will disturb or redistribute the sediments. The *Impounded Sediments Document*[10] contains detailed guidance on evaluating contaminant levels in impounded sediments. Depending on the levels of contaminants found in the sediments, alternative sediment management options should be considered. There are cases where dredging of sensitive habitat may do more harm than allowing the sediment to redistribute downstream. Therefore, careful consideration should be taken, weighing the advantages and disadvantages of dredging on the natural ecosystem.

[8] Note that MassDEP is reviewing this threshold for modification and applicants should check the MassDEP website for future changes: www.mass.gov/dep/service/regulations/314cmr09.pdf

[9] As a general rule, the Army Corps of Engineers has determined that the discharge of substantial quantities of accumulated bottom sediment from or through a dam downstream waters constitutes a discharge of dredged material (and possibly of fill material) that requires a section 404 permit (see www.usace.army.mil/cw/cecwo/reg/rgls/rgl_05_04.pdf). For projects requiring a Section 404 permit, a 401 Water Quality Certification is also required.

[10] Footnote 4, Section III, Sediment Evaluation: Contaminant Screening

2. Massachusetts Contingency Plan (MCP) Responsibility for Exposed Sediments: Frequently dam removal results in the exposure of sediments that were previously under water. Upon exposure, (i.e. above high water mark), these sediments will qualify as soil under the MCP. The MCP does not have notification thresholds for contaminants in sediment. However, once contaminated sediment becomes exposed on the new shoreline, the former sediment would now be considered soil and the MCP has notification thresholds for contaminant levels in soil. The effect is that the property owner would now have a MCP notification obligation if the sampling of the soil exposed as the result of the dam removal is found to be above MCP reportable concentrations. When sediments will be exposed as a result of dam removal, testing of the material that will be exposed is recommended to prevent human and environmental contamination concerns and to avoid future liability for cleanup. Project proponents should contact MassDEP Wetland and/or Waste Site Clean Up Programs for guidance on testing and proper disposition of soils in these areas[11] as appropriate management techniques may exist for these scenarios.

3. Alternative Management Options at Highly Contaminated Sites: In highly contaminated situations[12] , alternatives such as removal and disposal, capping it with a layer of clean material (Confined Aquatic Disposal) or use of a containment structure (Confined Disposal Facility)[13] in place may need to be considered to insure the protection of both the ecological resources and people who may contact the exposed sediment. Dredging options must be evaluated in consultation with local, state and federal regulators, including staged, partial, or full removal sediments. Sometimes, sediments may be too contaminated to dredge, as dredging will resuspend a certain portion of sediments. In these situations, capping of "hot" sediments may be needed. If capping is being evaluated, it must be demonstrated that this action will reduce contaminant availability to aquatic and terrestrial ecosystems, and to humans. Long-term stability of the proposed cap should also be evaluated since the river current has the potential to erode the cap. In general, it should be demonstrated that capping won't unnecessarily disrupt the remaining ecosystem. Projects of this nature will require compliance with the Confined Disposal requirements at 314 CMR 9.07(8).

4. Quantity Assessment: If the due diligence and particle size tests demonstrate that contamination is unlikely, or if additional sampling and analysis concludes that the project will protect ecological and human resources; then a project may proceed with in-stream management of sediments, provided that the following matters are considered. Once a dam is removed, sediment will exit the impounded area and will move downstream with the release of impounded waters. Some sediment, though, will remain in the formerly impounded area. In addition to initial assessments of sediment particle size and potential contaminants, an evaluation should be made as to what quantity of materials will be "mobilized". The quantity that is mobilized is roughly equivalent to the length by the cross-sectional area of the stream that will form in the formerly impounded area.[14] Once the quantity of the sediment to be mobilized is determined, the morphological effects of sediment release should be evaluated. Although in-stream management restores the natural sediment transport functions including stream bed and flood plain development and nutrient transport that were interrupted by dam placement, a project should not result in any long-term changes in downstream morphology by filling natural pools or burying natural riffles.[15] Projects must include best management practices to avoid turbidity in upstream and downstream waters. Incremental or staged dam removal controls the rate of sediment transport and is often preferable. A staged removal can be accomplished by slowly drawing down the impoundment level either by utilizing an existing gate or by incrementally removing the dam structure. Consideration must also be given to avoiding work during time of year restrictions for aquatic species.

[11] See section III of the *Impounded Sediments Document* for Guidance on evaluating contaminants in exposed sediments (i.e., dewatered and stabilized in place).

[12] Note that highly contaminated situations are where levels of constituents exceed the MA Contingency Plan thresholds found at 310 CMR 40.0000 and also at www.mass.gov/dep/water/laws/ecoturss.pdf; or if indicated after following the contaminant screening section of the Impounded Sediments document.

[13]See 314 CMR 9.07(8) for further details.

[14] *"Impounded Sediment and Dam Removal in MA - A Decision-Making Framework Regarding Dam Removal and Sediment Management Options"* page 23, June 2003, contains detailed guidance on handling sediments for dam removal projects. www.mass.gov/dfwele/river/pdf/damremoval_impounded_sediment.pdf

V. Channel/Riparian Restoration

When a dam is removed, the impounded sediments are exposed and may become unstable and subject to erosion. Some of these sediments will move downstream; what remains may require stabilization to limit erosion. The upstream banks of the former stream channel may reappear and, while historically these banks were held in place by vegetation, upon re-emergence, that vegetation does not exist. The most important aspect of bank stabilization is having a channel configuration that is appropriate for the stream flow and sediment load of the stream. If the stream slope, cross section size and shape, and meander pattern fits the river system, then only minimal bank stabilization may be necessary. More extensive bank stabilization or bank reconfiguring through bioengineering techniques and grade control may be required in the short term until natural recolonization or where the exposed channel configuration does not match natural conditions.

Once a dam is removed, the affected channel characteristics will likely undergo change due to the reintroduction of the sediment-carrying function of the stream. Immediate channel reconfiguration will likely be limited to the extent of impounded sediments, but may cut into the original substrate. If channel cuts extend beyond the historic bank substrate, there may be a need for a grade control. There are many methods for providing grade control (e.g. cross vanes) however, it is most important that the method used is appropriate for the specific characteristics of the river or stream.

As part of the dam removal project and subsequent riparian restoration, aquatic habitat enhancements may be considered. These enhancements may include creating pools, adding boulders installing logs and enhancing irregular edges.

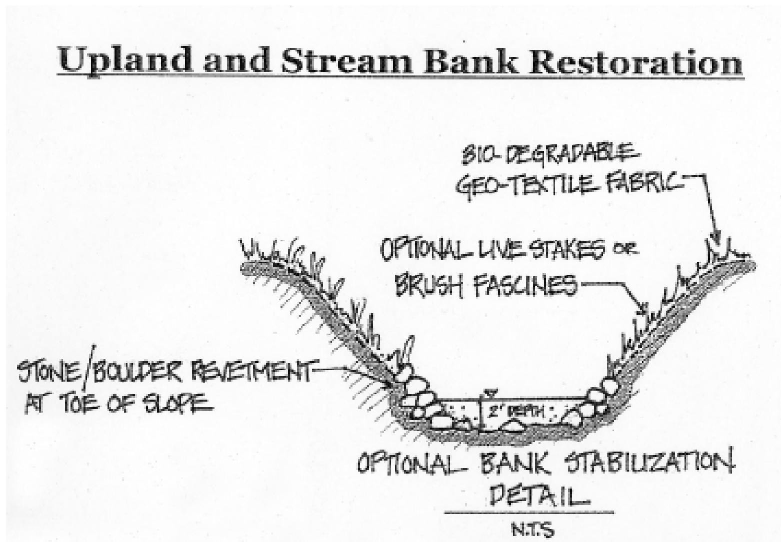

Figure 2: Example Channel Stabilization

VI. Weighing the Benefits and Impacts of Dam Removal

Because dam removal projects may be (and have been) considered as limited projects under 310 CMR 10.53(4), traditional mitigation requirements are discretionary. Due to the nature of these projects, the purpose of which is to improve the natural capacity of a resource area, the mitigation benefits include the general restoration of wetland resources and, specifically, the riverine ecosystem. During project review, applicants should document the benefits and impacts associated with dam removal. In doing so, the long-term benefits of a dam removal project are likely to outweigh the short-term impacts and the distinction should be addressed in

Boulders placed along the edge of restored stream channel to enhance fish passage upon removal of Ballou Dam in Becket, MA the application. Although a project does not need to improve the natural capacity of the resource area to protect all of the interests of the WPA (e.g. flood control, storm damage prevention, protection of fisheries), it must improve at least one interest and it should minimize the adverse affect on the interests that are not targeted for improvement. The following are some examples.

- The regulations for bordering vegetated wetland (BVW) at 310 CMR 10.55 require a 1:1 replacement to loss ratio. While providing many benefits, dam removal may result in the loss of upstream BVW due to the changes in hydrology, and the requirement of BVW replacement may be a disincentive for a dam removal proponent. Because dam removals are limited projects, under 310 CMR 10.53(4), the issuing authority may waive the requirement for 1:1 replacement since these projects will restore or otherwise improve the natural capacity of resource areas to protect Wetland Act interests. Dam removals typically result in changes in the type or specific location of wetland resources. Often, when BVW is lost at one elevation around the impoundment, BVW will be established at a lower level associated with the restored, and highly productive riverfront area. In more developed areas where BVW cannot reestablish, the benefits may be in improved wildlife, fisheries and storm damage prevention functions of the free flowing river (see Sections below). In some cases, restoration of the stream channel in the immediate vicinity of the dam should be proposed and may include proactive bioengineering or revegetation to promote streambank stabilization. For instance, proactive efforts would be advisable when BVW is expected to be impacted within the footprint of the project or when the stream channel requires reconfiguration. In other cases, natural succession and revegetation may be adequate. In these cases, replanting is not required but projects should be conditioned to help prevent the growth of invasive species in the dewatered impoundment and to require regular monitoring.

- Dams fragment habitat. Many species that depend on flowing water, such as Atlantic salmon, brook trout, river herring, shad and sturgeon have suffered dramatic population declines, in part due to the loss of flowing water and riverine habitat caused by dams and the loss of access to upstream spawning habitat. The removal of a dam reconnects the upstream and down stream river lengths, significantly expanding the area and quality of land under water for fisheries habitat. While the presence of additional dams upstream or downstream may limit the extent of restoration, dam removal can still provide benefits, even on limited reaches of rivers.

- Dam removal can significantly improve the fisheries and prevention of pollution interests of land under water by restoring natural riverine thermal regimes that support cold water fisheries habitat. Trout and other cold water species have very restrictive temperature requirements for survival, growth and reproduction. Impoundments increase summer water temperatures significantly by creating larger, slower moving water surface areas exposed to sun. Warmer temperatures decrease the dissolved oxygen content of the water both in the impoundment and for some distance downstream of the dam. Dam removal can eliminate thermal pollution and associated water quality problems along miles of resource area.

- Dam removal can significantly improve the flood control and storm damage prevention functions of wetland resource areas by restoring the natural ability of the riverine system to moderate flow and absorb floodwaters. Except for dams specifically designed for flood control, most dams do not provide flood control benefits and their removal may actually alleviate upstream flooding while eliminating potential catastrophic dam failures. An unanticipated failure of a dam will result in much more severe impacts than a prudently planned dam removal. Preservation of human-made ponds formed as a result of a dam require dam maintenance in perpetuity. Unless there is a reason to preserve the human-made impoundment, such as an endangered species living in the impoundment[16], prevention of erosion of contaminated sediments or to protect against downstream flooding, then replacement of the "impoundment" wetland with a "riverine" wetland may be preferable in order to restore the natural ecosystem functions. As part of dam removal planning, down stream hydrology should be assessed both short-term (during the actual dam removal and a few days after) and long-term (permanent hydraulic change). The hydrolgic assessment must include an analysis as to whether the dam removed will increase the horizontal or vertical extent of flooding downstream.

VII. Wetland Impacts

In some cases, the loss of upstream wetlands may be offset by the overall benefits of the river restoration. For example, in some cases, dam removals have resulted in new or even increased amounts of wetlands overall. The effects of the changed hydrology and sediment and nutrient transport on upstream or downstream receptors (e.g. rare or endangered species, vegetated wetlands, drinking water supplies, groundwater tables, spawning areas or other habitat features for species of fish, shellfish, reptiles and amphibians) should be evaluated and mitigation measures proposed as necessary.

Short-term impacts may include increased turbidity, altered flows, and disturbances from heavy equipment. These disruptions, though short-term, should be timed appropriately to lessen impacts. Dam removal should be timed so as to avoid coinciding with fish spawning runs. Applicants should be aware that time-of-year restrictions are commonly required for projects through Section 404 Dredge and Fill permits administered by the Army Corps of Engineers, WQC issued by MassDEP, and Orders of Conditions issued by local conservation commissions. Consultation with the Division of Marine Fisheries (coastal) and/or the Division of Fish and Wildlife (inland) is recommended.

VIII. Design and Construction Details

A plan showing the dam removal and site restoration design, along with a discussion of construction techniques and equipment staging areas are required in a permit application. Because dams are located within dynamic riverine environments, a multidisciplinary consulting team with expertise in such diverse areas as engineering, hydraulics, aquatic biology and fluvial geomorphology should be consulted during project planning to minimize short and long-term adverse impacts and ensure successful long-term ecosystem restoration.[17]

Application details should include:

- A plan prepared in accordance with the additional information requirements for the Notice of Intent Site Plan as detailed in the Notice of Intent instructions (WPA Form 3: Notice of Intent) at: http://www.mass.gov/dep/water/approvals/wwforms.htm.
- Existing wetlands shown on a plan along with anticipated changes. See USGS maps or DEP Orthophotos at: http://maps.massgis.state.ma.us/WETLANDS12K/viewer.htm (Note that while maps and photos may be used to show upstream and downstream resources, field delineation should be conducted in the immediate vicinity of the dam).
- A typical drawing showing how the area will be dewatered (if required) prior to dam removal to prevent flooding and limit downstream sedimentation. The plan should address use of low-level outlets, or, if not available, the use of siphons for dewatering. Stockpiling locations and stabilization of dewatered materials should also be addressed.
- Methods of dam removal and associated structures should be discussed, including methods for demolition of concrete, if applicable.

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[16] In the case of State Listed Rare Wetlands Wildlife, the Massachusetts Endangered Species Act (MESA) and its regulations will be triggered. MESA, in the case of an endangered species taking, can require mitigation and issuance of a permit.

[17] For more information regarding this document, contact the Riverways Program at 617/626-1540 or go to their website: www.mass.gov/dfwele/river/index.htm

- Sediment management practices as required by 314 CMR 9.00 and discussed in Section 3: Sediment Management above(e.g. dredge, in-stream channel and bank stabilization)
- Specifications detailing stream channel and bank restoration in the vicinity of the dam removal.
- Type and location of erosion and sedimentation control measures to be implemented to protect resource areas.
- Description of the sequencing of construction activities (e.g. clearing first, silt fence installation next, dewatering)
- Minimization of impact on aquatic organisms can be achieved by a controlled drawdown rate, a plan to move species before the start of construction, or a fish salvage plan if disconnected pooled water is anticipated during dewatering.
- Invasive vegetative species monitoring and control plan.

IX. Monitoring

There are two levels of monitoring at dam removal projects, post-construction monitoring and habitat monitoring. The first should be completed at all projects and includes periodically evaluating the project site for any risks to infrastructure such as utilities, retaining walls, bridges, and culverts, and evaluating the river channel for excessive erosion or sediment deposition. Photo stations should be set up to periodically create photo documentation of the site over time. Habitat monitoring can also be completed to assess the development of habitat features of particular interest at the project site. These features could include measurement of changes in vegetation (particularly invasive species), sediment, stream channel geometry, hydrology, fisheries and wildlife.[18]

Concrete demolition at the Ballou Dam after a precision dam cut away from the adjacent retaining walls in Becket, MA.

X. Dam Removal as 10.58(5) Mitigation

The Wetlands Protection Act Regulations include a section on Redevelopment of the Riverfront Area found at 10.58(5). This section provides for the redevelopment of previously developed or degraded riverfront areas. In some cases, applicants may choose to restore or otherwise mitigate riverfront area (See Section 10.58 (5)(g)). Dam removal is a form of river restoration, so such a proposal may be considered a mitigation project by the issuing authority under 10.58(5) *Redevelopment*.

[18] Barrier removal monitoring standards are being developed by the Gulf of Maine Council for the Marine Environement in conjunction with the MA Riverways Program. Contact the Riverways Program for details.

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Impounded Sediment and Dam Removal in Massachusetts

A Decision-Making Framework Regarding Dam Removal and Sediment Management Options

June 2003

Massachusetts Department of Fisheries, Wildlife, and Environmental Law Enforcement

Riverways Programs
River Restore

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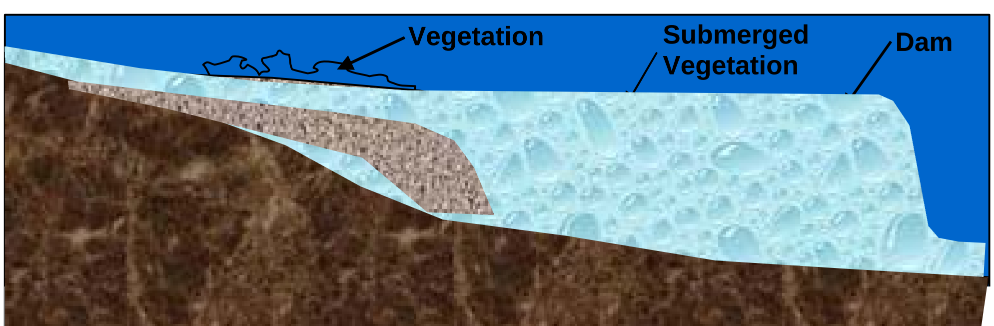

Diagram courtesy of Laura Wildman, American Rivers

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TABLE OF CONTENTS

PURPOSE

This report summarizes the sampling, analysis, evaluation and management strategies associated with breaching or removing a dam and restoring riverine habitat in Massachusetts. In addition, the report also lays out a decision-making framework regarding dam removal and in-stream management options for impounded sediment. Managing impounded sediment during dam removal and river restoration projects has been a growing challenge for Massachusetts local and state regulatory authorities because current regulations do not explicitly address sediment management for these types of projects. Furthermore, dam owners in Massachusetts will likely be considering removing or breaching their aging dams in the coming decades due to a growing concern for liability, cost and safety of an unplanned dam failure and the awareness of the environmental impacts dams can have on our waterways. This summary document is necessary so that private, public, non-profit, local, state, and federal project partners can more effectively address sediment management issues related to dam removals and river restoration projects in Massachusetts.

The regulatory framework in Massachusetts has addressed management of sediment generally in the context of dredging projects where sediment is dredged from the channel and then re-used or disposed of in adjacent areas, off-site upland environments, or in marine waters (e.g. harbor or ocean disposal for navigation). For example, there are regulations addressing re-use of dredged sediment for beach nourishment, cover at landfills, shoreline and beyond shoreline placement, and disposal at landfills and hazardous waste facilities. However, dredging is not the only option for managing impounded sediment in dam removal projects. In-stream sediment management is also an option. This may include simply allowing the impounded sediment to be released so that the river naturally attenuates and re-distributes the sediment downstream. Also, sediment management may include in-stream stabilization whereby the breaching or removal is designed so sediment become stabilized with vegetation or in-stream features (e.g. constructed riffles). A combination of these sediment management techniques is generally applied for dam removal and breaching.

WHAT'S IN THE REPORT?

The **Introduction** to the report describes the many reasons dam owners and local, state and federal agencies and organizations are increasingly considering dam removals, the impacts dams have on river ecology and sediment transport and basic sediment management approaches.

Section I discusses the first step in making an informed decision about the appropriate sediment management strategies for a given dam and river: developing a sediment-sampling plan that will include the necessary information and answer key questions. The section describes the information needed and approaches to creating a sediment-sampling plan, which includes describing the quality (physical and chemical) and quantity of the impounded sediment as well as the sediment quality of the free-flowing sections of the river (preferably upstream and downstream).

Section II looks at sediment transport dynamics and describes how the potential erosion and downstream transport of impounded sediment can be estimated using various sediment transport models and simple estimation techniques.

Section III describes how to evaluate the results of the chemical testing relative to sediment quality guidelines to assess the effects of contaminants on human and aquatic ecosystem health. The contaminant levels in the impoundment can also be used to compare with current contaminant levels in the river system both upstream and downstream of the dam site.

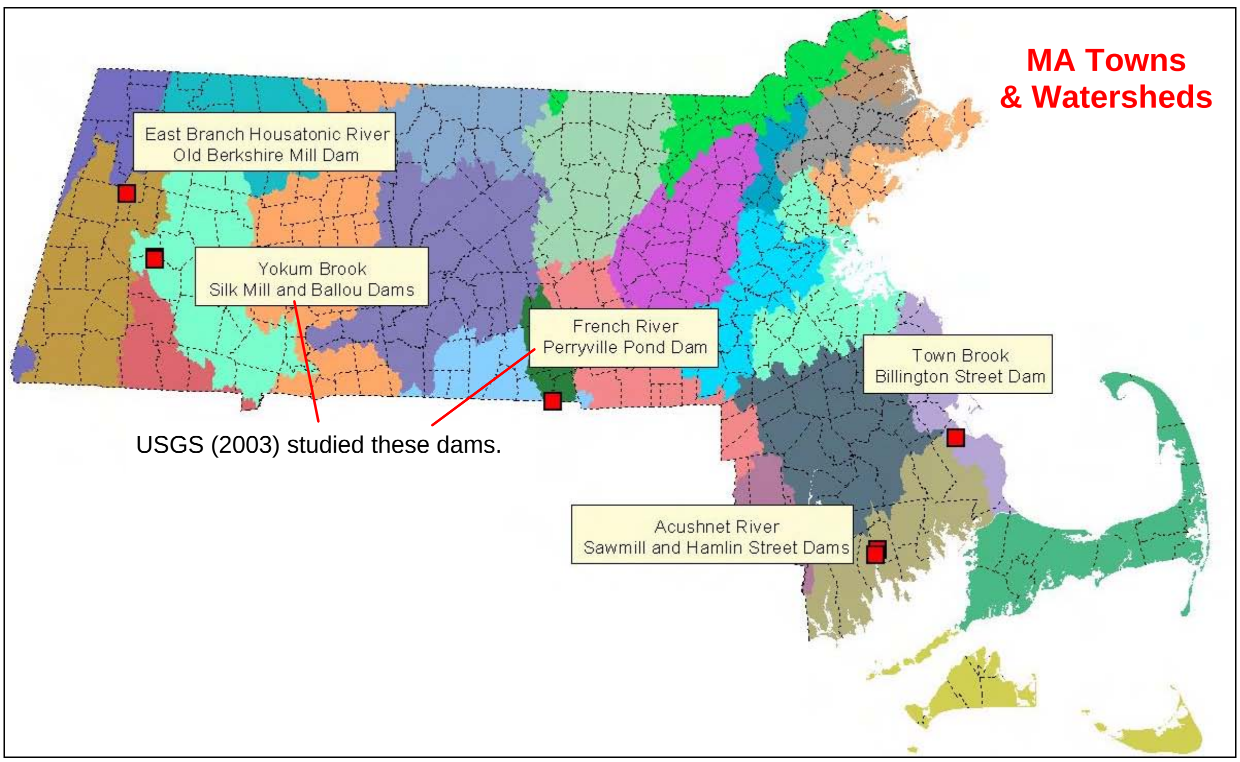
Section IV examines ways to determine if any long term physical impacts will occur from releasing the sediment. The physical effects of transporting the mobile portion of the impounded sediment must not overwhelm and degrade the downstream system for an extended period of time. This requires balancing the short and long-term benefits and impacts of the project. To determine the levels that may be detrimental to system the volume and type (e.g. grain-size) can be compared with what the river system 'naturally' transports and how sensitive the downstream habitats are to sediment.

Section V discusses the creation of a sediment management plan that incorporates information from the previous four sections (e.g. sampling and evaluation of potential sediment impacts). This section summarizes the 'in-stream' sediment management options and discusses the decision-making process regarding in-stream sediment management for dam removals.

Appendix I contains the sediment sampling, results, and management summaries for multiple dam removal/breaches in Massachusetts. These sites are shown in Figure 1.

Appendix II includes portions of selected Massachusetts Department of Environmental Protection (DEP) guidance documents and regulations referenced in this report as well as a summary of the New England Dam Removal Sediment Management Workshop (October 2001), which formed the foundation for much of the information in this report.

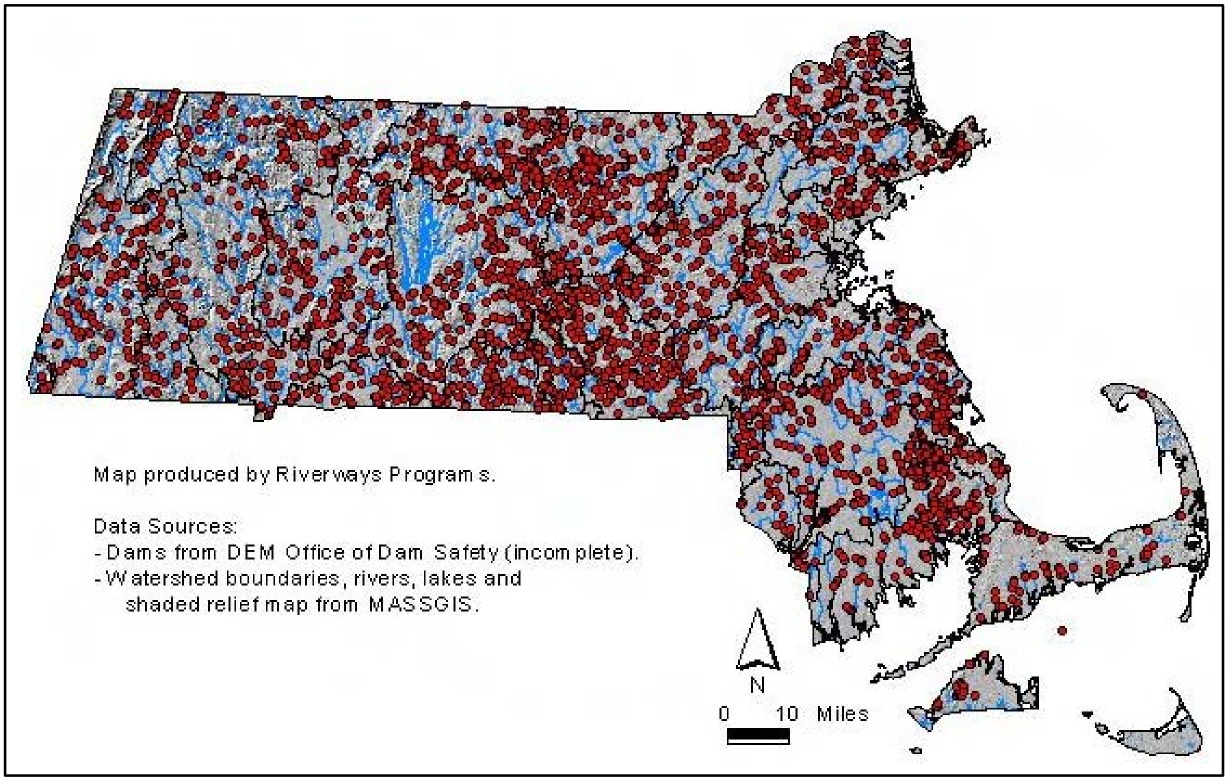
Figure 1. The dam sites summarized in this report relative to sediment sampling, results, and management plans



INTRODUCTION

There are many reasons that dam owners are considering removal of their dams and why local, state, and federal agencies and organizations are helping to fund this work. Public safety and liability concerns are growing as our aging dam infrastructure deteriorates. In Massachusetts, almost 85% of the approximately 3,000 dams in the state's jurisdiction (see Figure 2) are over 50 years of age, the normal design life of a dam. As the costs of repairing and maintaining these aging dams rise, many dam owners simply cannot afford to bring the dams up to current dam safety standards. In addition to the safety and liability concerns, a growing understanding of the environmental impacts of dams has prompted resource agencies and river and watershed associations to consider dam removals to improve habitat and water quality by returning the site to its pre-existing free-flowing riverine environment.

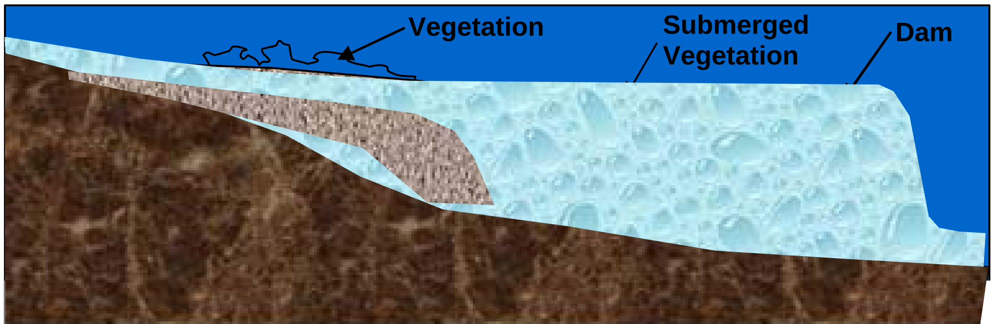
Figure 2. Dams in the Massachusetts DEM Office of Dam Safety database *(data are incomplete)*.



Dams can negatively impact rivers and streams in a number of ways with effects extending upstream and downstream in the watershed. Dams act as barriers to local fish movement of resident species and block the migration of anadromous fish species. Dams have caused many fish species to be extirpated from thousands of miles of streams in Massachusetts because they fragment the rivers into small, disconnected units. Dams also cause the direct loss of river and riparian wetland habitat by transforming the free-flowing habitat into slow moving lake-like habitat. This habitat transformation has caused fish diversity in many streams in Massachusetts to decrease dramatically. The streams lose those species dependent on fast flowing habitats (fluvial-specialists) and become dominated by generalist species tolerant of lentic (pond-like) habitats and poorer water quality. Water quality can also be negatively impacted by dams because impoundments will generally have lower oxygen levels and higher temperatures than the free-flowing streams they inundate.

In addition to moving water, nutrients, and aquatic organisms, rivers naturally transport sediment through the landscape. Erosion and deposition of sediment in rivers and streams are natural processes that aquatic organisms are adapted to and rely upon for many of their needs (e.g. vital nutrients are associated with sediment; coarse sediment such as gravel and cobbles provide spawning habitat). However, dams can substantially alter the natural sediment dynamics in both the upstream impoundment and the downstream river channel. The reduction in water velocities behind dams causes sediment to be trapped in the quiescent areas of the upstream impoundment (see Figure 3). If environmental contaminants are associated with this sediment, the contaminants may accumulate and concentrate in the impoundment, potentially impacting the organisms living in the impoundment and throughout the watershed. The river channel downstream of the dam may be affected as sediment is trapped behind the dam and water flowing over the dam becomes sediment 'starved'. This lack of sediment, in turn, may cause the river to replenish its sediment load by eroding the downstream channel and banks, causing habitat degradation in the downstream reaches. The disruption of natural sediment transport will vary considerably depending on the size of the dam and river and the sediment trapping efficiency of the impoundment. However, considering these impacts to natural riverine sediment dynamics, removal of a dam can be an important tool to restore the natural balance of sediment transport and deposition in river systems.

Figure 3. River profile of dam and impounded sediment. Diagram courtesy of Laura Wildman, American Rivers



become perched river or wetland systems. These shallow ponds will often be highly nutrient rich causing algal blooms and submerged vegetation to grow which may degrade habitat and limit recreational opportunities.

The management of impounded sediment is an important issue when considering dam removal in order to minimize the potential negative impacts to the river and maximize the long-term benefits. In most cases, the removal of the dam will alter the artificial sediment dynamic that has been established since the dam was built. Indeed, one of the reasons for the removal may be restoring the natural sediment transport dynamics of the river. However, mobilizing large quantities of impounded sediment can potentially create negative impacts to downstream aquatic resources. Excessive quantities of fine-grained sediment can act as a physical pollutant if they cover critical habitats downstream. For example, the sediment may smother eggs and fill in interstitial spaces in the streambed that are important for benthic (bottom-dwelling) aquatic organisms. Often certain levels of short-term impacts will be ‘acceptable’ when weighed against the long-term benefits of dam removal. Therefore, it is important to avoid sediment impacts that will continue to plague the system over a longer period of time. For example, contaminants associated with the impounded sediment may be released downstream in higher concentrations than what is currently moving downstream and act to further degrade aquatic habitats. The short and long-term benefits and impacts should be carefully considered as an appropriate sediment management plan is developed.

A number of sediment management options are available for consideration when removing a dam. BOX 1 summarizes these sediment management options. These are grouped generally into ‘in-stream’ and ‘dredge and re-use or dispose.’ The ‘in-stream’ options include natural river erosion, which simply means allowing the river to erode and redistribute the impounded sediment downstream while forming its own channel through the former impoundment. Stream channel formation may proceed by an upstream migration of the initial head-cut (where the dam was removed) until the dimensions of the channel reach a new quasi-equilibrium at which point sediment is no longer being eroded faster than it is being replaced by upstream sources (Pizzuto 2002).

Additionally, in-stream management options include the in-place stabilization of the impounded sediment. In many cases, sediment can be stabilized in-place within the newly formed stream channel through the use of grade controls such as large cobbles and boulders or as part of the restored stream banks and adjacent riparian areas (e.g. floodplain) using techniques of bioengineering and re-vegetation. These ‘in-stream’ options may also include relocating some of the impounded material to isolated or contained areas within the stream bank or floodplain in or near the former impoundment areas. Stabilizing and revegetating sediment in the former impoundment, not only is a sediment management solution, but also, in many cases, is restoring riparian wetlands that were inundated by the dam.

The second option is the traditional ‘dredge and re-use/dispose’ option that involves dredging (e.g. sediment is first removed from the water prior to lowering the impoundment, or drawdown) or excavating (e.g. sediment is removed post-drawdown after the sediment is de-watered) the impounded sediment and disposing or re-using it in upland areas or off-site. The destination of the sediment and its ultimate re-use or disposal depends significantly on the contaminant concentrations, but also on issues of volume, physical characteristics, methods of transport, and potential nuisance conditions. A combination of these sediment management options has been employed during dam removal projects in Massachusetts thus far.

BOX 1

Sediment Management Options for Dam Removal

'In-stream' Management

- ✍ Natural river erosion
  - ? Allow the sediment to move downstream on its own to naturally re-distribute and form its own channel through the sediment
- ✍ In-stream and riparian stabilization
  - ? Stabilize headcuts with coarse sediment (gravel, cobbles, boulders)
  - ? Stabilize banks and de-watered sediment using bioengineering approaches and re-vegetation, restoring bordering vegetated wetlands and floodplain area
  - ? Isolate or Cap (e.g. cover with an impermeable layer) in-stream or de-watered sediment
- ✍ Alternative/Innovative Treatments – 'in-situ'
  - ? Chemical or Biological treatment – remediation using specialized bacteria or vegetation to decrease toxicity or availability

Dredge and Re-use/Disposal Management

- ✍ Re-use
  - ? Shoreline
  - ? Beyond Shoreline
  - ? Landfill re-use
  - ? Beach or dune replenishment
- ✍ Aquatic Disposal
  - ? Unconfined open water disposal
  - ? Confined Aquatic Disposal (CAD)
- ✍ Upland Disposal
  - ? Confined Disposal Facilities (CDF)
  - ? Unlined Landfill disposal
  - ? Lined Landfill disposal
  - ? Receipt at 21E Site
  - ? Hazardous waste disposal
- ✍ Alternative/Innovative Treatments with Proper Disposal
  - ? Incineration
  - ? Chemical or Biological treatment

SECTION I. SEDIMENT SAMPLING: QUANTITY AND QUALITY

Key Questions:

- How much sediment is in the impoundment? [Volume]
- What are the physical characteristics of the impounded sediment and upstream/downstream sediment? [Grain size, organic matter, water content, etc]
- What are the chemical characteristics of the impounded sediment and upstream/downstream sediment? [Metals, Organics, Pesticides, etc.]

One of the most important steps in making sediment management decisions is the development of a well-planned sediment sampling strategy. The sediment-sampling plan should determine an approach to estimate the impounded sediment volume, the number of sediment samples to take for chemical and physical analysis; and how the sediment samples will be taken (e.g. type of sediment coring methods, will cores be composited (mixed together), will cores be sub-sectioned (individual sediment layers are separated and analyzed), what is the distribution of the coring locations); and the chemical and physical parameters to be analyzed.

There is no one formula for a sediment sampling plan for potential dam removal projects. Each plan should be developed in consultation with local, state, and federal agencies and stakeholders. At the state level, the Massachusetts Department of Environmental Protection (DEP) plays a large role in issuing the permits necessary for river restoration projects involving the removal or breaching of a dam. Depending on the size and type of resource area affected and to be restored, and the activities involved with the project, permits may be necessary for work in wetlands, waterways, and dredging and re-use/disposal of sediment. Therefore, it is important that the sediment sampling plan not only yields adequate information to make sediment management decisions, but also addresses the regulatory requirements necessary for obtaining the permits.

Policies for the sampling and analysis for dredged sediment to be re-used or disposed of are fairly well established and guidelines exist. For example, the Massachusetts Department of Environmental Protection (DEP) has both the: '*Interim Policy, Reuse and Disposal of Contaminated Soil at Massachusetts Landfills*' (COMM-97-001 see www.state.ma.us/dep/bwp/dswm/files/97%2D001.htm) and '*Interim Policy for Sampling, Analysis, Handling and Tracking Requirements for Dredge Sediment Reused or Disposed at Massachusetts Landfills*' (see www.state.ma.us/dep/bwp/dswm/files/dredge.htm - COMM-94-

007). In addition, DEP has been rewriting the regulations for *401 Water Quality Certification for the Discharge of Dredged or Fill Material, Dredging, and Dredged Material Disposal in Waters of the U.S. Within the Commonwealth* (314 CMR 9.00 see **Appendix II** for a recent draft, please contact DEP or the Riverways Programs to obtain the most up-to-date version).

DEP regulations have recommendations and guidelines for sampling sediment that is to be dredged prior to or as part of a dam removal. The highlights of the sampling and analysis requirements include [see 314 CMR 9.07(2) in **Appendix II** for the full regulations]:

- Conduct a 'Due diligence' review of potential contaminants (see BOX 2)
- Sampling may not be necessary if there will be less than 100 cubic yards of material dredged, 'due diligence' shows limited potential for contamination, or if there are 10% or less fines (silt and clay) present.
- For projects up to 10,000 cubic yards, one core for every 1000 cubic yards of dredged material shall be collected. Up to three cores may be composited (mixed together) to create a single sample, provided:
    a. the grain-size distribution and likelihood of contamination are similar based on depositional characteristics, spill history, and location of point source discharges;
    b. cores are composited from the same reach; and
    c. samples collected for volatile organic compound analyses are obtained from an individual core and not composited from multiple cores.
- For projects over 10,000 cubic yards, develop a project-specific sampling and analysis plan, taking into account the likely requirement for the option(s) being considered for management of the dredged materials. This plan shall be submitted in draft form to the DEP for review and comment as part of the pre-application process.
- At a minimum, analysis should include those contaminants listed in **Section III** Table 3 - Column 1 (401 WQC Reporting Limits, see **Appendix II** for full regulations) unless specifically exempted by the DEP
- Other contaminants may include those listed in BOX 3 and will depend on the 'due diligence' review for potential contaminants
- Develop the plan in consultation with DEP and other local, state, and federal agencies

Although there have been no formal policies or guidelines for sampling and analysis of impounded sediment specifically to make decisions on the in-stream sediment management options, a sampling approach similar to the dredging guidelines can be used. Additional information useful for informing the 'in-stream' management options may include characterizing the stream channel and sediment downstream of the dam.

To supplement the DEP sampling recommendations and guidelines for dredged sediment, a study was funded in order to test and develop a sampling protocol for impounded sediment and to explore sediment screening techniques for contaminants. An associated Water-Resources Investigations Report (03-4013) by the U.S. Geological Survey (USGS) entitled, Sediment Quality and Quantity at Three Impoundments in Massachusetts*, describes an approach for sediment sampling and screening of impounded freshwater sediment relative to exploring dam removal alternatives. The USGS sediment sampling approach is summarized below and the full report can be found on-line at: http://water.usgs.gov/pubs/wri/wri034013/.

* This study (Zimmerman and Breault, 2003) was primarily financed by federal funds from the Environmental Protection Agency (EPA) to the MA Department of Environmental Protection (DEP) under section 104(b)3 of the Clean Water Act. These funds were augmented by the Department of Fisheries, Wildlife, and Environmental Law Enforcement's (DFWELE) Riverways Program, the Executive Office of Environmental Affairs' (EOEA) Watershed Initiative, Department of Environmental Management (DEM) Office of Water Resources, and the USGS.

Summary of the USGS Sediment Sampling Protocol

USGS conducted their sampling at three different impoundments; Silk Mill and Ballou Dams on Yokum Brook; and Perryville Pond Dam on the French River. (see Figure 1 and **APPENDIX I**). The dams' basic characteristics are summarized in Table 1.

Table 1. Massachusetts dams studied by USGS (2003)

Dam Name	**Silk Mill Dam**	**Ballou Dam**	**Perryville Pond Dam**
River Name	Yokum Brook	Yokum Brook	French River
Owner	Abandoned	Town of Becket	Abandoned
Structural Height (ft)	14	11.5	18
Crest Length (ft)	80	57	350
Drainage Area (mile^2)	8.5	8.6	94
Normal Storage (acre-feet)	0.5	2	80
Condition (at time of USGS study)	Poor	Fair	Poor
Current Status	Removed February 2003	Dam breach in design stage	Emergency repairs conducted in 2002

Sediment thickness and bathymetry maps were developed for each impoundment using Global Positioning System (GPS) in conjunction with recent aerial ortho-photographs to determine locations of sampling points for sediment depth measurements. Depositional areas with fine-grained sediments were identified and sampled. The water depths were measured using both manual methods (using a measuring rod) and a 'depth finder' linked to a GPS unit. For the sediment thickness mapping USGS determined that manual probing of the sediment using an extendable, thin steel rod to measure thickness worked better than the relatively complex and expensive method involving Ground Penetrating Rader (GPR). These data were then used to create contour maps and calculate sediment volumes using geographic information systems (GIS).

Based on the size of the impoundment, sediment thickness and volumes, along with the 'due diligence' review for potential contaminants (see BOX 2), the USGS consulted with state and federal agencies to determine the number of samples to take behind each of the dams and the contaminants to sample for. They took sediment cores and sub-sectioned many of these for individual analysis. The number of samples taken varied by site; for the site with an estimated volume of 71,000 yards^3 (Perryville Pond) they took 9 cores with 32 sub-sections; for the site with 1,600 yards^3 (Silk Mill Dam) they took 3 cores with 11 sub-sections total; for the site with

BOX 2

'Due Diligence Review' for Potential Contaminants – Possible Sources of Information

Existing and historic industrial use at the dam and impoundment
- review Sanborn Fire Insurance Maps [http://sanborn.umi.com/] for industrial history of site
- review local Historical Society information

Existing and past land use in watershed and at site (e.g. urban areas, agricultural areas, etc.)

Existing and past industry within the watershed and near the site
- See MA DEP - Source Water Assessment Program (SWAP): Land Use/Associated Contaminants Matrix (DRAFT February 1999) for reference

Review of environmental databases in watershed with added focus within a 1 mile of the site
- ✍ Federal Environmental Databases (See http://www.rtk.net/rtkdata.html)
  - ✍ Comprehensive Environmental Response, Compensation and Liability Information Services (CERCLIS) or Superfund Sites
  - ✍ Resource Conservation and Recovery Information System (RCRIS)
  - ✍ Toxic Release Inventory (TRI)
  - ✍ Emergency Response Notification System (ERNS) Database (e.g. toxic spills)
  - ✍ National Pollutant Discharge Elimination System (NPDES) permits
- ✍ Massachusetts Environmental Databases (available at regional DEP offices)
  - ✍ 21E Sites (MA Contingency Plan (MCP) – Hazardous Waste sites)
  - ✍ Underground Storage Tanks
  - ✍ State Landfill and/or Solid Waste Disposal Sites
  - ✍ SPILLS Database
  - ✍ DEP Regional Files Review
- ✍ Local-Municipal Files
  - ✍ Board of Health
  - ✍ Department of Public Works

800 $yards^3$ (Ballou Dam) they took only one core with 3 sub-sections (see Table 2).
Chemical testing of the sediment at the three study impoundments included analysis for thirty inorganic elements including the likely contaminants arsenic, cadmium, chromium, copper, lead, nickel, and zinc (based on the results from 'Due Diligence' review). The USGS study made use of a screening technique called Enzyme-Linked, Immunosorbent Assays (ELISA) to analyze samples for total Polycyclic Aromatic Hydrocarbons (PAHs), total Petroleum Hydrocarbons (TPHs), total Poly-chlorinated Biphenyls (PCBs), and chlordane. The ELISA technique will determine if a family of contaminants (e.g. PAHs) is present in elevated concentrations; if so, further laboratory analysis for specific contaminants within the family (e.g. specific PAHs, such as Fluorene, Anthracene) can be analyzed in the laboratory if necessary. This screening technique is less expensive than the specific laboratory tests, therefore it allows a greater number of samples to be taken at a site. USGS also measured grain-size of the samples using pipet settling methods, but in many cases a sieve test (e.g. ASTM D422 method) may be sufficient for informed sediment management decisions. Please refer to the full USGS publication for the complete explanation and description of the sampling plan and results at Silk Mill, Ballou and Perryville Pond Dams (//water.usgs.gov/pubs/wri/wri034013/).

In many cases, the impoundment may consist of sediment that is too large to sample with a typical coring device (which may have only a 1.5" diameter) and the sampling may overestimate the amount of fine grained sediment (clay, silt and sand). For example, gravel, cobbles, and boulders may be present in impoundments located on steep gradients where the stream channel has the capacity to move very large material. In these circumstances, the core sampling and grain size analysis will overestimate the volume of clay, silt and sand in the impoundment due to sampling bias (the inability to sample large diameter sediment). For example, at the Silk Mill Dam site, the presence of gravel, cobbles and boulders in many parts of the impoundment did not allow USGS to sample those locations with their coring equipment.

Using traditional pebble counts techniques (Wolman 1954) or taking large volume grab samples may help accurately assess the volume and type of large-grained sediment on the surface of the sediment, but this will not accurately represent the distribution of large-grained sediment in deeper sections of the sediment. No simple and definitive techniques have been established (except for draining the impoundment and digging a sediment pit with an excavator and using industrial-sized sieves) to consider the distribution of large-grained sediment (gravel, cobbles, boulders), but the presence of large-grained sediment should be noted and considered when estimating the volume and type of sediment in an impoundment.

In their report, the USGS discusses a method to evaluate if a representative sampling of the impoundment for a particular contaminant has been taken. The method is based on the variation in chemical concentrations among the samples and what potential error is acceptable for the project (for example, a 25% error is generally acceptable between laboratory duplicates). In other words, the more uniform the concentration of a contaminant in the sediment the fewer samples that are needed to accurately describe the average concentration. On the other hand, if there is a high variability of a particular contaminant in the sediment more samples need to be taken in order to accurately characterize the sediment. Of course, quite often, best professional judgment must be used, because for a large site with significant variability, the number of samples needed may be beyond the available funding for the project. As a comparison of the sampling effort at the locations sampled thus far in Massachusetts, Table 2 shows the number and density of locations and samples analyzed for each site relative to the volume of sediment estimated for each site.

No restoration or remediation plan has been developed for the abandoned Perryville Pond Dam; however, the DEM Office of Dam Safety was able to gain access to the site to conduct emergency repairs to the dam in order to prevent a dam failure and release of contaminated sediment. Silk Mill Dam was fully removed in February 2003 and a breach of Ballou Dam is in the design stages. The sediment management plans for Silk Mill and Ballou Dams are described in **Appendix I.** In addition to the USGS sediment sampling work in Massachusetts just discussed, detailed sediment sampling plans have been developed at a number of dam sites in Massachusetts and we present a summary of the sediment sampling at these sites (Figure 1). Also, another USGS study, entitled Sediment Characteristics and Configuration within Three Dam Impoundments on the Kalamazoo River, Michigan, 2000 (Rheaume, et al 2002) discusses sediment sampling methods that can be employed to assess sediment characteristics behind dams (http://mi.water.usgs.gov/pubs/WRIR/WRIR02-4098/).

Table 2. Summary of sampling effort for selected MA sites. Full summaries are in **Appendix I.**

Site	Total Sediment Volume[a] ($yards^3$)	Number of Locations Sampled for Chemistry[b]	Location Density ($yards^3$/sites)	Total Number of Samples for Chemistry[c]	Sample Density ($yards^3$/ samples)
Old Berkshire Mill	5,000	15	333	13	385
Billington Street	1,500	7	214	3	500
Sawmill	7,400	8	925	4	1850
Hamlin Street	4,500	5	900	2	2,250
Perryville	71,000	9	7,889	32	2,219
Silk Mill	1,600	3	533	11	145
Ballou	800	1	800	3	267

a. estimated total volume, not necessarily volume that will become mobile or dredged
b. unique x,y locations in the impoundment of cores or grab samples
c. samples are a combination of subsections, composites and/or individual cores/grabs - individual uncomposited samples for VOC or EPH not included in sample number

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RECOMMENDATION FOR SEDIMENT SAMPLING:

Based on experience thus far in Massachusetts, Riverways recommends taking a phased approach to sediment sampling behind dams when exploring dam removal or breaching alternatives:

Conduct 'Due Diligence' review for potential contaminants and gather data for site (BOX 2).

Develop a sediment sampling plan in consultation with DEP, Riverways and other local, state, and federal agencies. Follow latest DRAFT regulations from 314 CMR 9.00 – 401 Water Quality Certification "Dredging Regulations" (see **Appendix II**) for guidance in chemical sampling.

Phase I. Sediment Volume and Physical Characteristics

1) Map bathymetry, sediment thickness (using manual sediment probe), and grain-size distribution (standard sieve test)

2) If it is possible to de-water the impoundment through a low-level outlet or siphoning water over the dam, the sediment sampling will likely be easier and less expensive. In addition, archaeological and historical surveys can be done at the same time. In Massachusetts, local and state permits are necessary to lower the impoundment. In past projects, a phase I waiver has been granted to do this type of sampling.

3) Note presence and location of large-grained sediment (gravel, cobbles, and boulders) that may not be able to be sampled using sediment coring methods

4) Calculate sediment volume, potential mobility (see **Section II**) and potential downstream negative impacts (see **Section IV**).

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Phase II. Contaminant Testing

Testing for contaminants in the impounded sediment should be based on the sediment volume, sediment physical characteristics, "Due Diligence" review and the potential mobility and downstream negative impacts. Riverways suggests the following framework for choosing appropriate contaminant testing protocols (MA DEP and an interagency review team should be consulted on the sediment sampling plan):

1) A. If there is only a small volume of sediment present and "Due Diligence" shows low potential for contaminants, and coarse sediment dominates the impoundment.

   Then, no chemical testing may be needed.

   B. If a small volume of sediment is present and there is known or suspected contamination (either from "Due Diligence" review or from past studies) and only a small number of samples are necessary.

   Then, use standard laboratory testing for all potential contaminants.

   C. If a large sampling effort is necessary (large sediment volume), no previous sediment studies have been conducted, and 'Due Diligence' review indicates the possibility of contamination.

   Then, use standard laboratory testing for metals and,

   Use the ELISA screening techniques for Total Petroleum Hydrocarbons (TPH), Polychlorinated Biphenyls (PCB), total Polycyclic Aromatic Hydrocarbons (total PAH), and chlordane (cyclodiene pesticides).

   D. If a large sampling effort is necessary and if confirmed or suspected contaminants may be present based on past studies or if the ELISA screening shows that sediment standard values may be exceeded (see **Section III**).

   Then, use standard laboratory testing for all potential contaminants

2) If chemical sampling is necessary, collect at least one sediment sample from a free-flowing, depositional area downstream of the dam to gain an understanding of 'background' conditions in the system.

3) The number of samples taken should be commensurate with the size of the project and its potential benefits and impacts to the environment. Many dam removal or breaching projects are also viewed as environmental restoration projects that will benefit environmental resources. Therefore, the more sampling and analysis effort required, the more expensive the project becomes. The goal should be to put together a sampling plan that gathers enough information, but does not present a financial barrier to the restoration project.

Riverways Program Assistance: Riverways can help to organize the various local, state, and federal agencies to develop a sampling plan that is reasonable and meets the project's goals. Riverways also has equipment that can be used to measure water depth, sediment thickness, and to collect sediment samples: Tiled sediment probe, soil auger, sediment coring equipment, digital depth sounder, auto level, tripod, survey rod, tape measures. Riverways can provide assistance with the "Due Diligence" review. A number of Quality Assurance Protocol Plans (QAPPs) have been developed that can be referenced to ensure proper sampling and handling for chemical analysis.

BOX 3

Potential Physical and Chemical Data to Collect for the Impoundment and Sediment Behind Dams

Note: The amount of information gathered should reflect the size of the project and the scale of the potential impacts. In general, small sites with small potential alterations do not need as much sampling as large sites with large potential alterations. Sediment sampling plans should be developed with inter-agency cooperation and consultation.

Sediment Volume
- Map Sediment Depths (depth to refusal and/or former stream channel and wetlands)
- Volume of impounded sediment
- Volume of sediment estimated to become mobile post restoration

Water Depths and Elevations
- Bathymetry of impoundment
- Water surface and stream bed elevations to upstream influence and to downstream channel

Sediment: Physical Parameters
- Grain size distribution
- Possibly organic matter and moisture content

Sediment: Chemical Parameters
- Based on 'due diligence', grain size, and likely sediment management options, test for:
- Total Organic Carbon (TOC)
- Inorganic Elements – Heavy Metals - Ar, Cd, Cr, Cu, Pb, Hg, Ni, Zn
- Polycyclic Aromatic Hydrocarbon (PAH)
- Extractable Petroleum Hydrocarbons (EPH)
- Poly-chlorinated Biphenyls (PCB)
- Pesticides
- Volatile Organic Compounds (VOC)
- Other parameters based on due-diligence review and site
  (e.g. former wood-pulp manufacturing sites – sample for Dioxin)
- Possible need for Toxicity Characteristic Leaching Procedure (TCLP)

SECTION II. EROSION AND TRANSPORT OF IMPOUNDED SEDIMENT

Key Questions:

- ✍ How much sediment is likely to erode and continue to move downstream?
- ✍ How much sediment is likely to stabilize and re-vegetate?
- ✍ What is the shape and character of the resulting upstream channels in the former impoundment?

Once the volume and the physical and chemical characteristics of the impounded sediment are known (**Section I**), the next steps are to 1) estimate the amount of sediment that will potentially erode and move downstream and 2) understand how the channel within the impoundment and downstream will respond to the dam removal or breach. Techniques to estimate the amount of sediment that may become mobilized vary in their complexity and their applicability. See BOX 4, which has a listing of general approaches and techniques used to estimate the sediment transport. Generally, the more complex techniques are more data intensive, which then requires more resources (e.g. time and money) to collect and analyze the data**.** **It is important to remember that most studies of dam removals or partial breaches in Massachusetts will not need highly complex sediment transport analysis.** Of course, the level of analysis should depend on the results of the contaminant analysis (high or low levels, see **Section III**), the sensitivity of downstream resources (e.g. rare species), and the amount of sediment relative to the size of the river (see **Section IV**). Many of the dams in Massachusetts are very small and the amount of sediment behind them will not likely warrant a highly complex modeling and analysis of sediment transport.

There are many sediment transport models and techniques that are appropriate for different situations and vary in their complexity and appropriateness. This report discusses only a few of these. The reader is referred to a chapter written by **Laura Wildman (American Rivers) and Jim MacBroom (Milone & MacBroom, Inc.) entitled, "Sediment Transport Relating to Dam Removal"** that is in a compendium entitled <u>Engineering Dam Removal</u>. Their chapter includes more technical detail focusing on the engineering aspects of dam removal and sediment modeling. Much of the summary here is from a draft of this document and various presentations given by the authors.

As illustrated in Figure 3, impoundments generally begin to fill in from the upstream end where coarse sediment (e.g. sand and gravels) from the upstream free-flowing section meet the quiescent waters of the impoundment, causing the sediment to settle out from the water column. The fine-grained sediment will move farther into the impoundment due to the size and slower settling rate, often filling up the areas closer to the dam. The sediment often will begin to create depositional features, or deltas in the impoundment (e.g. islands or bars) where vegetation can take hold and act to further trap sediment as it moves into the impoundment.

Of course, impoundments vary as to their trapping efficiency. Trapping efficiency is related to the ‘Hydraulic Residence Time’ (HRT), which is defined as the ratio of water volume behind the dam and the stream flow into the impoundment. A small impoundment on a large river will have a relatively short HRT (e.g. 30 minutes), which may mean that only coarse sediment (sand, gravel) will deposit in the impoundment while fines are transported downstream. On the other hand a large impoundment on a small stream will have a large HRT (e.g. 1 day) and will be more likely to slow the water enough to trap both coarse and fine-grained sediment. All dams alter the natural sediment transport in a river system, yet various characteristics, like the HRT, dictate how much the transport processes are altered and the pattern of sediment deposition in the impoundment.

The total volume of sediment trapped behind a dam may not become mobile if the dam is removed. Also, it is important to remember that the removal or breaching of the dam can be engineered and designed to retain and stabilize much of the sediment while still accomplishing the goals of the project (e.g. safety, fish passage, water quality, etc.). It is important to remember that excessive techniques, such as the overuse of large angular, non-native rock (rip-rap), gabion baskets, concrete sills and retaining walls, can often hinder the restoration of the river to a fully dynamic, self-sustaining, functioning system.

One of the biggest sediment management challenges is to estimate the amount of material that will become mobile with the removal or breach of the dam. Once this is estimated, it can be determined whether this amount will cause degradation of the downstream reaches through the release of contaminants (**Section III**) or physical degradation by inundating the downstream reaches with excessive amounts of sediment (**Section IV**). Sediment transport modeling techniques can help estimate whether the channel will be dynamically stable within the impounded sediment or if the channel will 'unravel' by head-cutting into pre-dam sediment (a relatively unique situation often caused if the channel below the dam has degraded since the dam was constructed, or due to other artificial obstructions within the impoundment such as a waterline crossing through the impounded sediment).

Impounded sediment will naturally redistribute downstream following a dam removal or breach, yet the pattern of redistribution will vary depending on a number of factors, such as the amount of sediment, the sediment grain-size and type, the amount of stream flow (discharge) and whether the system is high-gradient (steep) or low-gradient (flat). The stream discharge and the slope of the streambed directly relate to the capacity of the stream to move sediment, or the stream power. For instance, a stream with more discharge and steeper slopes will be able to transport higher volumes and coarser sediment than a small, flat stream. Sediment transport models incorporate these factors and help to estimate how much and what types of sediment may potentially be transported.

A promising and relatively simple technique to estimate the amount of sediment that will become mobile was developed and tested in Wisconsin (see University of Wisconsin and River Alliance, 2002 www.wisconsinrivers.org/SmallDams/FishAmericaFinalRpt_7Apr02_.pdf). The first step of this technique is to estimate the length of channel and side channels that will form in the impoundment. Then measure a number of stream cross-sections upstream of the influence of the dam and calculate an average bankfull width and cross-sectional area. Using this cross-sectional area, the length of stream that will form in the impoundment, and the sediment survey (see **Section I**), the volume of sediment available to become mobile can be calculated. Figures 4a and 4b give an illustration of an example map and cross-section using the University of WI techniques.

Figure 4a. Example impoundment, sampled cross-sections and predicted stream channel.

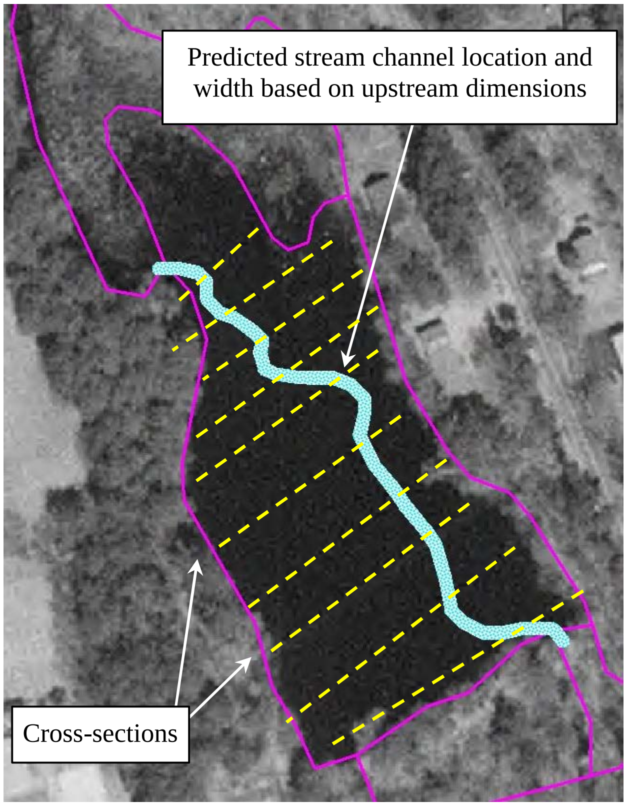
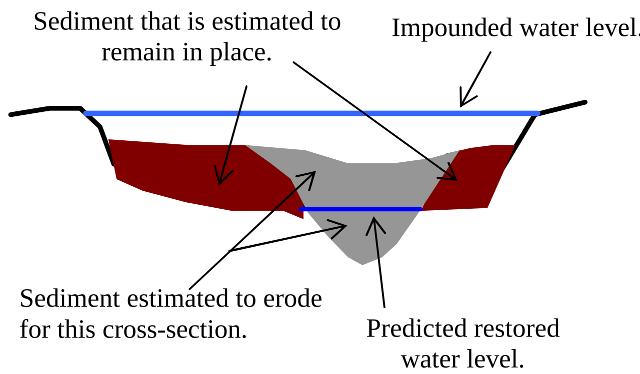


Figure 4b. Example cross-section and potentially mobile sediment portions.



Review of Selected Sediment Transport Models*

* This review has been excerpted from a review of sediment transport models, engineering students conducted for their CAPSTONE senior undergraduate design project at Tufts University. The Riverways Program and Tufts Civil and Environmental Engineering Department work in cooperation to identify projects evaluating various aspects of a potential dam removal or breaching project. See References for details on the CAPSTONE, Spring 2003 project.

More complex techniques make use of sediment transport equations and models. Upon the removal of the dam, the natural processes of erosion and deposition control how sediment moves through the former impoundment and the downstream river system. The following six models were reviewed by the Tufts CAPSTONE project (April 2003): EFDC, SED2D, HEC-6, GSTARS v2.1, HEC-RAS 3.1, and DREAMS.

EFDC Model

The Environmental Fluid Dynamics Code (EFCD) Sediment-Contaminant Transport Model is a public domain model that is maintained by Tetra Tech, Inc. (Stability Workshop, 2002). The model is a three-dimensional application designed for variable density fluids (i.e.

saltwater, freshwater, etc.). The model incorporates a transport-transformation equation that allows for proper representation of dissolved and suspended materials including sediment and pollutants. The model allows for accurate and detailed channel formations and is sensitive to the location of control structures and the impact of additional streamflows (i.e. joining tributaries). The model does have a few design features that impede its use with small projects. There are twenty-seven state variables required of the model in order to produce accurate transport conditions. Typical data available for most dam removal projects may not include many of these variables. For example, "time-varying concentrations of all water quality constituents in point sources," is required. To run the model effectively, our team would require daily concentrations of effluent released into the river of interest. The EFDC model also requires substantial information regarding the growth rate of algae, its settling rate, depth of algal production and basal metabolism. The model has been applied to studies in the Aberjona River, Massachusetts (however, it has not been applied to dam removal studies). (See www.hsrc.org/hsrc/html/ssw/sedstab/topic4/HayterTopic4c.pdf).

SED2D (TABS)

SED2D is a numerical sediment transport model developed by the U.S. Army Corps of Engineers Waterways Experiment Station (Boss 2003). The model is a two-dimensional application that makes use of a finite element mesh to provide solutions to transport problems. The model is improved from the older TABS models and provides more detailed predictions of deposition and erosion along a streambed. There are several drawbacks to the implementation of this mode. SED2D is a single sediment parameter model. A user may enter either sandy or clayey sediment into the model. The application must be run several times to incorporate streams that receive varying sediment grain size. The model does not provide new water surface elevations or stream velocities. Finally, control structures, such as dams, may not be inputted into the model. (See www.bossintl.com/html/sed2d.html)

HEC-6

Similar to SED2D, HEC-6 was developed by the U.S. Army Corps of Engineers. The HEC-6 model was developed to provide users of HEC and HEC-2 an opportunity to model sediment transport (Boss 2003). The one-dimensional model operates under steady-flow

conditions and requires basic data regarding sediment and flow regimes. One drawback to this model is the assumption of a fixed channel. The one-dimension of flow considered does not allow for the simulation of meanders within the river system. The model was designed to analyze long-term scour and deposition in a river system. This application may not accurately model initial sediment loss following the removal or breaching of a dam. The computer modeling program does not properly interpret the immediate loss of water from the impoundment and under predict the amount of sediment transported downstream. The computer model more appropriately predicts sediment transport following removal or modification of the dam, once the channel is established and better stabilized.
(See www.bossintl.com/html/hec-6-features.html and
www.hec.usace.army.mil/software/legacysoftware/hec6/hec6.htm).

GSTARS v2.1

The Generalized Stream Tube Model for Alluvial River Simulation (GSTARS) is a numeric hydraulic and sedimentation model developed for the U.S. Bureau of Reclamation to solve complex river engineering problems. GSTARS version 2.l has advantages over HEC-6 functionality. GSTARS is a two-dimensional model, which allows for channel movement (no fixed boundaries) in both the longitudinal and transverse directions. The model was designed to function under variable flows and treats unsteady flows in incremental steps based on the energy gradient. The model is sensitive to geometric inputs and flow regime data. The GSTARS model has generally been implemented in the Pacific Northwest and Rocky Mountain States and has been designed for the topography and sediment transport dynamics in these regions. Therefore, careful use of this model will be necessary if applying it to projects in Massachusetts. (See http://www.usbr.gov/pmts/sediment/gstars/2.1/)

DREAMs (Dam Removal Express Assessment Models)

The DREAMs models were created by number of cooperators, including the University of California at Berkley, National Oceanographic and Atmospheric Administration (NOAA) and Stillwater Sciences, Inc. Because many of the existing sediment models were not necessarily appropriate for dam removal evaluations and were not developed to assess the changes associated with dam removal, this group developed their own set of sediment

transport models. The models use existing sediment transport models and equations (e.g. HEC-6) as a base, but improve and expand on them. The 'DREAM' models may be more applicable to larger dams and rivers that have a large component of very coarse sediment (e.g. sand and gravel) and steep stream slopes. Also, because the software is proprietary, free use of the model may be contingent on NOAA involvement in the project.
(See www.stillwatersci.com/pubs/JoHRDREAMPart1.pdf)

HEC-RAS 3.1.1

HEC-RAS is another Army Corps of Engineers model and has incorporated many of the sediment transport functionality of their HEC-6 model and is more user friendly with a graphical user interface (not DOS-based as HEC-6). The HEC-RAS modeling program provides graphic output as well as tabular output that allow the user to more easily interpret and alter the sediment transport information. The HEC-RAS model is still a one-dimensional model that does not allow for the simulation of meanders or lateral changes to the river system. However, the program provides a sediment transport rating, which means that for a particular flow, the model will indicate the amount of sediment transported by the river system at each river reach. The model program differs from HEC-6 in that it can provide accurate initial sediment loss immediately following the removal of a dam.

Several sediment transport modeling options are included in the HEC-RAS package. These models include Ackers-White, Engelund Hansen, Laursen-Copeland, Meyer-Peter Muller, Toffaleti and Yang Sediment Transport Function for analysis. In this model, each transport equation was developed with different parameters and limitations. For example, the Ackers-White Transport Function was developed based on particle size, mobility and transport. The function is applicable to non-cohesive grain sizes larger than 0.04mm. In essence, the Ackers-White Function is limited to modeling transitory and coarse sediment. Another Transport Function, called the Toffaleti transport function was developed based upon the Einstein total load function. This function breaks the distribution of sediment within a flume or river into four vertical zones. The upper, middle, and lower zones were created to evaluate suspended loads while the bed zone evaluates bed sediment transport. The summation of the four independent zones represents the total sediment transport. The

Toffaleti function can analyze grain sizes as small as 0.095mm, but is not limited to non-cohesive sands. This function may be applicable to many rivers in Massachusetts where the grain sizes vary from clays to silt and sands. (see www.hec.usace.army.mil/software/hec-ras/hecras-hecras.html)

For the dam removal or breaching projects done thus far in Massachusetts, the sediment modeling has varied from simple estimation of what volumes might move to more complex sediment transport modeling exercise. For example, the Silk Mill Dam removal planned to remove the majority of the sediment, so there was no need to model sediment movements. The Acushnet River feasibility study used HEC-RAS to model water level elevations, velocities and depths based on the data from the Flood Insurance Studies as analyzed by Federal Emergency Management Agency (FEMA), along with some additional survey work. The output data from HEC-RAS was then be fed into a spreadsheet which calculated many of the critical sediment threshold equations (e.g. velocity and shear stress) which helped to predict if the sediment will become mobile (Milone & MacBroom, Inc.). (The newest version of HEC-RAS (3.1.1) will now allow most of these analyses and additional sediment transport equations to be done directly in the model.) See **Appendix I** for summaries.

It is important to remember that the scale of the analysis should match the size of the project. The amount of time and resources applied to modeling sediment transport should reflect the volume, contaminant levels (**Section III**), and impacts the sediment may have on the downstream resources (**Section IV**). There is no need to spend a lot of resources analyzing sediment transport if the sediment will have no long-term impacts or acute short-term impacts.

RECOMMENDATION FOR EVALUATION OF SEDIMENT EROSION AND TRANSPORT:
Based on experience thus far in Massachusetts, Riverways recommends:

1) Consult with Riverways and other local, state, and federal agencies to apply an appropriate technique to evaluate sediment erosion and transport for the particular site.

2) Use the University of Wisconsin method to estimate volume of sediment that may be available for transport. This requires understanding the channel size (e.g. typical cross-sectional area) from a free-flowing section of the river; an upstream or downstream stream reach that is outside the influence of a dam.

3) A more complex sediment transport analysis (e.g. HEC-RAS 3.1.1) may be necessary if:

   - Contaminants exist in the sediment at elevated levels and care must be taken to stabilize the sediment and not allow them to move downstream (**Section III**) OR,

   - There is potentially a large volume of sediment relative to the capacity of the river downstream (**Section IV**) OR,

   - There are sensitive downstream habitats or species (consult with Natural Heritage and Endangered Species Program – NHESP and the Division of Fish and Wildlife) (**Section IV**) OR,

   - Infrastructure (such as bridges, waterlines) that may be susceptible to scour (**Section IV**) OR,

   - Areas where potential stream bed aggradation may lower the flood capacity of the channel. (**Section IV**)

Riverways Program Assistance: Riverways can provide assistance in estimating the potentially mobile sediment volume using the University of Wisconsin model. Riverways can provide a copy of the FEMA studies for the rivers and towns of Massachusetts and potentially access to the original study data (e.g. input cross-sections) via the Department of Environmental Management's Flood Hazard Mitigation Program. These FEMA studies and the data collected for them are very useful and models such as the HEC-RAS 3.1.1 can utilize these FEMA data. Additionally, Riverways can provide access to other dam removal studies in Massachusetts, which discuss the ways in which sediment erosion and transport was predicted.

BOX 4
General Techniques for Estimating Sediment Transport

Based on information presented by Jim MacBroom (Milone & MacBroom, Inc.) and Laura Wildman (American Rivers) and from: Wildman, L. and J. MacBroom. Sediment Transport Relating to Dam Removal. chapter *in* Engineering Dam Removal.

Sources of Empirical Data

Conduct a controlled drawdown of water levels to monitor where sediment moves and where the channel forms within the impoundment.

Analyze historical photos of the stream prior to damming (generally aerial photographs are available starting from the 1930 and 1940's).

Use photographs of past dam repairs when the impoundment was drawn down.

Estimate sediment volume using sediment probes throughout the impoundment to determine depth to consolidated (pre-dam) riverbed

Measure channel geometry in comparable reference reaches and estimate the amount of sediment that will be eroded to form that size channel (see the Univerisity of Wisconsin Study example)

Profile Analysis

Use FEMA or surveyed profile of upstream and downstream slopes to estimate the slope of the river profile through the impoundment and calculate the amount of sediment mobilized. The assumption that there is no ledge or sharp grade break in the impoundment must be verified, generally with data from sediment probes throughout impoundment.

Regime Method

Calculate channel geometry based on equations using slope, discharge, grain size, etc. using techniques from:

– Lacey equations
– Leopold (USGS)
– Hey and Bray

Hydraulic Geometry Equilibrium

Calculate channel geometry using generalized versions of regime theory by region using techniques from:

– Leopold, Maddock, Wolman Data
– Regional Data
– Schumm Silt / Clay Factor
– Rosgen Classifications

Incipient Motion (What does it take to start the sediment moving or eroding?)

Calculate the stability of the channel sediment based on:

Threshold Velocity

What are the critical velocities which will initiate sediment transport?

Tractive Shear Stress

What are the critical shear stress values which will initiate sediment transport?

Sediment Transport Modeling

Calculates channel geometry and stability.

– Individual Cross Section
– Fixed Boundary
– Mobile Boundary
– 2 And 3 Dimensional Models

SECTION III: SEDIMENT EVALUATION: CONTAMINANT SCREENING

Key Questions:

- How do the contaminant levels compare to allowable contaminant thresholds?
- How do the levels compare with reference levels (e.g. upstream, downstream, or reference/ background)?
- Are the contaminants currently biologically available? Will contaminants become more biologically available with disturbance?
- Does the sediment need to be isolated (e.g. to decrease human exposure) or contained (e.g. capped)?
- Do the levels of contaminants require specific disposal actions?

In Massachusetts there are currently no general environmental testing or reporting requirements for impounded sediment. Nor does the state have any sediment screening criteria specifically addressing 'in-stream' sediment management of impounded sediment relative to dam breaching or removal. However, there are various sediment, soil, and dredged material standards and contamination criteria that we can look to for guidance in order to make in-stream sediment management decisions. For example, the dredging regulations (30 CMR 9.00) address re-use and disposal limits while other regulations set benchmarks for soil and sediment clean-up goals at contaminated sites (e.g. Massachusetts Contingency Plan (MCP), see below).

DEP has organized a helpful matrix that indicates the regulatory procedures and applicability for the activities and management scenarios under the state's dredged materials regulatory framework. This Dredged Material Regulatory Matrix is included in **Appendix II** for reference. This framework addresses dredged sediment and the placement, re-use or disposal of the dredged sediment in various locations. For example, there are established contaminant criteria/standards for re-use and/or disposal of dredged sediment in locations designated as beyond shoreline, lined landfills and unlined landfills (see Table 3). Though they fall under the jurisdiction of the DEP 401 WQC Dredging Regulations, there are no general contaminant standards used for aquatic or shoreline placement of dredged sediment and are evaluated on a case specific basis (see matrix). Furthermore, these regulations do not directly address how to evaluate the potential in-stream management scenarios (release or stabilization of impounded sediment) when dredging is not proposed. However, we can still refer to some of these contamination reporting limits and criteria for dredged sediment for general comparisons. Selected contaminants and various sediment, soils, and dredged material criteria/limits are listed in Table 3.

The primary law dealing with contaminated sites and release of oil and hazardous materials in the state is the "Massachusetts Contingency Plan" (MCP; *Massachusetts Oil and Hazardous Materials Release Prevention and Response Act or Chapter 21E and Implementing Regulations @ 310 CMR 40.0000*). However, MCP applies testing and reporting requirements only to 'soils' and not 'sediment' and defines these as:

> Sediment means all detrital and inorganic or organic matter situated on the bottom of lakes, ponds, streams, rivers, the ocean, or other surface water bodies. Sediment is found: (a) in tidal waters below the mean high water line as defined in the Wetlands Protection Act –WPA (310 CMR 10.23); and (b) below the upper boundary of a bank, as defined in WPA (310 CMR 10.54(2)), which abuts and confines a water body.

> Soil means any unconsolidated mineral and organic matter overlying bedrock that has been subjected to and influenced by geologic and other environmental factors, excluding sediment.

The soils at many locations throughout Massachusetts have been tested due to MCP regulations, which have established Reportable Concentrations for Soil for various contaminants (see RCS-1, RCS-2 www.state.ma.us/dep/bwsc/files/rcs_899.htm). There are some sites in Massachusetts where testing of the sediment has occurred because the upland soil at a site is believed to be an ongoing source of pollution to the waterway and its sediment (e.g. Housatonic River sediment has been tested in some locations because of a contaminated upland site). However, if no specific upland contaminated site is found adjacent to a waterway, the river or pond sediment is not routinely tested and therefore, very little is known about the distribution and extent of sediment contamination behind dams and in Massachusetts waterways.

Contaminant standards for soils may be useful for comparison with the levels in the impounded sediment, especially if the sediment may be de-watered and stabilized in-place as a management option. The impounded sediment would then become wetland or upland soil in the riparian area. MCP regulations set methods to characterize site risk, which take into account the specific set of exposure considerations for soils and groundwater at a site. Under Method 1, soil and groundwater standards are given for various soil and groundwater categories into which the site falls. Table 3 presents S-1/GW-1 and S-2/GW-2 for reference. Though no 'background' levels have been calculated for sediment in Massachusetts, one can look to the technical update from DEP describing the "Background Levels of Polycyclic Aromatic Hydrocarbons (PAHs) and Metals in Soil", which can be used as guidance for disposal site risk characterization (see Table

3). These 'background' levels may be appropriate to use when portions of the sediment are proposed to be de-watered and stabilized and thus function as soil.

Although, as discussed above, there are no specific testing or reporting requirements for sediment in Massachusetts, one can potentially refer to MCP Method 3 evaluation of site-specific risk characterization for general sediment contaminant benchmarks. DEP has recently accepted as final the *Freshwater Sediment Screening Benchmarks* (see **Appendix II** for full technical update) that were developed to be used during MCP Disposal Site Risk Characterization for assessing Environmental Risk. The benchmarks refer to the 'Threshold Effects Concentrations' (TEC), which are the concentrations below which harmful effects are unlikely to be observed in freshwater benthic (sediment-dwelling) organisms (see Table 3). The TECs are to be used in the "Stage I Environmental Screening" portion of the characterization. They are NOT necessarily protective of higher trophic level organisms (e.g. fish, piscivorous birds) exposed to bio-accumulating chemicals (e.g. PCBs, Mercury). Under MCP, exceedances of TECs would trigger the need for a Stage II Site-Specific Risk Characterization to evaluate harm and/or the risk of harm. Also, under MCP, if the site-specific risk characterization is being conducted for marine and estuarine environments, DEP continues to recommend comparing the sediment contaminant levels with the Effects Range-Low (ER-L) values from Long and Morgan (1991).

Other sediment screening criteria used throughout North America to evaluate the potential for impacts to freshwater benthic (sediment-dwelling) organisms are also useful for reference for additional information for screening sediment behind dams. These include the Threshold Effects Level (TEL), Probable Effects Level (PEL), and Probable Effects Concentration (PEC), which are the concentrations below which adverse effects are rarely observed, commonly observed or are expected, respectively. Some of these values are given in Table3.

We can potentially use these benchmarks to determine when the sediment does not need to be dredged because of contamination concerns. However, a portion of the sediment still may have to be dredged because of the physical impacts that may result from release of large quantities of sediment (see **Section IV**).

If the contaminant levels in the impounded sediment exceed the screening benchmarks then these levels can be compared with sediment quality upstream and/or downstream of the impoundment in the same river system. If the contaminant levels in the impoundment are less than or closely approach the levels in the upstream and/or downstream river reaches then release of the sediment may be considered a viable option because the sediment will not be 'degrading' the downstream reaches. However, the decision to allow sediment to naturally re-distribute must be made in consultation with many local, state, and federal agencies and stakeholders to assure that release of this sediment will not be negatively impacting important resources downstream.

As discussed above, there are no specific guidance standards that have been developed to inform in-stream sediment management decisions when removing or breaching a dam. For selected contaminants, Table 3 lists various soil and sediment standards, benchmarks, and reporting concentrations from a number of sources. It is important to use these various levels appropriately when comparing the contaminant levels in the impounded sediment. Below is a short description of the contaminants and the relevant standards listed in Table 3 along with where you can find more information.

Table 3. Various soil, sediment and dredged material quality guidelines, reporting limits, and criteria for selected contaminants. See descriptions above for interpretations.

See Descriptions and Interpretations Listed Below	Column (1)	Column (2)	Column (3)	Column (4)	Column (5)	Column (6)	Column (7)	Column (8)	Column (9)	Column (10)
	401 WQC Reporting Limit	Freshwater Sediment Benchmarks	Threshold Effects Level (TEL)	Probable Effects Level (PEL)	Probable Effects Concentration	Background "Native Soil"	MCP S1-GW1	MCP S2 – GW3	Lined Landfill	Unlined Landfill
Metals (mg/kg – ppm)										
Arsenic	0.5	9.79	5.9	17	33.0	20	30	30	40	40
Cadmium	0.1	0.99	0.6	3.53	4.98	2	30	80	80	30
Chromium	1.0	43.4	37.3	90	111	30	1,000	2,500	1,000	1,000
Copper	1.0	31.6	35.7	197	149	40	-	-	-	-
Lead	1.0	35.8	35	91.3	128	100	300	600	2,000	1,000
Mercury	0.02	0.18	0.17	0.49	-	0.3	20	60	10	10
Nickel	1.0	22.7	18	35.9	48.6	20	300	1,000	-	-
Selenium	-	-	-	-	-	0.5	400	2,500	-	-
Silver	-	-	-	-	-	0.6	100	200	-	-
Zinc	1.0	121	123	315	459	100	2,500	2,500	-	-
Polychlorinated biphenyls (µg/kg – ppb)										
Total PCBs	10	59.8	34.1	277	676	-	2,000	2,000	<2,000	-
PAH - Polycyclic aromatic hydrocarbons (µg/kg – ppb)										
Anthracene	-	57.2	-	-	-	1,000	1,000,000	2,500,000	-	-
Fluorene	-	77.4	-	-	-	1,000	400,000	2,000,000	-	-
Naphthalene	-	176	-	-	-	500	4,000	1,000,000	-	-
Phenanthrene	-	204	41.9	515	-	3,000	700,000	100,000	-	-
Benzo[a]anthracene	-	108	31.7	385	-	2,000	700	1,000	-	-
Benzo(a)pyrene	-	150	31.9	782	-	2,000	700	700	-	-
Chrysene	-	166	57.1	862	-	2,000	700	10,000	-	-
Dibenz[a.h]anthracene	-	33.0	-	-	-	500	700	700	-	-
Fluoranthene	-	423	111	2,355	-	4,000	1,000,000	1,000,000	-	-
Pyrene	-	195	53	875	-	4,000	700,000	2,000,000	-	-
Total PAHs	20	1,610			22,800	-	-	-	100,000	-
Total Petroleum Hydrocarbons (TPH) **(mg/kg – ppm)**							200	2,000	5,000	2,500
Total Volatile Organic Compounds (VOC) **(mg/kg – ppm)**							-	-	10	4
Organochlorine pesticides (µg/kg – ppb)										
Chlordane	-	3.24	4.5	8.9	17.6	-	1,000	2,000	-	-
Dieldrin	-	1.90	2.85	6.67	-	-	30	40	-	-
Sum DDD	-	4.88	3.54	8.51	-	-	2,000	3,000	-	-
Sum DDE	-	3.16	1.42	6.75	-	-	2,000	2,000	-	-
Sum DDT	-	4.16	-	-	-	-	2,000	2,000	-	-
Total DDTs	-	5.23	6.98	4,450	-	-	-	-	-	-
Endrin	-	2.22	2.67	62.4	-	-	600	1,000	-	-
Heptachlor epoxide	-	2.47	0.6	2.74	-	-	60	90	-	-
Lindane	-	2.37	-	-	-	-	-	-	-	-

Description of standards/benchmarks, reporting concentrations listed in Table 3:

Table 3. Column 1: 401 WQC Reporting Limits
Source: DRAFT Reporting Limits for 314 CMR 9.00: 401 *Water Quality Certification For Discharge of Dredged or Fill Material, Dredging, and Dredged Material Disposal In Waters of the United States Within the Commonwealth of Massachusetts*. See **Appendix II** for most recent DRAFT.

Interpretation Note: These levels are simply reporting limits for sediment that will be dredged under the 401 Water Quality Certification.

Table 3. Column 2: Freshwater Sediment Benchmarks
Source: Freshwater Sediment Screening Benchmarks for Use Under the Massachusetts Contingency Plan; Update to: Section 9.4 of *Guidance for Disposal Site Risk Characterization – In Support of the Massachusetts Contingency Plan* (1996); Use of Sediment Screening Criteria in a Stage I Environmental Risk Characterization.
(see **Appendix II** or www.state.ma.us/dep/ors/files/sedscrn.doc)

Interpretation Note: For use when characterizing environmental risk using Method 3 of MCP. Sediment quality guidelines for metals in freshwater ecosystems that reflect Threshold Effects Concentrations (TEC): concentrations below which harmful effects on benthic organism are unlikely to be observed.

Table 3. Columns 3 and 4: TEL and PEL
Source: reported in Breault et al., 2000, originally from Ecosystem Conservation Directorate Evaluation and Interpretation Branch, 1995. see **Reference**s below.

Interpretation Note: Bottom sediment quality guidelines and their relation to the potential frequency of adverse effects on benthic organisms.
- TEL: Threshold Effects Level, concentration below which adverse effects are rarely observed
- PEL: Probable Effects Level, concentration at which adverse effects are commonly observed

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Table 3. Columns 5: PEC
Source: reported in Zimmerman and Breault, 2003, originally from U.S. EPA, 2000. see **References** below.

Interpretation Note: Bottom sediment quality guidelines and their relation to the potential frequency of adverse effects on benthic organisms.
- PEC: Probable Effect Concentration, concentration above which adverse effects are expected

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Table 3. Columns 6: Background "Natural Soil"
Source: Background Levels of Polycyclic Aromatic Hydrocarbons and Metals in Soil Updates: *Section 2.3 Guidance for Disposal Site Risk Characterization – In Support of the Massachusetts Contingency Plan*.
See www.state.ma.us/dep/ors/files/backtu.pdf

Interpretation Note: DEP has obtained background data from various sources documenting the concentrations of PAHs and metals in soil. These default background levels cover both "natural" soils and soil affected by human activities, particularly soil associated with wood and coal ash. There is not one concentration of a chemical, of course, which can correctly be labeled ***the*** background level. Hundreds of years of human activities have only broadened the naturally occurring range of concentrations reported as "background", and this range is best thought of as a statistical distribution. In the evaluation of environmental contamination, we often select point values from the range of background levels, and consider these to be representative of background. The use of such point-value "background" levels is essentially a short-cut method that allows consideration of background in the absence of site-specific information. The intent of DEP policy is to protect public health while minimizing the routine site-specific determinations at sites in the statewide cleanup program. Table 3 lists on the "Natural Soil" levels, see website for listing of concentrations in "Fill Material".

Table 3. Columns 7 and 8: MCP S1-GW1 and MCP S2-GW3
Source: Massachusetts Contingency Plan 310 CMR 40.000; Method 1 – site risk characterization soil and groundwater standards, see Table 2, 3 and 4 of 310 CMR 40.0970 www.state.ma.us/dep/bwsc/files/310cmr40.pdf for full listing.

Interpretation Note: MCP Method 1 soil standards consider both the potential risk of harm resulting from exposure to the oil and/or hazardous materials in the soil and the potential impacts on the groundwater at the disposal site.
- MCP S1-GW1: S1: Soil category 1, which is the most strict soil use where the soil is accessible or potentially accessible with human receptors present with varying frequency-intensity of use depending whether a child or adult (see 310 CMR 40.0933(9) AND GW-1: Groundwater category 1, which is within a current or potential drinking water source area (see 310 CMR 40.0932 for more details).

- MCP S2-GW3: S2: Soil category 2, which are soils where the soil is accessible or potentially accessible with human receptors present with varying frequency-intensity of use depending whether a child or adult (see 310 CMR 40.0933(9) AND GW-3: Groundwater category 3, minimum level where groundwater is expected to discharge to surface water, (see 310 CMR 40.0932 for more details).

Table 3. Columns 9 and 10: Lined Landfill and Unlined Landfill
Source: *COMM-94-007: Interim Policy for Sampling, Analysis, Handling and Tracking Requirements for Dredge Sediment Reused or Disposed at Massachusetts Landfills*.

Interpretation Note: If all contaminants in the material are below the "Table 1" Criteria (and the material does not have significant concentrations of "other contaminants" not included in "Table 1" (e.g., dioxin)), AND the landfill where the material is to be placed complies with its permits and operating requirements, than no specific DEP approval is required for re-use or disposal at lined or unlined landfills. This does not necessarily mean that soils/sediment with contaminant concentrations above the Table 1 criteria cannot be reused or disposed at the landfill; it just REQUIRES a specific DEP approval.

Contaminants and their potential toxicity

The USGS sediment sampling report discusses the use of the consensus-based contaminant criteria, and the PEC, or Probable Effect Concentration, or that concentration above which adverse effects on benthic organisms are expected (see Table 3). They then divide the resulting concentration of the sediment samples by this PEC to get a quotient or proportion of the expected toxicity. The PEC quotient can be calculated for each contaminant of concern and then can be averaged to get what is called the Mean MPP. In their study, USGS calculates the Mean MPP using metals, PAH, and PCB. The resulting value can be compared with values associated with sediment of known toxicity to such standard test organisms as the amphipod *Hyalella azteca*, or the insect larvae, *Chironomus sp*. With this method, an estimate of the sediment toxicity can be calculated without going through the expense of additional biological assessment. See the USGS report for more details: http://water.usgs.gov/pubs/wri/wri034013/.

BOX 5

Websites: sediment criteria and ecological risk assessment

NJ Sediment Quality Evaluations (based on the 'Ontario Guidelines')
http://www.state.nj.us/dep/srp/regs/sediment/table_01.htm (Freshwater Sediment Screening Guidelines)
http://www.state.nj.us/dep/srp/regs/sediment/table_02.htm (Marine.Estuarine Sediment Screening Guidelines)

Ontario Ministry of the Environment:
Lowest Effect Level (LEL) and Probable Effect Level (PEL):
http://www.ene.gov.on.ca/envision/decomm/append_e.pdf

EPA - Great Lakes National Program - Assessment and Remediation of Contaminated Sediment (ARCS):
http://www.epa.gov/glnpo/ (GLNP home page)
http://www.epa.gov/glnpo/arcs/EPA-905-B94-002/B94002-ch1.html (ARCS Assessment Guidance Document)
http://www.epa.gov/glnpo/sediment/gltem/index.html (Dredged Material Testing & Evaluation Manual)
http://www.sediments.org/ Ecotoxicological Screening Benchmark Tables and calculator

USACOE - USEPA Inland Testing Manual: http://www.epa.gov/ost/itm/itmpdf.html

USGS: focus on Sediment Toxicity: http://www.cerc.cr.usgs.gov/pubs/sedtox/

NOAA references:
Effect Range Low (ERL) and Effect Range Median (ERM) values:
http://www.nwn.noaa.gov/sites/hazmat/cpr/sediment/SQGs.html
Screening Quick Reference Tables: http://www.nwn.noaa.gov/sites/hazmat/cpr/sediment/squirt/squirt.html

Oak Ridge National Laboratory
Sediment benchmarks: http://www.esd.ornl.gov/programs/ecorisk/ecorisk.html

Comparing the contaminant levels in the impounded sediment with the sediment screening values or the other potential benchmarks (Table 3) is a good start to understanding the potential ecological impacts of a particular sediment management option. However, the biological availability of contaminants should also be considered when making sediment management decisions. For example, benthic organisms may only be exposed to sediment in the top six inches simply because they are only active in this layer (e.g. oxygen levels may prevent them from inhabiting deeper sections).

Because of the history of use of toxic pollutants, the deeper sediment (e.g. older) may be more contaminated than the more recent sediment (e.g. shallower). Disturbance of the deeper sediment may release contaminants into the water column at higher concentrations than they otherwise would be if left in place. In certain impoundments, sediment may be continually re-suspended during flood events, thereby releasing contaminants periodically. For many contaminants researchers do not understand all the factors that cause a contaminant to move up or down in the sediment and water column. A full discussion of toxicity and biological availability is outside the scope of this report, but it should be acknowledged and explored during the sediment management decision-making process in situations dealing with contaminated sediment.

RECOMMENDATION FOR SEDIMENT EVALUATION: CONTAMINANT SCREENING

Based on experience thus far in Massachusetts, Riverways recommends:

Consult with DEP, Riverways and other local, state, and federal agencies to decide the most appropriate sediment management options relative to the contaminant levels in the impounded sediment when considering dam removal or breaching.

1. In general, release and natural distribution of impounded sediment may be considered when:

   The contaminants are below or closely approximate the most appropriate sediment screening criteria/benchmarks: DEP Freshwater Sediment Benchmarks, Effects Range Low (ER-L) (if estuarine/marine habitats downstream), or TEL, PEL, PEC and sediment does not contain mercury, pesticides or PCBs or other constituents that would bioaccumulate;

   OR

Impounded sediment is not substantially different from downstream levels and the release is not expected to increase contaminant levels significantly downstream.

2. In general, dewatering and stabilization of impounded sediment may be considered when:

   The contaminants in the impounded sediment are below or closely approximated the DEP Background Soil levels.

   OR

   The contaminants in the impounded sediment are below or closely approximate the appropriate MCP soil/groundwater category for the newly exposed sediment AND the newly exposed sediment is not substantially different from adjacent soil levels. For example, if the sediment will be de-watered when the dam is removed, stabilized, and re-vegetated and the site will get frequent use from children and it is in the groundwater recharge area of a public drinking supply well, then MCP S1- GW1 levels might be the most appropriate.

Riverways Program Assistance: Riverways can help coordinate with the local, state and federal agencies that will review which sediment standards to use and evaluate how sediment is to be managed relative to contaminants.

Note: Due to the lack of data on contamination levels in impounded sediment (for reasons discussed above), the Riverways Program recommends an ongoing program to screen for sediment contamination behind dams in Massachusetts. Riverways, through a grant from the Massachusetts Environmental Trust (MET) is developing an Index of Environmental Risk, which considers the impact to environmental resources if a dam were to fail (see www.state.ma.us/dfwele/RIVER/riv_toc.htm for more information). The potential to release contaminated sediment is a part of this risk to environmental resources. The work hopes to identify methods to rank dams as to their potential for contamination (e.g. contaminant sources in the watershed, and impoundments with high sediment trapping potential). By tackling this problem proactively, an understanding of the contaminants behind dams will inform the Massachusetts Office of Dam Safety and state and federal environmental agencies where there are potential environmental hazards if a dam were to fail and where impounded sediment continues to contribute to the degradation of environmental quality. An ongoing sediment sampling effort will also help build the information base on which to make future sediment management and dam removal decisions.

SECTION IV. SEDIMENT EVALUATION: POTENTIAL PHYSICAL IMPACTS

Key Questions:

- How do the potential sediment loads compare to what the river 'naturally' transports (natural sediment transport capacity)?
- Are there sediment-sensitive downstream habitats and species?
- Are there any structures that may be impacted upstream or downstream of the dam through undermining and scour or capacity reduction?

If it has been determined that the sediment may be released and naturally re-distributed based on sediment chemistry (**Section III**) then it must be determined whether any long-term physical impacts may result from releasing the sediment. It is important to understand the characteristics (timing and volume) of how a river naturally transports sediment through the watershed so that the amount of sediment estimated to become mobile when removing or breaching a dam can be analyzed and compared with this natural capacity to move sediment. Many of the same techniques used to evaluate sediment transport in the former impounded section can also be applied to the downstream channels to understand sediment dynamics. For instance, by continuing the sediment modeling into the downstream channel you will illustrate where sediment may deposit or if the sediment will begin to bury habitats and aggrade over time. Because channel aggradation changes the cross-sectional area and, therefore, the flood capacity of the stream, released sediment may also increase the chances of downstream flooding and should be considered in the sediment management decisions.

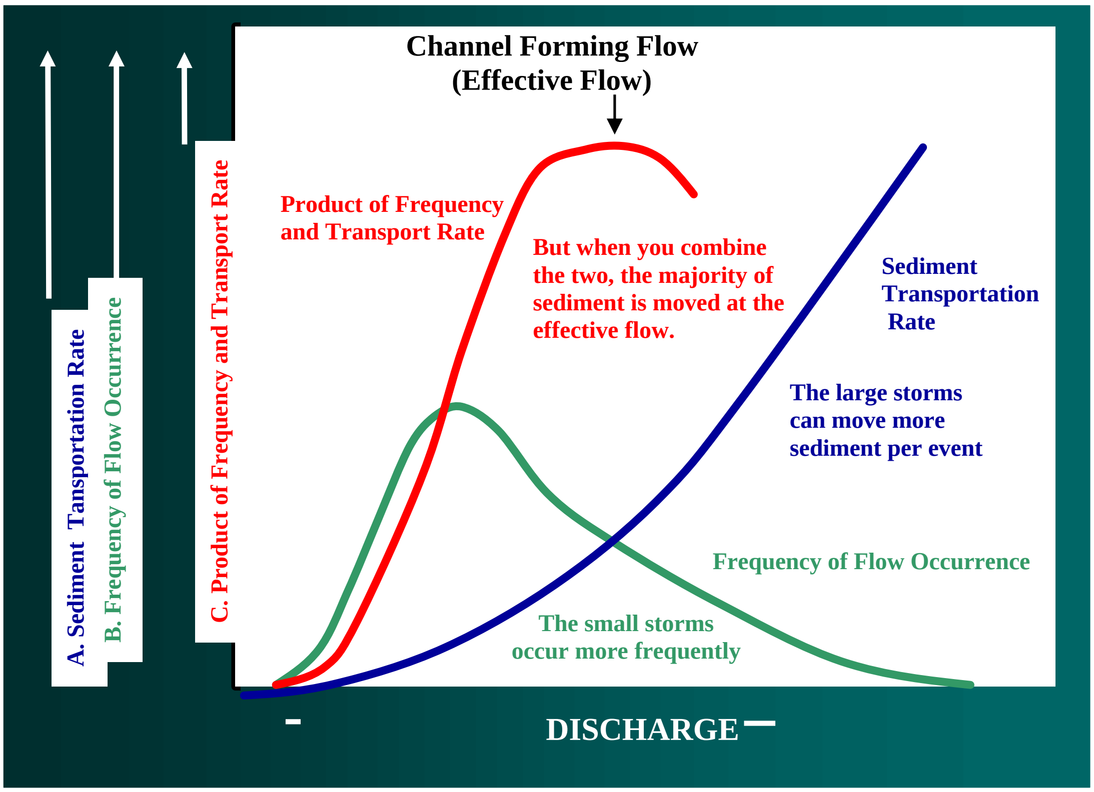
Pizzuto (2002) summarized the two main processes of downstream sediment movement after a dam is removed or breached. The released sediment may decay in-place, by slowly dispersing the sediment downstream over time. Conversely, the impounded sediment may move downstream through a process of translation, or as a coherent wave that moves downstream as a pulse and does not decrease in magnitude. These will have different impacts on the downstream channel and biota. For example, relatively large impacts may result from a sediment pulse translation because of the large volume inundating habitat, but the impacts may be short-term because the passing sediment wave continues to moves downstream without remaining in place. Conversely, when sediment is slowly dispersed effects may be smaller (less sediment at one time), but may continue to impact the system for a longer time.

In general, sediment transport occurs in the river system either as suspended sediment (clay, silt and fine sand) in the water column (sometimes the dissolved fraction is included in this) or as bedload (sand, gravel, cobbles) transported along the river bottom. Sediment yields for watersheds vary based on the capacity of the river to transport the sediment and the sources of sediment to the system. For example, a watershed with a high percentage of row crop agriculture and roads or housing construction has more soil erosion occurring than in an undisturbed forested watershed that leads to the sediment in the river system. Of course, the physical characteristics of the river itself dictate how much it can transport. For example, a larger (more discharge) and steeper river system has the capacity to move more sediment than a smaller, slower moving river.

The timing and volume of natural sediment transport are important characteristics to understand so that these can be compared to the predicted sediment loads during and after dam removal or breaching. For example, large floods will often carry a large portion of the annual sediment yield in one event. Indeed, Bent (2000) found that the suspended-sediment load over a two-day rain event transported about 27% of the total load for the entire two-year study of a number of river study sites in Western Massachusetts. Shortly after a dam is removed or breached, sediment loading to the stream will be the highest and therefore, it may be useful to compare this sediment load to that of various flood events. For example, the sediment load after a dam removal may be equal to the amount of sediment moved during a 5, 10, 50, or 100-year flood event. This gives the resource managers and biologists a frame of reference to determine whether this will be a problem for the river system.

However, because small floods occur more often they will, over time, be the primary mechanism by which the majority of sediment is transported through the system. The intersection of the amount of sediment a storm transports and the frequency with which it occurs gives an idea of the channel forming flow. Figure 5 is a conceptual graph showing the sediment transport rate, the frequency of flow occurrences and the product of these two. The shape and slope of the lines will vary depending on the region and watershed characteristics (e.g. basin slope, surficial geology, etc), but there will generally be a certain discharge that is considered the ‘effective flow’ or ‘channel forming discharge’. This is the flow occurrence (e.g. a 1.5 year return interval) that transports the majority of the sediment in the system. The channel that will form after the dam removal will be formed, in large part, based on this discharge which moves the most sediment over time.

Figure 5. Sediment Transport rate and flooding frequencies determine the channel forming flow where most of the sediment is moved. (Figure from Laura Wildman, American Rivers, modified from Rosgen (1996) and Wolman and Miller (1960).



These sediment transport and discharge rates (Figure 5) will not usually be available because long-term sediment gage data are necessary to create these graphs and these sediment gages will rarely be available near a project site. Sediment gages are used to estimate sediment concentration (mg/L), load (tons), sediment discharge (tons/day), and yield (tons/mile^2/day). In the Northeast U.S. there has not been as long a history in researching sediment transport as in other parts of the country where empirical studies have resulted in regression equations used to estimate sediment load and yield. A few estimates of sediment yield exist from older regional studies, which show a range of 30 to 1,210 ton/mile^2/year in the North Atlantic region where Massachusetts is located (see Tables 4 and 5).

Table 4. Sediment yield from drainage areas of 100 mile^2 or less of the U.S. (from U.S. Water Resources Council 1968, Part 5, Chap. 5, p.4) (subset of the regions are shown here).

Region	Estimated Sediment Yield (tons/mile^2/year)		
	High	Low	Average
North Atlantic	1,210	30	250
Great Lakes	800	10	100
Ohio	2,110	160	850

Table 5. Land use, region and sediment yields as measured throughout the United States from 1980 – 1989. (source: Jim MacBroom presentation)

Land Use: 1980 – 1989	Suspended Sediment Yield (tons/mile^2/year)
Ag – Wheat	10
Ag – Corn and Soybeans	100
Ag – Mixed	79
Urban	23
Forest	31
Range	33
Region: 1980 – 1989	
North Atlantic	32
Great Lakes	36
Ohio-Tennessee	85

More recent and geographically relevant studies that are available for comparison are the studies conducted by USGS on two rivers in Connecticut for water years 1982 – 1986; see Table 6 (Morrison 1998). Also, another study by USGS collected data on the suspended-sediment characteristics in the Housatonic River Basin in MA from 1994 – 1996 (Bent 1996). Table 7 shows the loads and yields for the watersheds studied (both continuous records and partial records).

There have been other sites throughout the Northeast U.S. where sediment data have been collected, yet the data have not been published or reported in research or agency studies. The sediment data for many of these gaging sites are kept in the USGS sediment and water quality data website; for more information see http://water.usgs.gov/osw/sediment/datasummary.html and http://webserver.cr.usgs.gov/sediment/). Potentially, there will be a site that has sediment data near a project or from a site with similar watershed and river characteristics. If so, the partial data series can allow you to estimate what the annual yield or typical daily loads may be.

Table 6. Suspended-sediment loads and yields in the Salmon and Coginchaug River Basins, Central CT. Measured for water years 1982 – 1986. (Morrison, 1998).

Site	Watershed Size ($mile^2$)	Total Load for study period – Apr 1994 to Mar 1996 (tons)			Yield for study period ($tons/mile^2/year$)		
		minimum	mean	maximum	Minimum	Mean	maximum
Salmon River	100	1,060	27,500	116,000	10.6	276	1,160
Coginchaug River	29.8	276	876	1,640	9.3	29.3	55

Table 7. Suspended sediment loads and yields from USGS (Bent 2000), Western, Massachusetts.

	Site	Watershed Size ($mile^2$)	Total Load for study period – Apr 1994 to Mar 1996 (tons)	Yield for study period ($tons/mile^2/year$)
Continuous record series	Housatonic River near Great Barrington	282	11,603	21
	Green River near Great Barrington	51	7,929	78
	Housatonic River near Ashley Falls	465	54,347	58
Partial record series	Williams River near Great Barrington	43.2	3,052	35
	Ironworks Brook at Sheffield	11.2	1,758	78
	Konkapot River at Ashley Falls	61.1	17,927	147

The University of Wisconsin study cited earlier (**Section II**) estimated the volume of sediment that may become mobile and then estimated the mass of this sediment at a number of sites in order to compare the released sediment to the annual sediment yield for their respective rivers. Their report gave the densities of clay (26 lb/ft^3), silt (70 lb/ft^3), and sand (97 lb/ft^3) as impounded sediment in order to convert the volume and percentage sediment fraction (from grain size analysis) into an estimate of mass. The mass of sediment can then be compared to the annual yield of sediment typically transported in the river system. In the University of WI study, they found that the amount of sediment released from the dams was 1.5 to 10 times the annual sediment transported by those rivers. However, some caution should be taken when comparing these numbers. In general, sediment yield studies have calculated only the suspended sediment fraction of the sediment load and do not account for the bedload moving through the system, or that fraction that rolls or skips along the streambed and is not in suspension or dissolved. To correct for this, suspended sediment yield should be compared to the fine sand, silt and clay fraction, which are generally transported as suspended sediment. The remaining portion of the sediment (medium to coarse sand, gravel, cobbles, boulders, etc.) will be generally transported as bedload (except for large flooding events when sand can be in suspension).

In order to make comparisons for the Massachusetts sites (see Figure 1), the University of Wisconsin model was used to calculate the mass of impounded sediment from the reported volumes and grain size distribution for these impoundments. The fraction of fines (silt and clay) and coarse sediment were averaged for the samples and used to distinguish between potential sediment export as suspended sediment (fines) and as bedload (coarse sediment). These are reported in Table 8. The total sediment volume for each impoundment was used to calculate the most conservative estimate if all sediment were to become mobile. However, only a small fraction of the impounded sediment has been allowed to move downstream for the dam removal/breaches conducted thus far in Massachusetts.

The range of 21 to 147 tons/mile^2/year in annual sediment yields from the USGS study (Bent 2000, Table 7) can be used to compare to the values calculated in Table 8 for the potential mass exported. Though coarse sediment (sand) can be transported as suspended sediment on occasion, it is more appropriate to compare the silt and clay fractions in the impoundment than the total volume of sediment that may include coarse sands and gravels. The coarse fraction of the impounded sediment will not be transported as suspended sediment, but rather it will be moved through the system as bedload along the channel bottom. The comparison of the fine sediment fraction with the yields calculated in the Bent (2000) study resulted in 0.1 to 1.5 times the annual sediment yield potentially being released from the impoundments. However, as discussed in the sediment summaries in **Appendix I,** for all the dams removed or breached in Massachusetts thus far, the total sediment volume was not released and most of the sediments were either dredged and re-use/disposed of or stabilized in place.

Table 8. Conversion of sediment volume to sediment mass for fines and coarse sediment for selected Massachusetts impoundments using University of WI method.

Site[a]	Total Sediment Volume[b] (yards^3)	Drainage Area (mile^2)	Fines[c] (%)	Coarse Sediment[c] (%)	Total Mass of Fines per Area[d] (tons/mile^2)	Total Mass of Coarse Sediment per Area[d] (tons/mile^2)
Old Berkshire Mill Dam	5,000	55	8	92	2	110
Billington Street Dam	1,500	5.5	20	80	35	287
Sawmill Dam	7,400	18.7	41	59	106	304
Hamlin Street Dam	4,500	16.4	35	65	60	228
Perryville Pond Dam	71,000	94	36	64	227	628
Silk Mill Dam	1,600	8.4	5	95	9	236
Ballou Dam	800	8.6	10	90	8	110

[a] Site descriptions are in **Appendix I**.
[b] Volume is the entire impounded sediment and not the potentially mobile or dredged portion.
[c] Average percentage fines for all sediment samplers for each site and includes silt and clay. Coarse sediment includes particles larger than silt (i.e. >0.075 mm, sand, gravel, etc.)
[d] Estimates using densities given in University of WI report.

Depending on the type of river system and how the sediment 'pulse' moves downstream (see earlier discussion of dispersion versus translation), a bigger concern may be the medium and coarse sand fractions of the impounded sediment that are transported as bedload and not as suspended sediment. These sands may take longer to move through the system and may build up the stream channel as they cover important habitats for longer periods of time, whereas the small particles will cause only temporary turbidity issues. This impact from either the fines (silt and clay) or the sand fraction will be dependent on the river system. If the sediment released complements or matches the sediment grain-sizes in the downstream areas, the organisms in the downstream habitats will likely be less impacted because they are adapted to this type of sediment. For example, if the river system is largely dominated by fines the organisms in the downstream area are likely adapted to these fines and fines released from the site will not impact them as much. Conversely, if the downstream system is normally dominated by gravel and cobble, then release of fines may cause the channel to become highly embedded if too much sediment covers these habitats. For the majority of dam removals cited in Hart et al. (2002), the observed effects of increased sediment transport resulted in only temporary impacts followed by downstream improvements to the biota.

Additionally, when considering the consequences of allowing the sediment to naturally redistribute, it is important to know if there are sensitive habitats downstream of the site and how they respond to high sediment loads. For example, there may be rare freshwater mussels downstream. These aquatic organisms can become smothered by sediment and because they are not highly mobile, isolated populations may be susceptible to local extirpation. Indeed, the one exception to the downstream improvements from dam removal summarized by Hart et al (2002) was a case in which a decrease in freshwater mussel abundance due to sedimentation was observed (Johnson 2001). In some cases, these organisms can be collected and released in appropriate and safe habitat prior to removing the dam and releasing sediment. In the long-term the removal and restoration project will likely result in more natural, self-sustaining habitats in addition to restoring connections to upstream populations.

Dam removal project partners should always consult with resource managers and biologists as to how much sediment may or may not overwhelm the downstream system. They are very familiar with the streams and will have a good sense of what is too much sediment for a given timeframe. The regional fish biologists for the Massachusetts Division of Fisheries and Wildlife have commented on past projects and should be consulted closely. Also, if rare and endangered species may be impacted in the impounded or downstream reaches by sediment or other alterations, biologists from the Natural Heritage and Endangered Species Program should be consulted. For the dam removals that have occurred thus far in Massachusetts, the short term impacts of the limited amount of sediment released were expected to be low as compared with the long-term benefits of dam removal and a free–flowing system.

As with the decisions made regarding contaminant levels, the assessment of the potential physical impacts of sediment on the downstream channel should involve multiple agencies at the local, state, and federal levels.

RECOMMENDATION FOR SEDIMENT EVALUATION: PHYSICAL IMPACTS

Based on experience thus far in Massachusetts, Riverways recommends:

Use the University of Wisconsin method to estimate the mass of impounded sediment that is potentially mobile. Calculate the mass of fines (silt and clay) separately from the coarse fraction (sand and gravel). Compare the mass of fines with the suspended sediment yields for a similar river system. Look for sediment gages or studies for streams with similar watershed characteristics, such as similar eco-region, similar basin slope, and similar land uses. If no gages or studies exist, use the ranges of sediment yield found in Morrison 1998 and Bent 2000.

In the absence of site-specific data, in general, the mass of fines (silt and clay) released from the impoundment should not exceed the estimated annual suspended-sediment yield. However, resource managers and biologists should be consulted to determine what amount of impounded sediment can be released without long-term impacts to the system. They should also be consulted as to the appropriate timing (e.g. avoid spawning season for sensitive species) to release impounded sediment in order to minimize short-term impacts.

If sensitive habitats, species or environmental resources are present in the impoundment or downstream; such as rare and endangered aquatic species or natural communities; coldwater fisheries habitats; surface water withdrawals; or water supply reservoirs, resource managers and biologists should be consulted as to the amount and timing of released sediment. Actions may need to be taken to minimize the amount of sediment released or the dam removal or breach may need to be planned to coincide with the least sensitive time of year.

Identify locations where sediment aggradation may increase local flooding or scour: such as bridges and culverts that already constrict or narrow the waterway; or areas where retaining walls or other infrastructure narrow and constrain the channel. The mass and volume of coarse-grained sediment may be more important to analyze for this potential impact. Additional sediment transport modeling may need to be done to predict impacts on the infrastructure and flooding capacity.

Riverways Program Assistance: Riverways can assist in the location of potential sediment gages or studies of the suspended-sediment near the study site. Riverways can also assist in applying the University of Wisconsin techniques to assessing impounded sediment. Riverways can help coordinate communication with the other state and federal agencies and biologists that will help determine how much sediment the downstream system can assimilate without long-term impacts.

SECTION V. SEDIMENT MANAGEMENT PLANS

After going through the steps outlined above: sediment sampling (**Section I**), sediment erosion and transport modeling or estimation (**Section II**), and evaluation of impounded sediment impacts relative to contaminants (**Section III**) and physical degradation (**Section IV**) a sediment management plan can be developed. As with all the steps thus far, the sediment management plan should also involve consultation with local, state and federal regulatory agencies and organizations. **Appendix I** summarizes the sediment management plans for selected dam removal/breaches in Massachusetts. A sediment management plan will answer many of these questions:

1) What local, state, and federal permits and environmental review are necessary?
2) Will sediment be allowed to naturally re-distribute (be released) downstream? How much?
3) Will sediment be stabilized? How much?
4) Will sediment be stabilized with channel grade controls, re-vegetation, etc.?
5) Will sediment be dredged or excavated prior to or following drawdown of the impoundment?
6) Where and how will the dredged sediment be re-used or disposed?
7) Will the work be done in phases?

The sediment management options for dam removal include "in-stream" and "dredge and re-use/dispose". Generally, the Dredge and Re-use/Disposal Management options are fairly well established. In fact, as discussed earlier, DEP has a regulatory framework for dredged sediment (see **Appendix II**). However, dredging all of the sediment from impoundments in association with dam removal or breaching may be quite expensive and possibly unnecessary because the river can naturally re-distribute and attenuate the sediment on its own. The 'In-stream' sediment management options may be considerably cheaper and therefore more dam removal or breaching projects can be undertaken, thus allowing more rivers in Massachusetts to be restored. This report has laid out a framework for making decisions regarding the 'in-stream' sediment management of impounded sediment when removing or breaching a dam. Box 6 summarizes the contaminant and volume criteria for the general categories of 'in-stream' sediment management options. Please refer to the appropriate sections of this report for the full description and recommendations. Of course, all sediment management decisions associated with dam removal or breaching should be made in consultation with DEP, Riverways and other local, state, and federal agencies.

BOX 6

Summary of Riverways Recommendations for In-Stream Sediment Management Options for Dam Removal

All sediment management decisions associated with dam removal or breaching should be made in consultation with DEP, Riverways and other local, state, and federal agencies.

'In-stream' Management

- ✍ Natural river erosion
  - ? Allow the sediment to move downstream on its own to naturally re-distribute and form its own channel through the sediment
    Contaminants: Do not exceed sediment benchmarks and sediment does not contain constituents that would bioaccumulate OR similar to downstream levels and will not increase contaminant concentration significantly
    Volume: Volume of fines less than annual suspended sediment yield
    Restrict released sediment if: Sensitive habitats, species or natural communities or water supply in-take or reservoir downstream (limit volume or more strict contaminant criteria) OR Infrastructure susceptible to decreased flooding capacity through channel aggradation (limit volume)

- ✍ In-stream and riparian stabilization
  - ? Stabilize in-stream with grade control (e.g. using gravel, cobbles, boulders)
    Contaminants: Do not exceed sediment benchmarks OR Similar to downstream levels and will not degrade
  - ? Stabilize banks and de-watered sediment using bioengineering approaches and re-vegetation, restoring bordering vegetated wetlands and floodplain area
    Contaminants: Do not exceed DEP Background Soil levels OR Do not exceed appropriate MCP soil/groundwater category for the newly exposed sediment and will not degrade surrounding soil
  - ? Isolate or Cap de-watered sediment
    Contaminants: If exceed levels for appropriate MCP soil/groundwaters category

- ✍ Alternative/Innovative Treatments – 'in-situ'
  - ? Chemical or Biological treatment – remediation using specialized bacteria or vegetation to decrease toxicity or availability
    Contaminants: If exceed levels for appropriate MCP soil/groundwater category

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APPENDIX I

Sediment Sampling, Results and Management Summaries for Selected Massachusetts Dam Removal Projects

A. East Branch Housatonic River – Dalton, MA

Old Berkshire Mill Dam - Breached November 2000

B. Town Brook – Plymouth, MA

Billington Street Dam – Removed September 2002

C. Yokum Brook – Becket, MA

Silk Mill Dam - Removed February 2003

Ballou Dam - Proposed breaching

D. Acushnet River – Achusnet, MA

Sawmill Dam – Proposed breaching

Hamlin Street Dam - Proposed alteration

A. East Branch Housatonic River – Old Berkshire Mill Dam – Dalton, MA

SEDIMENT SAMPLING SUMMARY

As prepared by Crane & Company and GZA GeoEnvironmental, Inc. in consultation and approval by an interagency review team.

The information summarized is primarily from the MEPA Environmental Impact Report: Proposed Breaching of the Old Berkshire Mill Dam, East Branch Housatonic River, Dalton, MA. EOEA File No. 11994, April 14, 2000, GZA GeoEnvironmental, Inc.

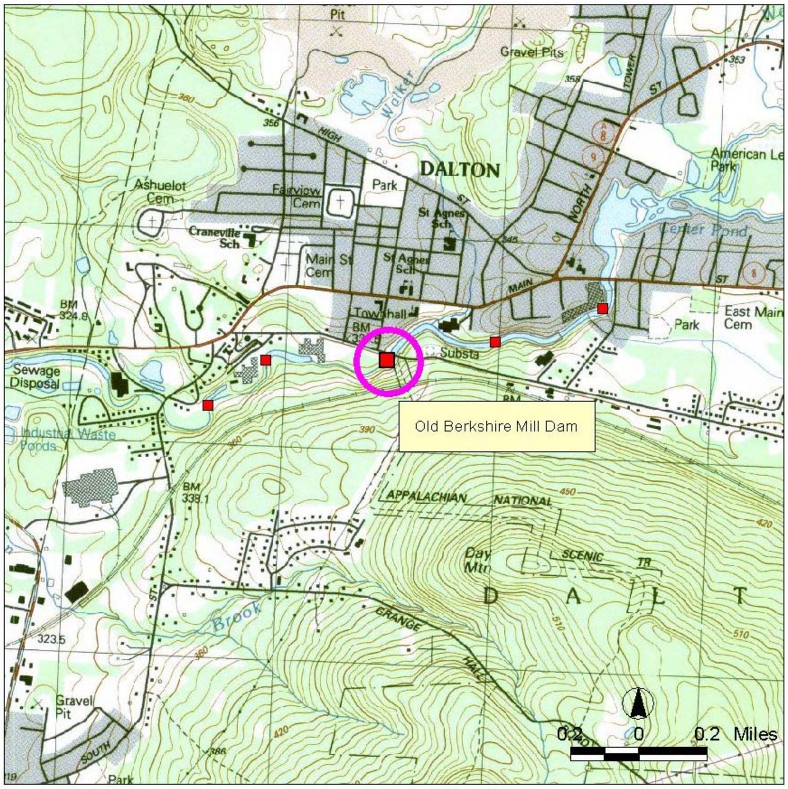
The first proactive dam breaching in MA was completed in November 2000 with the coordination of the Riverways' River Restore Program. The Old Berkshire Mill Dam needed major repairs and the impoundment was no longer used by the owners, Crane & Company. The breaching of the dam, not only left a safer, more accessible river, but also resulted in many benefits for the river's ecosystem, including increasing the amount of bordering vegetated wetland and improving and restoring access to 1.2 miles of coldwater habitat. Preliminary sediment sampling was conducted in May and August 1998 with supplemental sampling occurring in November 1999.

Brief Dam, Watershed and River Description

Old Berkshire Mill dam was the third dam in a series of six run-of-river dams owned by Crane & Co. on a 2.5 mile length of the East Branch of the Housatonic River (Figure A1). The current dam was an approximately 14 feet high and 130 feet long run-of-river concrete structure and was constructed around 1915 with major repairs in 1946. The remains of the former timber crib dam were buried in the sediment approximately 10 feet upstream of the concrete dam (the first dam at the location was built in 1801).

The watershed contributing flow to the Old Berkshire Mill Dam site is 55 $mile^2$. The watershed is composed primarily of forested areas, open water, and forested wetlands, as well as scattered residential and commercial developed areas including the Towns of Dalton and Hinsdale. The impoundment created by the dam was approximately 4.2 acres dominated by areas of open water with a narrow band of bordering vegetated wetlands. Average annual flow through the site was estimated at 106 $feet^3$/sec and the 100-year flood flow was estimated at 7,400 $feet^3$/sec.

Figure A1. East Branch Housatonic River, Dalton MA – Old Berkshire Mill Dam Location



Due Diligence: Potential Contaminant Sources

The segment of the East Branch Housatonic River where the dam was located is listed on the state's 303d list of impaired waters for priority organics, unknown toxicity, and pathogens. The upstream segment is also listed for priority organics. The impoundment receives road runoff from the Housatonic Street Bridge just upstream of the dam and pollutants may have been associated with this runoff. Because dioxin and furan emissions have been generally linked to past practices of the paper industry during the wood pulp bleaching process, MA DEP requested that Crane & Company analyze sediment samples for the possible presence of these chemicals. Though Crane does not process wood pulp at the Old Berkshire Mill Dam or at the upstream Byron Weston Mill, nor did an earlier investigation of Crane process effluents detect dioxins and furans in the Byron Weston Mill, these tests were conducted.

Collection Procedures

GZA GeoEnvironmental, Inc. performed preliminary sediment sampling in 1998. Four surficial samples (0-2 feet) were taken during a temporary dewatering of the impoundment using a hand auger in May 1998. Five more samples were taken from intermediate depths (3-7 feet) in August 1998. Samples were collected in 8-oz glass jars and stored in coolers for transport.

Based on comments by the Executive Office of Environmental Affairs (EOEA) and its agencies, supplemental sampling was requested to analyze the deeper sediment. This supplemental program provided for sampling to refusal using a split spoon sampler at three locations to estimate sediment thickness and sample deeper (older) sediment for laboratory grain size analysis and chemical quality testing. Two additional samples were taken near the location of the submerged timber crib dam directly behind the concrete dam. Because water was not drawn down, a floating platform was needed. It was maneuvered to the location and tied off to the riverbanks to stabilize the sampling rig during coring. See Figure A2 the map of sediment sampling locations. See Table A1 for a summary of sediment sampling sites and analytes examined.

<u>Laboratory Analysis</u>

Sediment collected at the site was analyzed for the following contaminants:

- Total Petroleum Hydrocarbons (TPHs) by ASTM Method D3328 / EPA Method 8100/8015B
- Total Polychlorinated Biphenyls (PCBs) by EPA 8082
- 8 RCRA metals by mass analysis by EPA 7470/7471
- Polynuclear Aromatic Hydrocarbons (PAHs) by EPA Method 8270
- Dioxin and Furans (TCDD and similar compounds) EPA Method 8290

In addition, grain size analysis using sieves 2”, 1”, ¾”, ½”, #4 (4.75mm), #10 (2mm), #20 (0.84mm), #40 (0.42mm), #60 (0.25mm), #100 (0.15mm), and #200 (0.075mm) was conducted, which provided insight into the potential erodibility of the impounded sediment.

Figure A2. East Branch Housatonic River, Dalton MA – Old Berkshire Mill Dam Sediment Sampling Locations (1995 Aerial photo)

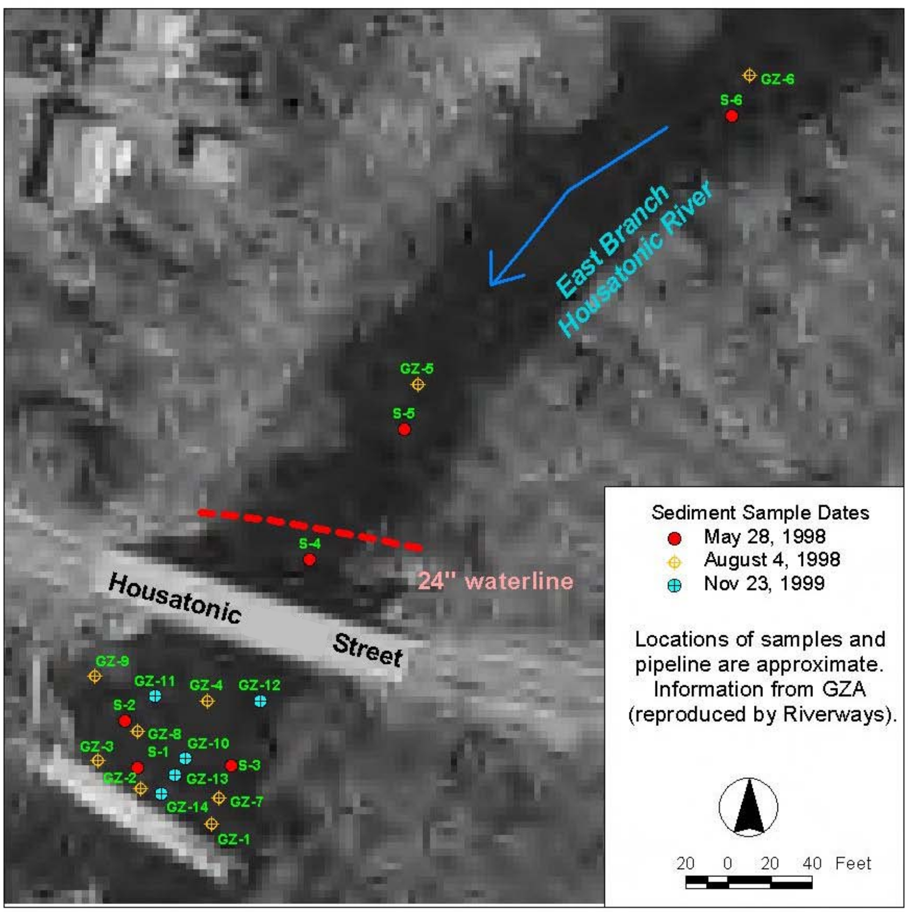


Table A1. Summary of sediment samples and parameters tested for Old Berkshire Mill Dam

Location see Figure A2	Sample No.	Depth* (ft)	Date	Parameters Tested (see lab analysis section)					
				TPH	**PCB**	**Metals**	**PAH**	**Dioxins Furans**	**Grain Size**
S-1	-	0-2	May 1998	x	x	x			
S-3	-	0-2		x	x	x			
S-4	-	0-2		x	x	x			
S-5	-	0-2		x	x	x			
GZ-1.5	S-2	6.6-6.9	August 1998	x	x	x			
GZ-2	S-2	6.7-6.9		x	x	x			
GZ-3	S-2	4.3		x	x	x			
GZ-8B	-	3.7-4.0		x	x	x			
GZ-9	-	3.4		x	x	x			
GZ-10	S-1	0-2	November 1999						
	S-2	2-4							
GZ-11	S-1	0-2							x
	S-2	2-4							x
	S-3	4-5.25							x
GZ-12	S-1	0-2							
	S-2	2-4							
	S-3	4-6							
	S-4	6-6.75							
GZ-13	S-1	3-5							
GZ-14	S-1	3-4							x
COMPOSITE A	GZ-10 S-1	0-2					x	x	
	GZ-12 S-1	0-2							
COMPOSITE B	GZ-11 S-1	0-2					x	x	
	GZ-12 S-2	2-4							
COMPOSITE C	GZ-11 S-2	2-4		x	x	x	x	x	
	GZ-12 S-3	4-6							
COMPOSITE D	GZ-10 S-2	2-4					x		

* Composites represent samples taken from similar elevations.

SEDIMENT SAMPLING RESULTS SUMMARY

Chemical Analysis Results

Though in-place sediment were not regulated under the MCP unless removed from the river, the sediment sampling report compared the results to MCP Reportable Concentrations (RCS-1 and RCS-2) soil levels. TPH concentrations ranged from 13 to 700 ppm, which all fell below the MCP RCS-2 (ie non-residential) soil of 2,000 ppm. Total PCBs all fell below the MCP RCS-1 and RCS-2 levels with just one sample over 100 ppb. All results for the metals were below the MCP RCS-1 and RCS-2 levels.

Seventeen separate PAH compounds were tested for and ranged from 330 ppb to 3.9 ppm. Concentrations of three PAH compounds (specifically Benzo[a]Anthracene, Benzo[b] Fluoranthene, and Benzo[a] Pyrene) in composite sample "A" slightly exceeded MCP reportable concentrations of 1.0, 1.0, and 0.7 ppm, respectively, for MCP RCS-2 soil. Composite sediment sample "A" contained surficial sediment from locations GZ-10 and GZ-12. Location GZ-12 is in an area of the impoundment that was likely to receive exhaust emissions and road runoff from Housatonic Street, which contributed to the presence of PAHs due to incomplete combustion.

Analysis of composite samples for dioxins and furans showed that the Estimated Maximum Possible Concentration levels – expressed in 2,3,7,8-TCDD equivalents (TEQ) – ranged from 0.623 parts per trillion (ppt) to 2.31 ppt. Dioxins are present everywhere in the environment, therefore the detection at low levels was not unexpected. Data subjected to preliminary analysis by EPA showed that the average North American background level of dioxins in sediment is 3.91 ppt of TEQ and in soil is 7.96+- 5.70 ppt of TEQ. The levels sampled fell well below these levels, however, they were above the reportable concentration for the MCP (0.03 ppt).

Table A2. Chemical analysis results for sediment samples of Old Berkshire Mill impoundment.

Analyte		S-1	S-3	S-4	S-5	GZ-1.5	GZ-2	GZ-3	GZ-8B	GZ-9	C
TPH (ppm)		18	17	19	13	150	72	55	240	700	88
PCB (ppb)		<50	<50	<50	<75	<50	35[a]	<50	29[a]	230[a]	<10
Metals (ppm)	Arsenic	<15	<14	<16	<12.7	<17.9	<17.7	<17	<18.6	<28.8	<20.6
	Barium	9.67	11	26.4	14.9	30.5	20.8	25.6	23.9	96.6	28.9
	Cadmium	0.80	0.32	0.60	0.29	6.71	0.80	0.66	0.60	1.49	<0.53
	Chromium	3.41	6.13	9.55	6.24	22.1	20.8	12	11.7	37	10.3
	Lead	8.98	28	20.5	19	39.5	29.8	31.9	66.8	112	65.5
	Mercury	<0.03	<0.03	<0.04	<0.03	0.21	0.15	0.08	0.06	0.58	0.034
	Selenium	<11.4	<10.6	<12.1	<9.60	<16.2	<16.0	<15.4	<16.8	<26.1	<18.6
	Silver	<2.27	<2.12	5.08	<1.92	<5.78	<5.71	<5.48	<6.01	<9.31	<6.66

[a] Arochlor 1260 all other Arochlors <50

Physical Analysis Results

Grain size results of the sediment showed that there was trace to small percent silt and clay sized particles (samples ranged from 3 to 13%) with a predominance of sand and gravel sized particles. The depth of the sediment sampled from the impoundment ranged from 4 to 6 feet with sediment thickness greatest adjacent to the dam. Using the 400 feet of impounded area to calculate the total volume, it was estimated that the total volume of sediment trapped behind the dam was approximately 5,000 yards^3. Not all of the sediment was subjected to erosion and most was stabilized within the channel.

SEDIMENT MANAGEMENT SUMMARY

Old Berkshire Mill Dam was fully breached in November 2000. The work was done in two phases with the first receiving a Phase I waiver through MEPA (Massachusetts Environmental Protection Act). The water levels were drawn so that the timber crib dam just upstream of the concrete dam could be examined and documented as per the historical and archaeological reconnaissance. Because this drawdown occurred in the summer months, vegetation along the newly exposed banks was able to begin to establish and help in naturally stabilizing the banks before the dam was fully breached.

A number of infrastructure issues required 'hard' engineering solutions to stabilize the structures and prevent undercutting or scour. This included the water pipeline that crossed the river at stream bed elevation just upstream from the bridge abutments, which also needed stabilizing. Rip-rap and large boulders were used to armor the stream bed and pipeline.

Much of the concrete and debris from the dams and a portion of the sediment was used to fill in the old mill race that had not been used in a number of years and would no longer be a necessary feature once the dam was removed. The beneficial use of the material was permitted and the mill-race was filled in as the removal went forward and held a volume of approximately 850 $yards^3$ material.

The remaining sediment was stabilized at the site through grading of the river banks. Also, a portion of the abutments still remain standing and are still retaining a large amount of sediment. Another portion of the sediment was simply allowed to move downstream to fill in the scour hole that had formed just below the dam. The amount of sediment released was estimated to have been at least several hundred cubic yards. The HEC-6 modeling showed that this sediment would move downstream and re-distribute in the channel with some ultimately being trapped behind the next downstream dam. The gravels and large sediment fraction has filled in the scour hole and is providing high quality stream habitat for the restored coldwater fishery.

The downstream concrete apron of the dam was left mostly intact to provide some structure to stabilize the channel. A 'low flow' notch was cut into it to focus the flow during times of low flow. It was hoped that the notch and concrete apron might eventually break up to form a more natural channel.

Old Berkshire Mill Dam during an inspection of the site. The dam was fully breached in November 2000.

(Photo by Crane & Co., Inc., 2000).

Deconstruction of Old Berkshire Mill Dam in November 2000. Photo is looking upstream at the dam.

(Photo by Crane & Co., Inc., 2000).

Fully breached site on the East Branch of the Housatonic River. Portions of the dam still remain. The sill of the dam is expected to degrade slowly and be replaced by a more natural stream bottom.

(Photo by Riverways Program, 2001).

B. Town Brook – Billington Street Dam – Plymouth, MA

SEDIMENT SAMPLING SUMMARY

As prepared by Town of Plymouth and Milone & MacBroom, Inc. and NOAA-Fisheries with consultation and approval by an interagency review team.

Information summarized is from the MEPA Environmental Impact Report and Design Report: Billington Street Dam – Plymouth, MA. Anadromous Fish Restoration, Town Brook. EOEA File Number: 12133. May 15, 2001. Milone & MacBroom, Inc.

The Town of Plymouth along with many local, state and federal partners completed the first proactive dam removal in the Massachusetts coastal watersheds in September 2002. The goal of the project was anadromous fish passage and restoration of the free-flowing brook. For many years prior to the removal, River Herring had to be netted and transported to their upstream spawning habitat due to a failing fish ladder at the site. It was decided that because the dam was no longer in use and failing, dam removal was the best alternative relative to safety, liability and environmental benefits.

Brief dam, watershed and river description

Billington Street Dam was located in Plymouth, MA (see Figures B1 and B2). The dam was originally constructed in 1790 and as recently as the 1950's a commercial mill was present at the dam that produced anchors, tacks and nails. The dam was an earthen and mortared granite wall structure approximately 110 feet long and 4 to 6 feet high. Normal stream discharge from the dam was via a 48-inch diameter iron culvert. Town Brook was approximately 13 feet wide and 5 inches deep where it entered the impoundment. The impoundment formed by Billington Street Dam was small, ~0.3 acres and was partially covered by a shrub wetland community and the open water was very shallow due to a heavy accumulation of primarily coarse-grained sands, with commonly exposed sediment deltas and normal water depths less than 12 inches.

The watershed contributing flow to the Billington Street Dam was approximately 5.5 $mile^2$ and was characterized by rolling, glacial moraine and outwash features. A regional groundwater aquifer (also a sole source water supply aquifer) and the Billington Sea, a large (~269 acres) kettle pond dominated the hydrology of the watershed with normal spring flows estimated to be approximately, 18 ft^3/sec. The watershed land use consisted of single family residences, cranberry bog operations, forested and wetland areas and small amounts of commercial and industrial activities.

Due Diligence: Potential Contaminant Sources

A Phase I Environmental Assessment (Marin Environmental, Inc., 2000) was completed to identify potential oils or hazardous materials and their sources due to existing or past land uses. Results of the assessment indicated that the project site was historically a small mill where tacks, nails and anchors where produced until 1927. Between 1948 and 1961, the mill was occupied by the highway department and Ellis Curtain Company. The building was later destroyed by fire. Immediately upstream of the site was located the Standish Worsted Company between 1855 and 1927. The mill was destroyed by fire in 1927, and the Puritan Brass Foundry occupied the former mill site between 1948 and 1961. Each of these small industries was a potential source of contaminants, and other potential contaminant sources were also considered in the watershed such as herbicides and pesticides associated with cranberry operations and residential lawns and hydrocarbons and metals associated with urban road runoff.

Figure B1. Town Brook, Plymouth, MA – Location of Billington Street Dam

Collection Procedures

The sediment-sampling plan was developed to assess the site conditions for contaminants. Because dam removal or partial removal was the preferred project alternative, the sampling plan focused on sediment within the impoundment and soils within the earthen dam that would likely be removed as part of the project (see Table B1 for a description of each sample).

The sediment samples were collected using a hand-held core auger. Samples were taken to refusal (i.e. former natural channel armoring and the projected maximum dredge depth), and using clean stainless steel spoon and bowl, each composite core sample was homogenized, unless a core contained more than one distinct sediment layer greater than 4 inches. The samples for VOC and EPH were not composited.

Soils from the earthen dam were collected and sampled using a small backhoe. Samples were taken to a depth of proposed restoration elevation or apparent limits of human alteration. Each test pit was sampled by collecting soils immediately below the surface and every 1-foot increment thereafter, unless soil or hazardous material or other obvious anomalies (e.g. distinct color change) were observed. Soils were collected from the interior of a backhoe bucket sample where the soils had not been exposed to the bucket surface. As part of a field sampling trip (May 2000), EPA and NOAA identified two small discrete piles of building tiles (transite) and other tile material discretely scattered on the site. Analysis of the soil material indicated the material contained asbestos fibers that required additional sampling and analysis.

Figure B2. Town Brook, Plymouth, MA – Billington Street Dam, April 2001 aerial photo.

Laboratory Analysis

Based on the requirements identified in MA DEP's *Interim Policy for Sampling, Analysis, Handling and Tracking Requirements for Dredged Sediments Reused or Disposed at MA Permitted Landfills*, and the contaminants that may potentially occur in the watershed based on the 'Due Diligence' review, the following chemical analyses and methods were analyzed:

A combination of soil samples from the earthen dam and the sediment was analyzed for the following potential contaminants:

- 8 RCRA metals by mass analysis by EPA 7470/7471
- Total Volatile Organic Compounds (VOCs) by EPA Method 8260, including Volatile Petroleum Hydrocarbons (VPHs), MA DEP method
- MA DEP Extractable Petroleum Hydrocarbons (EPH)
- Total Polychlorinated Biphenyls (PCBs) by EPA 8082
- Pesticides by EPA 8081B
- Total Cyanide, EPA Method 9010
- Asbestos (volume %)

In addition, grain size analysis using sieve numbers #4 (4.75mm), #10 (2mm), #40 (1.425), and #200 (0.075mm) was conducted which will provide insight into the potential erodibility of the impounded sediment.

Table B1. Sediment and soil sample description for Billington Street Dam.

Sample ID	Parameters Tested (see lab analysis section)							Description	Type	Method of Collection	Composite	Depth of Sample (in)
	metals	PCB	pesticide	VOC	EPH	Cyanide	Asbestos					
SOIL1				x	x			S side of dam, 16ft W/SW of pipe outlet	soil	Grab		63
SOIL2				x	x			Downstream of dam, N side of culvert, 12 ft NW of ash tree	soil	Grab		27
SOIL3				x	x			15 ft E of upstream dam wall, 22 ft N of culvert	soil	Grab		3
SOILC	x	x	x			x	x	Composite of SOIL 1,2,3	soil	Grab	x	-
SOIL0	x	x	x			x	x	Duplicate of SOILC	soil	Core	x	-
SED1	x	x	x			x	x	Composite of SED1A,B,C – upstream of dam near S bank	sed	Core	x	-
SED1A				x	x			15 ft W of dam	sed	Core		22
SED1B								40 ft W of dam	sed	Core		26
SED1C								60 ft W of dam	sed	Core		22
SED2	x	x	x			x	x	Composite of SED2A,B,C – upstream of dam near central/N side of basin	sed	Core	x	-
SED2A				x	x			10 ft W of dam	sed	Core		24
SED2B								50 ft W of dam	sed	Core		24
SED2C								70 ft W of dam	sed	Core		24
SED3	x	x	x			x	x	50 ft downstream of dam along S bank composite of 2 grabs taken within 10 ft	sed	Grab	x	6
SEDM00				x	x			Duplicate of SED2	sed	Core	x	-
BSDM01							x	Downstream of dam and downslope of tile pile	soil	Grab		-
BSDMO2							x	3 ft upslope of BSDM01	soil	Grab		-

SEDIMENT SAMPLING RESULTS SUMMARY

Chemical Analysis Results

The sampling revealed minimal contamination on the site. Only the composite soil sample (SOILC) and duplicate (SOIL0) exceeded the MCP S1/G1 standard for lead (Table B2). Three sediment samples had lead levels (112 – 172ppm) slightly above background levels and the theoretical values at which the Toxicity Characteristic Leaching Procedure (TCLP) criteria may be met or exceeded. No other metals were found in the samples at or above the S1/G1 standards. Total PCBs were at non-detect levels and chlorinated pesticides were at very low levels (<85 ppb). Except for one soil sample (SOIL2), VOC were at non-detect levels. One sediment sample (SED2) and its duplicate (SED00) had EPHs slightly above (209-291ppm) the MA DEP level of concern of 200 ppm. Cyanide was at non-detect levels for all samples.

The asbestos fiber in samples of the earthen dam ranged from 1.2% to 5% which led to further tests to understand the extent of contamination and remediation methods.

Table B2. Results from chemical testing of sediment and soils at Billington Street Dam.

Analyte		SOIL1	SOIL2	SOIL3	SOILC	SOIL0	SED1	SED2	SED3	SDM01	SDM02	SEDM00
Metals (mg/kg)	Arsenic				<20	<20	<20	<20	<30			
	Cadmium				<3.0	<3.0	<3.0	<3.0	<3.0			
	Chromium				6.5	8.1	24.1	68.5	36.3			
	Copper				91	111	47.2	104	57.9			
	Lead				**480**	**328**	118[a]	172[a]	112[a]			
	Mercury				0.07	0.11	0.12	0.15	0.38			
	Nickel				<6.0	6.8	<6.0	<6.0	<6.0			
	Zinc				198	219	80	32.8	30.7			
Total PCBs (ug/kg)					ND	ND	ND	ND	ND			
Chlorinated Pesticides (ug/kg)					85	81	24.4	23.4	30			
	VOC (ug/g)	ND	0.05	ND			ND	ND	ND			ND
EPH (mg/kg)	C_9-C_{18} Aliphatics	ND	ND	ND			ND	ND	ND			ND
	C_{19}-C_{36} Aliphatics	ND	ND	ND			ND	453	ND			218
	C_{11}-C_{22} Unadjusted Aromatics	ND					ND	**291**[b]	ND			**209**[b]
Total Cyanide (ug/kg)					ND	ND	ND	ND	ND			
Asbestos (volume %)					0	0	0	0	0	5	1.2	

[U] Indicates sample collected from composite of upper organic material of cores listed

[a] Values are above the theoretical levels at which the TCLP criteria may be met or exceeded.

[b] Value is above the MA DEP level of concern of 200 mg/kg.

[2] ND = Non-Detect

Follow-up sampling and analysis was completed in November 2000 for petroleum hydrocarbons, lead, and asbestos. Six test pits were dug in the earthen dam and sediment was collected from immediately downstream of the dam. Using polarized light microscopy (PLM) methods, non-friable asbestos contaminated material (ACM) was found in four of the six pits generally to a maximum depth of 2 feet.

Total lead ranged from 21.4 to 487.4 ppm in the additional soil and sediment samples. Conversely, the TCLP revealed very low levels of potential leaching of lead, and no on-site material qualifies as hazardous material. The soil and sediment containing the low-level lead can be disposed of in an area landfill and in accordance with MA DEP regulations.

Physical Analysis Results

Grain size results of both the sediment and the soil of the earthen dam showed a predominance of fine to medium sand with lower percentages of coarse sand and gravel. One sample collected within the riparian wetland sediment downstream of the dam had a high portion of silt and clay. This wetland area will not be subject to excavation or disturbance associated with the dam removal project. Based on these results, excavation, de-watering, and disposal practices should be straightforward and result in negligible potential downstream sedimentation impacts.

Table B3. Sediment Grain Size Analysis for Billington Street Dam

Sieve # (Size)	Size Category	SOILC	SED1	SED2	SED3	SOIL0
		Percent in size category (%)				
#4 (4.75mm)	Gravel	0.3	0.4	0.3	0.2	1.8
#10 (2mm)	Coarse Sand	5.7	3.9	7.1	7.1	6.2
#40 (0.425mm)	Medium sand	40.3	32.4	45.9	48	39.3
#200 (0.075mm)	Fine sand	46.8	52.4	43.2	0.4	45.3
(<0.075)	Silt and clay	6.9	10.9	3.5	44.3	7.4

SEDIMENT MANAGEMENT SUMMARY

Billington Street Dam was fully removed in September 2002. The sediment and soil management for the site had proceeded in two phases. Due to the presence of asbestos contaminated material (ACM) in the earthen dam this material was removed and disposed of at an approved landfill using a contractor experienced and certified to handle these types of materials. This remediation phase of work was permitted through DEP's Bureau of Waste Prevention (under regulations: 310 CMR 30.000) and proceeded under the direction of a Licensed Site Professional (LSP). In June 2002, an estimated 2 feet over an area of 6,500 $feet^2$ (approximately 410 $yards^3$) of the earthen dam was excavated and properly dispose of at an approved site for ACM.

In early September 2002, the second and final phase of the work was begun by the U.S. Army Reserves who donated their services to the project through the Army's Innovative Readiness Training (IRT) program and Coastal America. Approximately, 1,500 cubic yards of soil and sediment was excavated and/or dredged and then stock-piled and covered at a Town site approved by DEP and the project partners for later testing. Based on the testing the material was eventually re-used in an asphalt-batching operation in a nearby town.

Finally, a constructed riffle at approximately 4% slope consisting of large gravel, cobble, and boulders was built in the stream channel through the section where the culvert and earthen dam was located. This riffle feature was designed to be passable by fish and other aquatic organisms as well as help stabilize the channel to prevent any head-cutting and loss of native sediment. Wetland vegetation was planted along with a wetland seed mix used in the upstream restored emergent wetland. The river banks were graded and hydro-seeded in order to prevent erosion.

U.S. Army Reserves prepare to excavate and remove the earthen dam and sediment in the impoundment. Town Brook flows to the left through culvert under earthen dam.

(Photo by Michael Merrill, Riverways Program, 09-2002).

Excavation of the restored channel as flow is diverted through the temporary culvert. Soil was pulled back and graded to form the river banks. Photo is looking upstream at the former dam site.

(Photo by Michael Merrill, Riverways Program, 09-2002).

Rock placement in constructing the 4% sloped riffle. Rock placement was designed to create a diversity of flow conditions at any one cross-section. This allows free passage of fish and other aquatic organisms while stabilizing the channel. Photo is looking upstream at the former dam site.

(Photo by George Zoto, MA Watershed Initiative, 09-2002).

Site conditions following constructing of the 4% sloped riffle. Banks were graded back and planted with wetland vegetation in the Spring 2003 to help stabilize the banks. Granite blocks from the dam were used to make an overlook with an historic plaque. Photo is looking upstream at the former dam site.

(Photo by Michael Merrill, Riverways Program, 10-2002).

C. Yokum Brook - Silk Mill and Ballou Dams - Becket, MA

SEDIMENT MANAGEMENT SUMMARY

(See USGS 2003 report for sediment sampling summary and chemical and physical sampling results)

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Information summarized is from the U.S. Geological Survey (USGS) Water-Resources Investigations Report, Sediment Quality and Quantity at Three Impoundments in Massachusetts and the Expanded Environmental Notification Form (ENF): Proposed Silk Mill Dam Removal, Becket, MA. September 2002. Prepared by Town of Becket, Foresight Land Services, Inc. with consultation and approval by an inter-agency review team.

Silk Mill Dam

Silk Mill Dam was fully removed in February 2003 through an expedited review due to the dam failing an undermining the adjacent roadway.

The original estimate of 1,600 cubic yards of sediment that USGS calculated for Silk Mill Dam included the depositional island just upstream from the dam (see photos below). The USGS also calculated the volume before the diversion culvert became exposed, opened-up and began transporting sediment from the impoundment. A portion of the sediment was lost' and naturally re-distributed in the old diversion channel, into Yokum Brook and likely deposited behind the downstream Ballou Dam. It is not known how much sediment was exported from the impoundment through the culvert which unexpectedly opened-up and began undermining the roadway embankment which warranted expediting the removal process. As part of the removal, approximately 800 - 900 cubic yards of sediment and dam material (cement, rebar, etc.) were removed from the site and re-used beneficially on an upland site a few miles away. The sediment was approved for unrestricted use because there were no contamination issues. It was hauled to a nearby farm and used to level and expand a horse-riding rink.

Much of the sediment was composed of large cobbles and boulders that were purposely left at the site as important natural channel structure which helped to stabilize the channel and create beneficially habitat. It is expected that as the restored stream channel re-shapes and re-creates its natural dimensions small portions of the depositional island will continue to erode. The majority of the depositional island will remain stabilized due to the established vegetation already covering the site. However, the site will continue to be monitored and if the erosion becomes more severe then a more active channel stabilization plan will be used.

Ballou Dam

Final designs and funding for a partial breach of Ballou Dam are being finalized currently. Due to the lack of contamination, the use of the sediment is unrestricted and an appropriate location will be found for a portion of the sediment with the rest being allowed to be redistributed naturally to the downstream channel. The West Branch of the Westfield is downstream approximately 400 feet and because it is a larger river, it will have the capacity to assimilate most sediment released from Ballou Dam.

Figure C1. Yokum Brook – Becket, MA, Silk Mill and Ballou Dams Locations

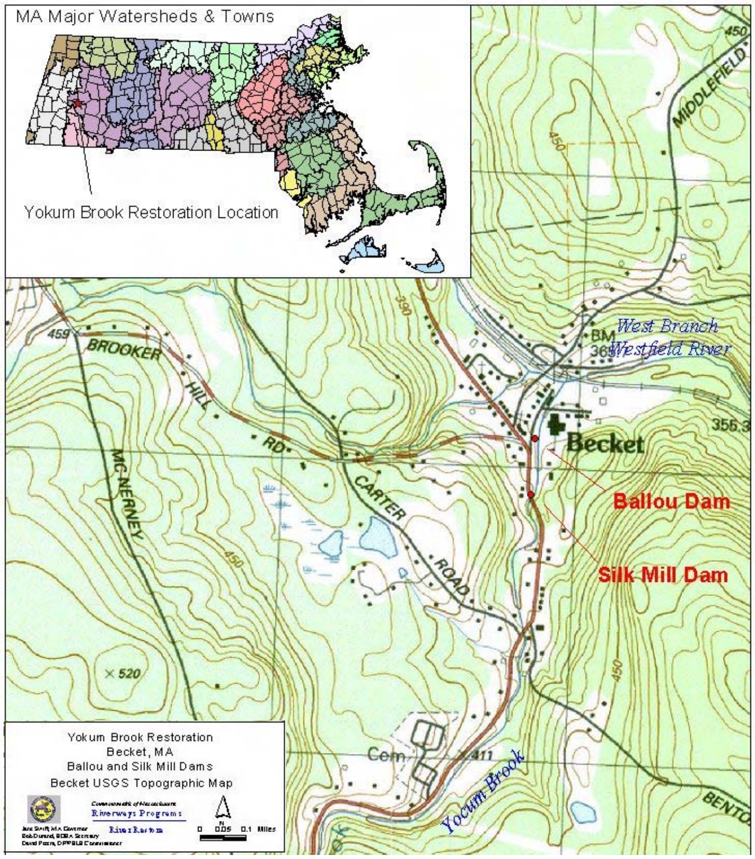
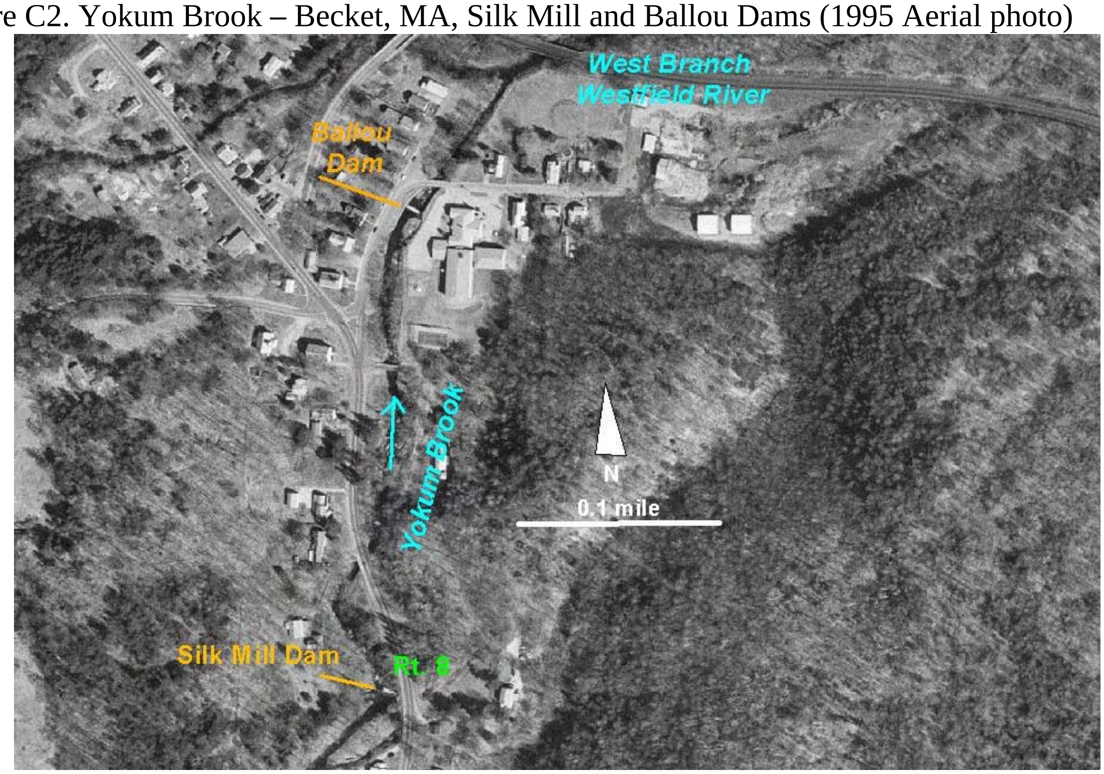


Figure C2. Yokum Brook – Becket, MA, Silk Mill and Ballou Dams (1995 Aerial photo)



Silk Mill Dam and impoundment, June 2002. No water flowing over the dam, but back towards newly opened culvert (out of view in the lower left of photo). Note the depositional island on the river right and the sediment which almost fills the impoundment.
(photo by Jeff Collingwood, Foresight Land Services 2002)

Silk Mill Dam during removal, February 2003. Fill was brought in for access road. Excavator is removing dam and sediment. Water was diverted through the culvert under the road (not in photo). Demolition and excavation took approximately 2 weeks.

(photo by Michael Merrill, Riverways Program 02-2003)

Yokum Brook after removal of Silk Mill Dam, February 2003. Note that as the newly restored stream channel adjusts to the proper channel proportions some more sediment from the depositional island will be eroded. The amount of sediment eroding at the site will be monitored, but fisheries biologists expect the short term impacts of this sediment to be negligible relative to the long term benefits of the restored stream.

(photo by Carrie Banks, Riverways Program 2003)

Final designs for the breaching of Ballou Dam are being discussed. The town uses this as an emergency fire water source and the design will incorporate a dry hydrant and storage tank.

(Photo by MA Division of Fish & Wildlife, 2000)

D. Acushnet River – Sawmill Dam and Hamlin Street Dam – Acushnet, MA

SEDIMENT SAMPLING SUMMARY

As prepared by Milone & MacBroom, Inc. with consultation and approval from an inter-agency review team.

Information summarized is from the DRAFT Dam Removal Feasibility Study, Sawmill and Hamlin Street Dams, Acushnet River, Acushnet, MA. 03-2003. Milone & MacBroom, Inc.

A river restoration and fish passage feasibility study is being conducted for the Acushnet River in the Town of Acushnet, MA with funding from the New Bedford Harbor Trustee Council. Dam removal/breaching alternatives at two dams, Sawmill and Hamlin Street Dams, are being studied. A sediment-sampling plan was approved in July 2001 and sampling proceeded shortly thereafter. The following is a summary of how the sites were sampled.

Brief dam, watershed and river description

The Sawmill and Hamlin Street Dams are located in Acushnet, MA (see Figure D1). The Sawmill Dam consists of an earthen dam with a concrete spillway approx. 100 feet in length. The structural height of the dam is five feet, creating a hydraulic head of three feet. The impoundment created by the dam is approx. 15 acres in size, and includes areas of open water and wetlands dominated by emergent vegetation (see Figure D2). The Hamlin Street Dam, located upstream of the Sawmill Dam, consists of an earthen embankment approx. 300 feet in length. The structural height of the dam is twelve feet, creating a potential hydraulic head of seven feet (see Figure D3).

The watersheds contributing flow to the Hamlin Street and Sawmill Dams are approx. 16.4 and 18.7 mile^2, respectively. The watersheds are composed primarily of wooded areas, forested wetlands, and cranberry bogs, as well as scattered residential and commercial developed areas. The 200-acre New Bedford Reservoir is also located within both watersheds. The topography of the watersheds is relatively flat and dominated by swamps with complex hydrology and unclear watershed boundaries.

Figure D1. Acushnet River – Locations of Sawmill and Hamlin Street Dams

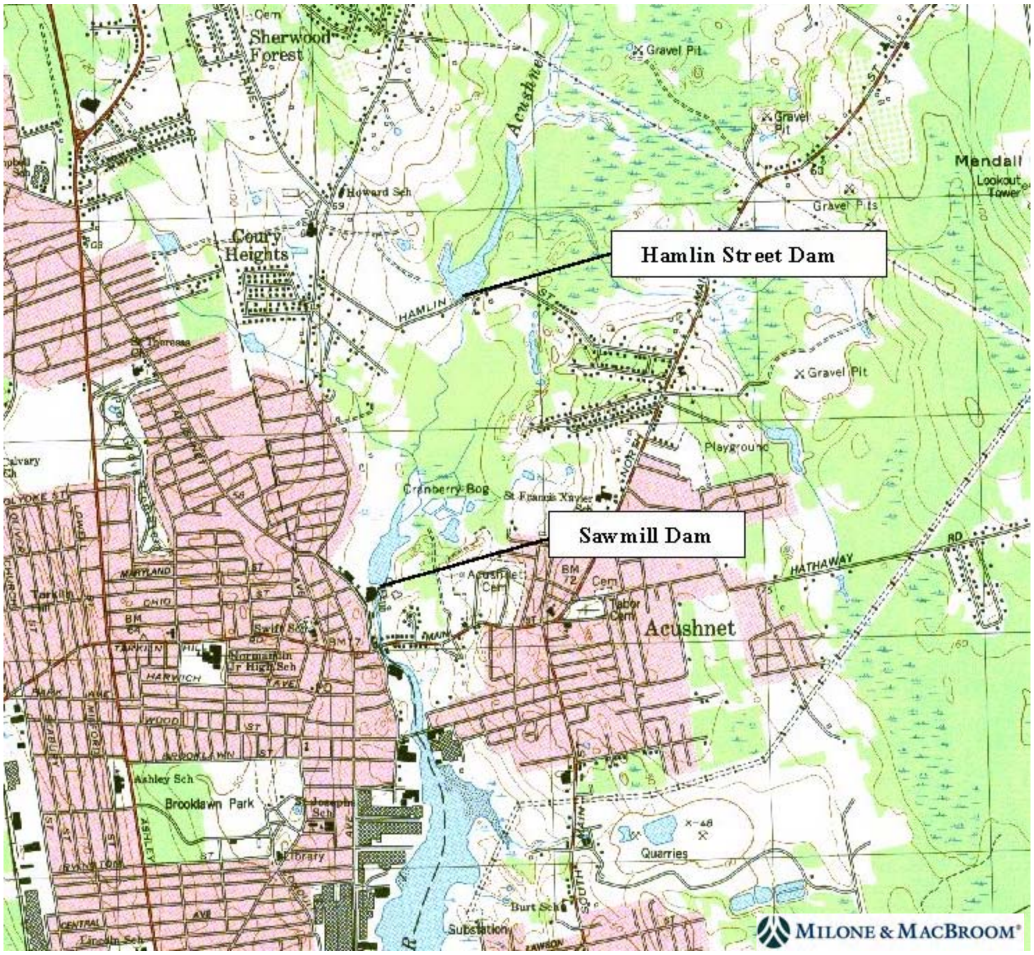


Figure D2. Acushnet River – Sawmill Dam - Proposed Sediment Sampling Locations

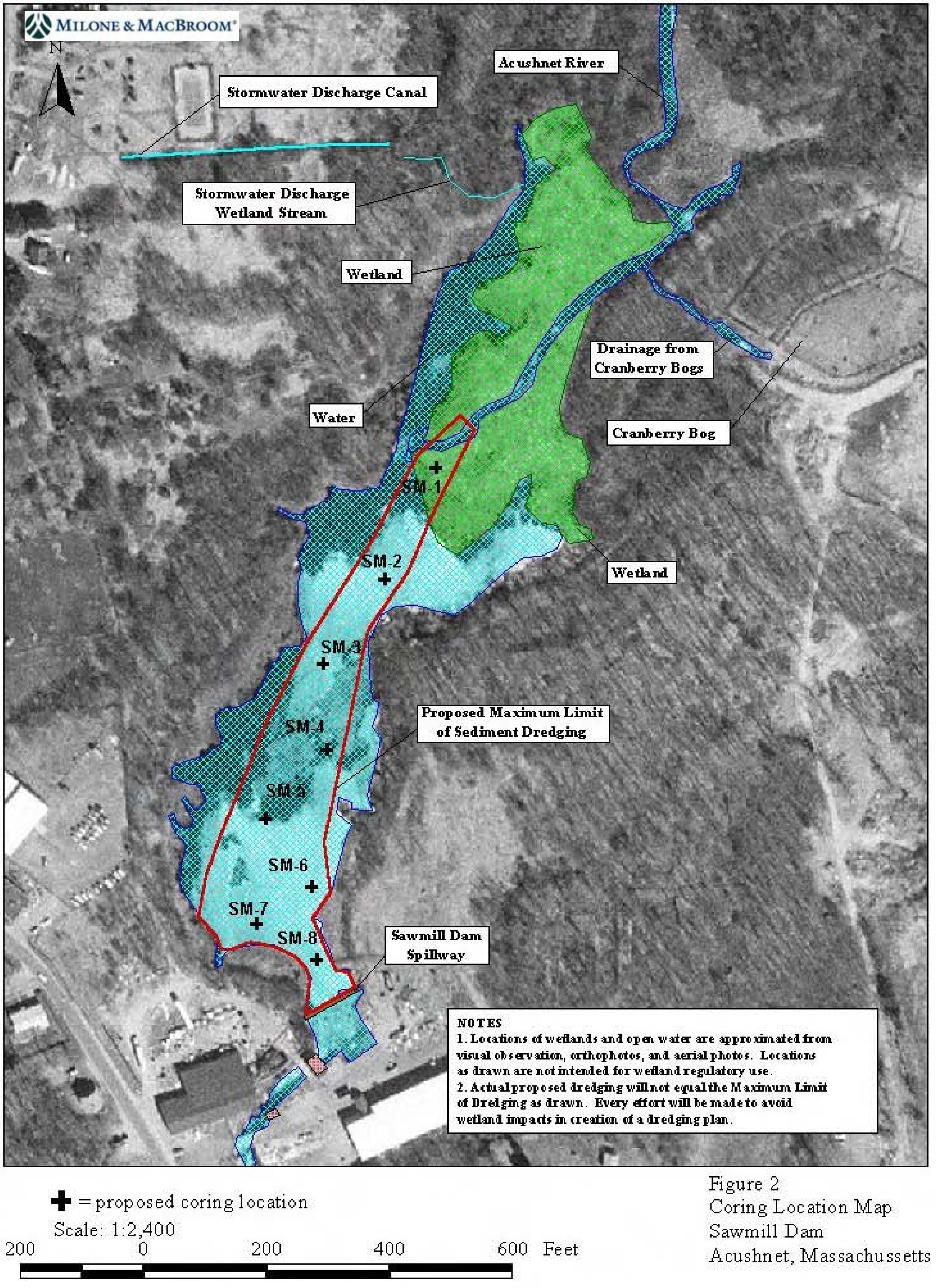


Figure D3. Acushnet River – Hamlin Street Dam - Proposed Sediment Sampling Locations

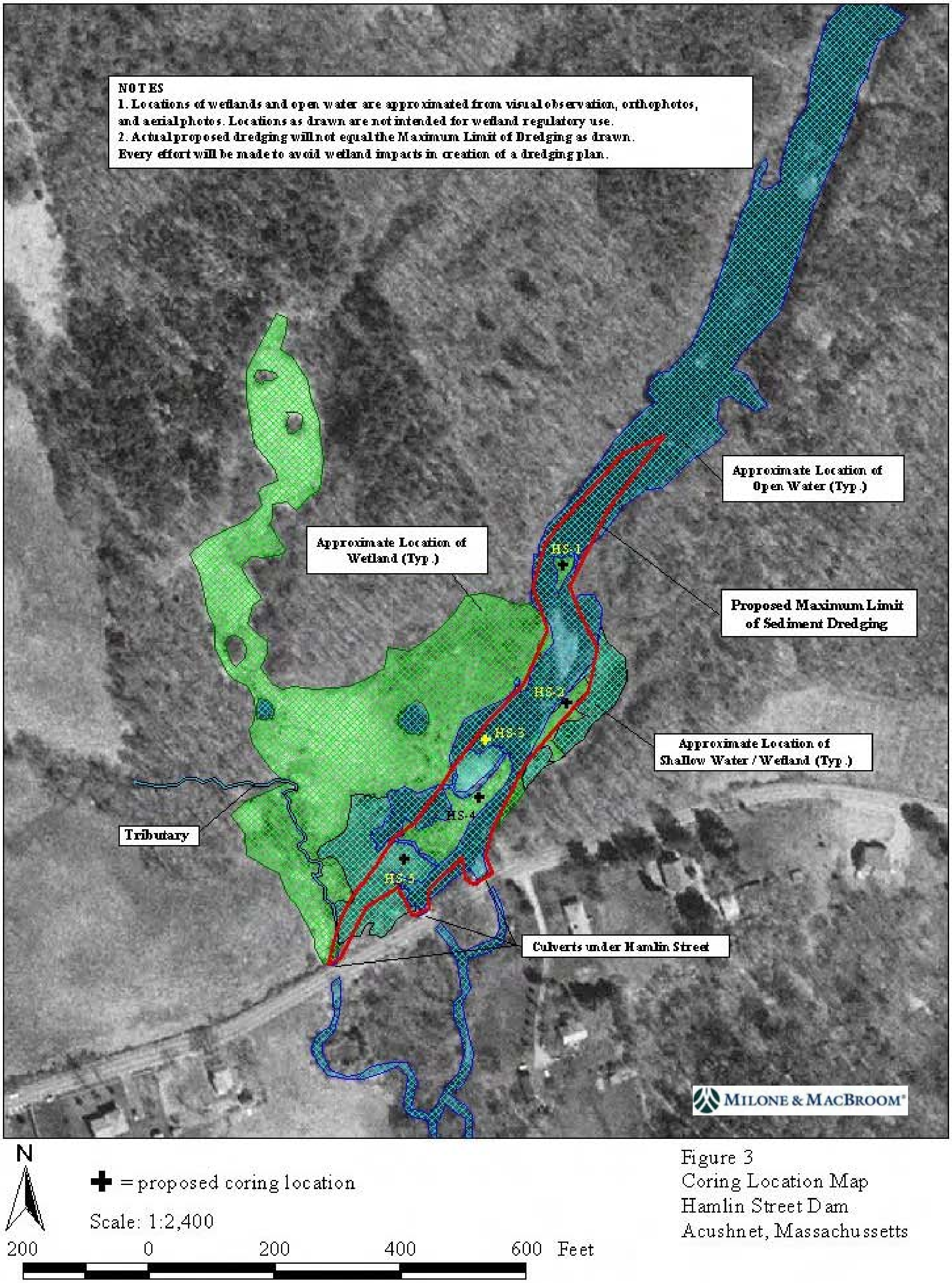


Figure 3
Coring Location Map
Hamlin Street Dam
Acushnet, Massachusetts

Due Diligence: Potential Contaminant Sources

There are no known pollutant sources to the impoundments. The most upstream combined sewer overflow known to the Acushnet DPW is located just downstream of the Sawmill Dam. There is one stormwater outfall that enters the western shore of the Sawmill Dam after passing through an open channel and a wetland. The Draft DEP Water Quality report shows that the Acushnet River does not meet the Clean Water Act water quality standards and certain sections require a TMDL. However, contaminated sediment has not been listed as a reason for impairment while nutrients, siltation, pathogens, organic enrichment/DO were cited as reasons.

The industrial history of the Acushnet River Watershed has been extensively researched as part of the New Bedford Harbor restoration effort. This research has discovered that the industrial activity on the Acushnet River including and upstream of the Sawmill Dam was primarily conducted in the eighteenth to early nineteenth centuries. This activity was focused around dams as a source of water and power for sawmills, grist mills, an iron factory, and cotton mills. The water impounded by the dams had been used for local irrigation and water supply. Previous studies found that the upper portions of the watershed appear to have been largely spared the industrial pollution seen in the New Bedford Harbor and Acushnet River estuary.

It has been determined that the greatest potential contaminants are those associated with agricultural land use and road run-off. There are two potential point sources for this runoff for the Sawmill Dam site and one potential point source of agricultural runoff for the Hamlin Street site. The remainder of the potential pollutant sources are non-point and as a result the sediment sampling plan has been developed with an exploratory intent. The pollutants frequently associated with stormwater and agricultural runoff include metals (e.g. lead and arsenic), petroleum hydrocarbons, and pesticides. Additionally lab testing included TOC and VOCs, common markers of pollution; and PCBs that have heavily contaminated the New Bedford Harbor and the Acushnet River estuary below Sawmill Dam.

Collection Procedures

Corings were taken within the impoundment areas upstream of the dams where sediment movement may occur as a result of dam removal and/or dredging may be proposed. Eight corings were taken for Sawmill Dam and five for the Hamlin Street Dam. The potential maximum area of where sediment may move and/or be dredged and the coring locations are shown on the Figures D2 and D3. It should be noted that the dredge areas depicted and volumes predicted are the hypothetical maximum area to be dredged; it is probable that the actual dredge area and actual volumes will be considerably smaller. The proposed maximum depth of dredging was used in determining the proposed coring depths.

Table D1. Summary of Collection Procedures

	Sawmill Dam	Hamlin Street Dam
Number of corings	8	5
Maximum dredge area	111,000 ft^2 or 2.5 acres	71,000 ft^2 or 1.6 acres
Volume of maximum dredging area (wet)	7,400 $yards^3$	4,500 $yards^3$
Depth of corings (whichever is first)	4 ft. or refusal	3 ft. or refusal

Each coring was advanced with a vibracore system mounted on a boat or tripod, or by a hand-operated motorized boring rig mounted on a tripod. Continuous corings were obtained extending from the top of the existing impounded sediment to the depth reported in Table D1. Preliminary hand corings of the impoundment conducted by Milone & MacBroom, Inc. have shown that a tight, fine sand refusal is located approximately at the depths reported in Table D1. A detailed log was maintained during boring operations in order to document boring location and depth, notes on sediment texture and condition, signs of contamination, and other pertinent observations.

For all analysis parameters except VOCs and SVOCs (including VPH), more than one sediment core was composited for analysis. These were conducted in the following manner: each of the cores was split in half vertically. One of the halves was used for compositing. The remaining half was split in half horizontally, representing the top and bottom portions of the original core. Samples for VOC and SVOC testing were collected from one of these quarters of each original core. The sediment remaining in these quarters was archived in the event that high contaminant values in the results necessitate further sub-sampling analysis. Due to their proximity to each other, and similarity of the sediments as observed by MMI, it is anticipated that the following sediment cores will be composited: Sawmill (SM)-2 and SM-3; SM-4, SM-5, and SM-6; SM-7 and SM-8; Hamlin Street (HS)-1, HS-2 and HS-3; and HS-4 and HS-5. Sediment core SM-1 was not proposed to be composited because it is unique at the Sawmill Dam in that it is located in a wetland. If visual inspection of the sediment cores to be composited were to reveal marked differences in grain size or sediment color between cores, or if signs of potential contamination were observed within a core (e.g. petroleum odor or darkened layer), then each representative sample core would have been submitted to the laboratory for analysis without being composited. (This did not occur during the sampling.)

Laboratory Analysis

Based on the requirements identified in MA DEP's *Interim Policy for Sampling, Analysis, Handling and Tracking Requirements for Dredged Sediments Reused or Disposed at MA Permitted Landfills*, and the contaminants that may potentially occur in the watershed based on the 'Due Diligence' review, the following chemical analyses and methods were proposed: See Table D2.

- Total Organic Carbon (TOC)
- 8 RCRA metals by mass analysis by EPA 7470/7471
- Total Volatile Organic Compounds (VOCs) by EPA Method 8260, including Volatile Petroleum Hydrocarbons (VPHs), MA DEP method
- MA DEP Extractable Petroleum Hydrocarbons (EPH)
- Polycyclic Aromatic Hydrocarbons (PAHs) by EPA Method 8100
- Total Polychlorinated Biphenyls (PCBs) by EPA 8082
- Pesticides by EPA 8081A
- Herbicides by EPA 8151a

Table D2. Samples and analytes for Sawmill Dam (SM) and Hamilin Street Dam (HS).

Analytes	SM1	SM2	SM3	SM4	SM5	SM6	SM7	SM8	HS1	HS2	HS3	HS4	HS5
TOC	U	C		C			C		C			C	
Metals	U	C		C			C		C			C	
VOC/VPH	UB	UT	UB	UT	UB	UT	UB	UT	UT	UB	UT	UB	UT
EPH	U	C		C			C		C			C	
PAH	U	C		C			C		C			C	
Total PCB	U	C		C			C		C			C	
Pesticides	U	C		C			C		C			C	
Herbicides	U	C		C			C		C			C	
Grain Size	U	-	-	C			C		-	-	C	C	

C = composited sample;U = uncomposited;UT = top of uncomposited sample;UB = bottom of uncomposited sample

In addition, grain size analysis using sieve numbers 4 (4.75mm), 10 (2mm), 40 (1.42), and 200 (0.075mm) was conducted which will provide insight into the potential erodibility of the impounded sediment. Also, many physical features of the sediment were tested; these included moisture content (%), Bulk density (lb/ft^3), Dry Density (lb/ft3), Specific Gravity @ 20?C, Porosity, Void Ratio, Ash Content (%), Organic Matter (%), Percent Solids (%), Coefficient of Consolidation. These parameters were used to estimate the amount of consolidation and compaction the newly dewatered soils/sediment would undergo.

SEDIMENT SAMPLING RESULTS SUMMARY

Chemical Analysis Results

The samples were below the detection limits for most of the parameters examined (e.g. PCB, herbicides, pesticides, PAH, VOC, metals). The reportable results are presented in the Table D3. These results are compared with the highest quality sediment standard available from the MA DEP, labeled as "Ref" in the table. The values represent the maximum concentrations of the listed parameters for upland placement of sediment. These concentrations are lower than the concentrations set as the standards for reuse of sediment in landfills. All the samples meet the upland placement standards. In the event that any dredging of the sediment were to occur as part of a full or partial dam removal, this sediment could potentially be placed in the adjacent floodplain or upland without any significant human health or ecological risk from contaminants.

Table D3. Sediment sampling results from the Acushnet Dams.

		Sawmill Dam					Hamlin Street Dam			
Analyte (mg/kg)	Minimum Detection Limit	SM1	SM2 SM3[U]	SM4 SM5 SM6[U]	SM7 SM8[U]	SM6 SM7 SM8[L]	HS1 HS2 HS3[U]	HS4 HS5[U]	HS3 HS4 HS5[L]	Ref.[1]
Arsenic	1.0	5.6	4.7	5.0	4.6	2.7	4.3	3.9	2.4	17
Barium	5	65	77	80	96	27	47	63	13	N/A[2]
Cadmium	0.5	1.1	0.8	0.7	0.7	BDL[3]	0.5	0.9	BDL	2
Chromium	0.5	9.0	8.9	8.8	9.0	3.8	6.8	8.8	3.8	29
Lead	0.5	84.8	70.7	56.2	70.8	6.4	45.8	79.6	6.4	99
Mercury	0.02	0.22	0.14	0.17	0.16	0.04	0.10	0.15	0.04	0.3
TOC (%)	0.10	4.46	3.18	2.75	2.45	4.64	2.35	3.93	0.65	N/A
EPH Fraction C11-C22	1.0	BDL	BDL	4.7	1.9	1.3	1.0	1.0	BDL	200
Total MA DEP EPH	1.0	BDL	BDL	4.7	1.9	1.6	1.0	1.0	BDL	N/A

[U] Indicates sample collected from composite of upper organic material of cores listed

[L] Indicates sample collected from composite of lower, more mineral material of cores listed

[1] MA Background Soil Concentrations or RCS-1 Standards from 310 CMR 40.1600 (mg/kg)

[2] N/A = Not Applicable

[3] BDL = Below Detection Limit

Physical Analysis Results

In general, the physical characteristics of the sediment show that the sediment is highly saturated and organic, with more water than sediment. The sediment can be expected to settle approximately eighteen inches if the water were to be drained out and the pore spaces are filled under the sediment's own weight.

Table D4. Sediment Grain Size Analysis for Sawmill and Hamlin Street Dams

SEDIMENT GRAIN SIZE	Sawmill Dam		Hamlin Street Dam	
	SM4,SM5,SM6	SM6, SM7, SM8	HS4, HS5	HS3, HS4, HS5
Sieve # (Size-mm)	% Finer			
#4 (4.75mm)	99.4	94.3	100	95.7
#10 (2mm)	96.8	86.7	98.5	93.3
#40 (0.425mm)	80.9	60.6	83.2	74.6
#200 (0.075mm)	54.9	27.7	49.9	19.5

Table D5. Sediment core descriptions for Sawmill and Hamlin Street Dams

	Core #	Water Depth (ft)	Core Depth (ft)	Description of Material
Sawmill	SM1	0.3	2.53	Organic soils & root matter
	SM2	3.3	3.66	Coarse silt and sand
	SM3	3.0	3.33	Organic soils and silt/clay
	SM4	1.7	3.08	Organic soils and silt/clay
	SM5	2.5	3.75	Organic soils and silt/clay
	SM6	2.8	3.33	Organic soils and sandy silt
	SM7	3.0	3.49	Organic soils and silt/clay
	SM8	3.2	3.02	Organic soils and clay and root matter
Hamlin Street	HS1	0	2.47	Organic soils and silt/clay transitioning to dense sand
	HS2	0	1.61	Organic soils & root matter
	HS3	0	2.08	Organic soils & root matter transitioning to fine sand
	HS4	0	2.40	Organic soils and sandy silt/clay
	HS5	0	3.02	Organic soils & root matter transitioning to fine sand

Table D6. Physical parameters measured for sediment at Sawmill and Hamlin Street Dams

Physical Parameters	SM2	SM5	HS5	HS6
Organic Matter (%) [GTX, CTL]	28.4	29.8	26.4	10.8
Moisture Content (%)[GTX, CTL]	436.7	368.2	154.3	145.2
Bulk density (lb/ft^3) [GTX]	62.9	70.6	81.6	72.5
Dry Density (lb/ft^3) [GTX]	16.4	28.8	32.1	25.9
Specific Gravity @ 20?C [GTX]	2.34	2.04	2.37	2.12
Porosity [GTX]	0.89	0.77	0.78	0.80
Void Ratio [GTX]	3.611	7.929	4.101	3.418
Ash Content [GTX]	71.6	70.2	73.6	89.2
Solids (%)[GTX]	-	-	24.1	40.8
Anticipated Settlement (in) [MMI]	18”		18”	
[GTX] Aindicates values determined by Geotesting Express, Inc.				
[CTL] Indicates values determined by CT Testing Labs, Inc.				
[MMI] Indicates values determined by Milone & MacBroom, Inc.				

SEDIMENT MANAGEMENT SUMMARY
(PROPOSED AS OF JUNE 2003)

Sawmill Dam

A partial dam breach is the recommended alternative for Sawmill Dam and is currently undergoing environmental review and has not been fully approved or permitted. What is summarized here is the proposed sediment management plan as of May 2003.

The partial dam breach is preferred at this site for a number of reasons (e.g fish passage, dam safety, minimize wetland changes) including minimizing the movement of the impounded sediment. The proposed alternative would involve notching the dam with the cross-sectional shape sized to the appropriate dimensions of the channel and excavating that same cross-section in the gravel backfill upstream of the dam at a four percent gradient, creating a shallow riffle. The riffle would extend approximately 40 feet upstream of the existing spillway. In order to prevent head-cutting, sheet pile or other methods of grade control would be installed in the sediment at the head of the riffle and the top of the sheet pile would be cut to match the proposed grade. The riffle would be lined with geotextile and armored with rounded cobbles to ensure stability. By notching the dam and creating a riffle at the site, the upstream sediment will remain and be stabilized through consolidation, compaction, and re-vegetation with wetland plants.

Approximately 150 c.y. of material would be excavated, including concrete and stone from the spillway, gravel backfill material, and organic sediment. Sediment testing has demonstrated that the sediment is uncontaminated and can be re-used on site. The stone would be re-used, lining the constructed channel or as downstream fill, and the organic sediment would be re-used as topsoil on the constructed banks. The excavated concrete would be re-used as downstream fill material and buried under natural materials. Approximately, 150 c.y. of material would be required as fill downstream of the existing spillway to create river banks and an appropriately sized channel. Also, fill will be placed at the entrance to the headrace in order to block flows through this section of the old mill complex. No additional excavation would occur upstream of the dam breach as an existing low-flow channel would serve as the new river channel.

Hamlin Street Dam

The removal of the concrete sill located upstream of the eastern most culvert is the recommended alternative at Hamlin Street Dam (Note: if the bridge replacement moves forward in the coming years,, it was noted that the central section should be used for fish passage) and is currently undergoing environmental review and has not been fully approved or permitted. What is summarized here is the proposed sediment management plan as of May 2003.

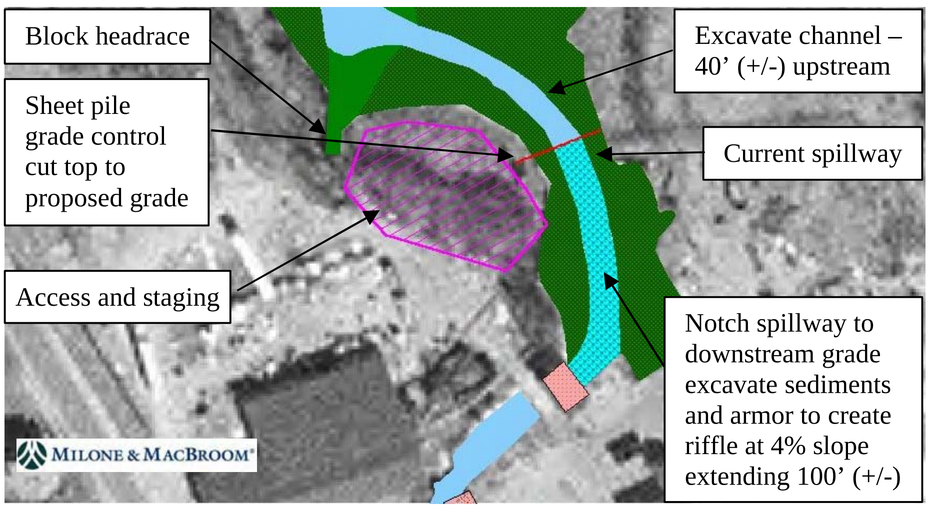
Removal of the sill would require removal of a small amount of concrete and backfill material. In order to maintain the existing impounded wetlands, the channel would be extended with a constructed riffle extending approximately 50 feet upstream. No change in water level elevations would occur and no sediment is expected to erode. Essentially, the existing conditions would remain and only minimal amounts of material is necessary to remove.

Looking upstream at Sawmill Dam.

Photo by Milone & MacBroom, Inc.

Sawmill Dam impoundment during drought conditions. Looking upstream at impoundment from spillway.

Photo by MMI.



Sawmill Dam proposed dam breach and riffle construction which will allow for fish passage while stabilizing the sediments and wetland in impoundment.

Design by Milone & MacBroom, Inc.

Hamlin Street Dam looking downstream from impoundment at eastern culvert under road (a) and looking upstream from road at remaining sill of dam at the eastern culvert (b). This sill is proposed to be removed and replaced with a constructed riffle.

Photo by MMI

b.

a.

APPENDIX II

SELECTED REFERENCES

A. MA DEP - Dredged Material Regulatory Framework: Draft 7/16/02 (2 pages)

B. MA DEP - Freshwater Sediment Screening Benchmarks for Use Under the Massachusetts Contingency Plan Section 9.4 of *Guidance for Disposal Site Risk Characterization* – (1996): 310 CMR 40.00 (3 pages)

C. MA DEP - 314 CMR 9.00 - 401 Water Quality Certification for Discharge of Dredged or Fill Material, Dredging, and Dredged Material Disposal in Waters of the United States Within the Commonwealth (33 pages)

D. New England Dam Removal Sediment Management Workshop Summary; Concord, MA; October, 15 2001

Dredged Material Regulatory Framework – MA DEP Draft

Regulated Activity		Management Scenario								
		? Aquatic	? Intermediate Facilities[2]	Upland						
				Reuse and Land Application					? Disposal	? 21E Response Action
				? 401 Certification			? Receipt at 21E Site	? Landfill Reuse		
				Shoreline	Beyond Shoreline	Dredge Material Reuse Decision (DMRD)				
Applicability		All Massachusetts Waters	Any facility operated specifically for the de-watering, treatment or storage of dredged material.	Placement proximal to the dredging activity bounded by the greater of the 100-year flood plain or wetland resource buffer zone.	Sediment that contains OHMs at < MCP RCS1 notification threshold and placed at location where OHMs exist at "similar" concentrations.	Sediment reuse at locations other than Shoreline and Beyond Shoreline	Sediment brought to and placed at a 21E Site (sediment not generated from on-site response actions).	Management at existing solid waste landfills	Any upland DISPOSAL includes within the shoreline when the placement of the sediment is determined by DEP under the 401 Certification to constitute disposal.	Dredged material management when Dredging activities undertaken as a response action at a 21E Site.
Dredging[1]		314 CMR 9.00 401 Certification	Not Applicable Receiving Location							314 CMR 9.00/401 Certification.
Point of Entry3	**Characterize**	314 CMR 9.00 and 401 Certification						314 CMR 9.00 & COMM-97-001 COMM-94-007	314 CMR 9.00 & 310 CMR 19.000	Off-site 401 Cert. On-site MCP
	Transport								314 CMR 9.00	MCP
	Tracking									MCP (21E BOL)
	ID Receiving Location								314 CMR 9.00 & 310 CMR 19.000	MCP and 401 Certification
Placement Location[4]	**Standard**	314 CMR 9.00 and 401 Certification (Case Specific)			314 CMR 9.00 401 Certification (MCP S1)	314 CMR and 401 Certification (case specific)	MCP (Integral part of remedy)	COMM-97-001 & COMM-94-007	310 CMR 16.00 and 19.000	Off-site 401 Cert. On-site MCP
	Activity	314 CMR 9.00 and 401 Certification								
	Post-placement Controls	314 CMR 9.00 and 401 Certification			Not Applicable	314 CMR 9.00 and 401 Certification				
	Public Notice	314 CMR 9.00 and 401 Certification					314 CMR 9.00 & MCP	310 CMR 19.000	310 CMR 16.00 & 19.000 and 314 CMR 9.00	MCP / Off-site 314 CMR 9.00
Applicability of 310 CMR 30.000		EPA Exclusion under 40 CFR 261.4(g) and Waiver under M.G.L. c. 21C Section 4		Applicable Sediment Cannot be a Hazardous Waste					Applicable Manage at Hazardous Waste Facility	MCP
Solid Waste?		NO	**NO (Provide Conditional Exemption in 314 CMR 9.00)**					YES		

Footnotes

1. Dredging – The actual dredging of the water body.

2. Intermediate Facilities include, but are not limited to, sites/locations proposed to be used for permanent or temporary; barge unloading, sediment storage/stockpiling, dewatering, sediment processing/treatment, truck/train loading/unloading, etc.

3. Point of Entry – Activities associated with the disposal of the dredged sediment. These include characterization of the sediment for purposes of the management option, transportation requirements, tracking documentation, and enforcing the shipment of the sediment to the proposed location.

4. Placement Location – The location to which the dredged sediment ultimately shipped and the authority for enforcing the standards for placement, the placement activities, post-placement controls (financial, monitoring, maintenance etc.), and for providing public notice and input.

Acronyms

310 CMR 16.00:	Site Assignment Regulations for Solid Waste Facilities
310 CMR 19.000:	Solid Waste Management Regulations
DMRD:	Dredge Material Reuse Decision @ 314 CMR 9.07(9)(c)
21E Site:	Disposal Site Under Massachusetts Oil and Hazardous Materials Release and Response Act @ 310 CMR 40.0000
MCP:	Massachusetts Contingency Plan @ 310 CMR 40.0000
OHM:	Oil and Hazardous Materials Under MCP
RCS1:	Reportable Concentration Soil Category 1 Notification Threshold @ 310 CMR 40.1600 (most stringent notification threshold, Unrestricted Use)
21E BOL:	Bill of Lading for Transportation of Soil Containing OHM Under MCP
COMM-97-001:	Interim Policy, Reuse and Disposal of Contaminated Soil at Massachusetts Landfills
COMM-94-007:	Interim Policy for Sampling, Analysis, Handling and Tracking Requirements for Dredge Sediment Reused or Disposed at Massachusetts Landfills

TECHNICAL UPDATE

Freshwater Sediment Screening Benchmarks for Use Under the Massachusetts Contingency Plan

Update to: Section 9.4 of *Guidance for Disposal Site Risk Characterization – In Support of the Massachusetts Contingency Plan* (1996) Use of Sediment Screening Criteria in a Stage I Environmental Risk Characterization

Under the Massachusetts Contingency Plan, 310 CMR 40.0995, Environmental Risk Characterization is required for all sites evaluated using Method 3, the site-specific risk assessment approach. The guidelines for conducting environmental risk characterizations are intended to be flexible, allowing the scope and level of effort of an assessment to be commensurate with the nature and complexity of the risks posed by the site.

The Stage I Environmental Screening is designed to enable site managers to determine relatively quickly and easily whether a more detailed (Stage II) environmental risk assessment is needed to evaluate a site. The Stage I Screening should (1) identify potential exposure pathways; (2) identify any *readily apparent harm*; (3) identify site conditions that exceed, or may exceed *effects-based screening criteria*.

This Technical Update describes sediment screening benchmarks that may be used in the Stage I screening step. Additional guidance is available (MADEP, 1996) on conducting MCP Environmental Risk Characterizations.

Summary of Previous Guidance

In 1996, DEP recommended the use lowest effect levels (LELs) from the Ontario Ministry of the Environment for screening risks to benthic organisms from freshwater sediment (section 9.4.2.3 of MADEP 1996). The LEL indicates a level of contamination below which no effects are expected on the majority of sediment-dwelling organisms.

The LEL was derived by Persaud et al. (1993) using field-based data on the co-occurrence of sediment concentrations and benthic species. The calculation of the LEL for a chemical is a two-step process. The screening level concentrations for each individual benthic species are calculated. The sediment concentrations at all locations at which that species was present are plotted in order of increasing concentrations. The 90th percentile was chosen as a conservative estimate of the tolerance range of species. In the second step, the 90th percentiles for all of the species are plotted, also in order of increasing concentration. From this plot, the 5th percentile is calculated and used as the LEL.

Recommended Freshwater Sediment Screening Values

DEP has adopted the consensus-based threshold effect concentrations (TECs) for the 28 chemicals listed in MacDonald et al. (2000) for use in screening freshwater sediment for risk to benthic organisms. A list of these consensus-based TECs is provided in Table 1.

The threshold effect concentrations are intended to identify contaminant concentrations below which harmful effects on sediment-dwelling organisms are not expected. These concentrations may not necessarily be protective of higher trophic level organisms exposed to bioaccumulating chemicals. DEP has chosen the consensus-based TEC values because they incorporate a large data set, provide an estimate of central tendency that is not unduly affected by extreme values, and incorporate sediment quality guidelines that represent a number of approaches for developing sediment benchmarks.

Table 1. Sediment quality guidelines for metals in freshwater ecosystems that reflect Threshold Effects Concentrations (TECs, *i.e.*, concentrations below which harmful effects are unlikely to be observed)

Substance	Consensus-Based TEC	Substance	Consensus-Based TEC
Metals		**Organochlorine pesticides**	
(in mg/kg DW)		(in µg/kg DW)	
Arsenic	9.79	Chlordane	3.24
Cadmium	0.99	Dieidrin	1.90
Chromium	43.4	Sum DDD	4.88
Copper	31.6	Sum DDE	3.16
Lead	35.8	Sum DDT	4.16
Mercury	0.18	Total DDTs	5.23
Nickel	22.7	Endrin	2.22
Zinc	121	Heptachlor epoxide	2.47
		Lindane (gamma-BHC)	2.37
Polychlorinated biphenyls			
(in µg/kg DW)			
Total PCBs	59.8		
Polycyclic aromatic hydrocarbons			
(in µg/kg DW)			
Anthracene	57.2		
Fluorene	77.4	Chrysene	166
Naphthalene	176	Dibenz[a.h]anthracene	33.0
Phenanthrene	204	Fluoranthene	423
Benz[a]anthracene	108	Pyrene	195
Benzo(a)pyrene	150	Total PAHs	1,610

The consensus-based TEC incorporates the Ontario Ministry of the Environment lowest-observed effect levels (LELs) (Persaud et al 1993) as well as data from up to five other sediment quality guidelines (when available), including:

? threshold effects levels (TELs) (Smith et al. 1996),
? effects range-low (ER-L) values (Long and Morgan 1991),
? threshold effect levels for Hyalella azteca in 28 day tests (TEL-HA28) (U.S.EPA 1996a; Ingersoll et al. 1996),
? minimal effect thresholds (MET) from EC and MENVIQ (1992), and
? chronic equilibrium partitioning thresholds (SQAL) (Bolton et al. 1985; Zarba 1992; U.S.EPA 1997a).

Consensus-based TECs were calculated by determining the geometric mean of the sediment quality guidelines that were available for a chemical. Consensus-based TECs were calculated only if three or more published sediment quality guidelines were available for a chemical from the sources listed above.

DEP continues to recommend the use of effects range-low (ER-L) values from Long and Morgan (1991) for screening in marine and estuarine environments.

For Further Information

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Draft

314 CMR 9.00: 401 WATER QUALITY CERTIFICATION FOR DISCHARGE OF DREDGED OR FILL MATERIAL, DREDGING, AND DREDGED MATERIAL DISPOSAL IN WATERS OF THE UNITED STATES WITHIN THE COMMONWEALTH

Section

9.01: Authority, Jurisdiction, and Purpose

(1) Authority - 314 CMR 9.00 is adopted pursuant to Section 27 of the Massachusetts Clean Waters Act, M.G.L. c. 21, §§ 26 through 53 and establishes procedures and criteria for the administration of Section 401 of the federal Clean Water Act, 33 U.S.C. 1251 et seq., for the discharge of dredged or fill material, dredging, and dredged material disposal in waters of the United States within the Commonwealth. 314 CMR 9.07 is also adopted pursuant to M.G.L. c. 21A § 14; M.G.L. c. 21C; M.G.L c. 21E; M.G.L. 21H; M.G.L. c. 91, §§ 52-56; and M.G.L. c. 111, §§ 150A-150A1/2 relative to upland reuse and disposal of dredged materials.

(2) Jurisdiction - 314 CMR 9.00 applies to the discharge of dredged or fill material, dredging, and dredged material disposal activities in waters of the United States within the Commonwealth which require federal licenses or permits and which are subject to state water quality certification under 33 U.S.C. 1251, *et seq*.. Generally, the federal agency issuing a permit initially determines the scope of geographic and activity jurisdiction (*e.g.* the Corps of Engineers for Section 404 permits for the discharge of dredged or fill material). **314 CMR 9.07 applies to the management of dredged material within the marine boundaries and at upland areas of the Commonwealth.**

(3) Purpose - 314 CMR 9.00 is promulgated by the Department to carry out its statutory obligations to certify that proposed discharges of dredged or fill material, dredging, and dredged material disposal in waters of the United States within the Commonwealth will comply with the Surface Water Quality Standards and other appropriate requirements of state law. 314 CMR 9.00 implements and supplements the Surface Water Quality Standards at 314 CMR 4.00 and is a requirement of state law under 33 U.S.C. 1251, *et seq*..

314 CMR 9.00 implements and supplements 314 CMR 4.00 by, without limitation:

(a) protecting the public health and restoring and maintaining the chemical, physical, and biological integrity of the water resources of the Commonwealth by establishing requirements, standards, and procedures for the following:

1. monitoring and control of activities involving discharges of dredged or fill material, dredging, and dredged material disposal or placement;
2. the evaluation of alternatives for dredging, discharges of dredged or fill material, and dredged material disposal or placement; and
3. public involvement regarding dredging, discharges of dredged or fill material, and dredged material disposal or placement.

(b) establishing a certification program for the Department to persons seeking to discharge dredged or fill material, conduct dredging, and dispose or place dredged material.

(c) focusing the certification program on activities for which Department oversight is necessary to ensure that the activities are protective of public health and the environment of the Commonwealth.

9.02: Definitions

Activity - Any proposed project, scheme or plan of action which will result in a discharge of dredged or fill material or a discharge from dredging, or dredged material disposal subject to jurisdiction under 33 U.S.C. 1251, *et seq*. and upland management of dredged material under 310 CMR 9.00. The entirety of the activity, including likely future expansions, shall be considered and not separate phases or segments thereof. The activity includes temporary and permanent, direct and indirect, and cumulative impacts from the construction and ongoing operation of a project. The square footage of the activity shall include the total of the applicable areas proposed to be lost from the impacts of the activity, without reduction for replication or restoration.

Aggrieved Person - Any person who, because of a 401 Water Quality Certification determination by the Department, may suffer an injury in fact which is different either in kind or magnitude from that suffered by the general public and which is within the scope of interests identified in 314 CMR 9.00.

Applicant - A person applying for certification under 314 CMR 9.00.

Aquatic Ecosystem - Waters of the United States within the Commonwealth, including wetlands, that serve as habitat for interrelated and interacting communities and populations of plants and animals.

Area of Critical Environmental Concern - An area designated by the Secretary pursuant to M.G.L. c. 21A, § 2 (7) and 301 CMR 12.00.

Bordering Vegetated Wetlands - Any land or surface area so defined by the Massachusetts Wetlands Protection Act, M.G.L. c. 131, § 40 and 310 CMR 10.55(2).

Clean Water Act - The federal statute at 33 U.S.C. 1251 *et. seq*. which contains Sections 401 and 404.

Confined Aquatic Disposal (CAD) – A subaqueous facility (typically a constructed cell or natural depression) into which dredged sediment is placed and then isolated from the surrounding environment.

Confined Disposal Facility (CDF) – A facility created in open water or wetlands consisting of confinement walls or berms built up against or extending into existing land.

Corps of Engineers - The United States Army Corps of Engineers, New England District.

Department - The Massachusetts Department of Environmental Protection.

Discharge of dredged or fill material - Any addition of dredged or fill material into, including any redeposit of dredged material within, waters of the United States within the Commonwealth. The term includes, but is not limited to:

(a) direct placement of fill, including any material used for the primary purpose of replacing with dry land or of changing the bottom elevation of a wetland or water body,

(b) runoff from a contained land or water disposal area,

(c) redeposit of dredged material including excavated material which is incidental to any activity including mechanized land clearing, ditching, channelization or other excavation, unless project-specific evidence shows that the activity results in only incidental fallback. This does not and is not intended to shift any burden in any administrative or judicial proceeding under the CWA.
(d) the placement of pilings when it has the effect of fill material.

<u>Dredged Material</u> – Sediment and associated materials that are moved from below the mean high tide line for coastal waters and below ordinary high water for inland waters during dredging activities.

<u>Dredging</u> - The removal of sediment or other material from land below the mean high tide line for coastal waters and below ordinary high water for inland waters. Dredging shall not include activities in bordering, or isolated vegetated wetlands.

<u>Environmental Impact Report</u> - The report described in the Massachusetts Environmental Policy Act, M.G.L. c. 30, §§ 61 through 62H and regulations at 301 CMR 11.00.

<u>Environmental Monitor</u> - The publication described in 301 CMR 11.19(1).

<u>Fastland</u> – Land above mean high water formed by the placement of dredged or fill material into waters of the United States within the Commonwealth.

<u>Final Order of Conditions</u> - The Order of Conditions issued by the Commissioner of the Department after an adjudicatory hearing or, if no request for a hearing has been filed, the Superseding Order or, if no request for a Superseding Order has been filed, the Order of Conditions issued under the Wetlands Protection Act and 310 CMR 10.05.

<u>High Energy Site</u> - Locations in the open ocean where the average movement of the water in contact with the bottom exceeds 0.3 feet per second and which are suitable only for unconsolidated material.

<u>Incidental Fallback</u> - The redeposit of small volumes of dredged material that is incidental to excavation activity in waters of the United States when such material falls back to substantially the same place as the initial removal. Examples of incidental fallback include sediment that is disturbed when shoveled and the back-spill that comes off a bucket when such small volume of dredged material falls into substantially the same place from which it was initially removed.

<u>Intermediate Facility</u> – A site or location that is to be utilized, on either a project-specific temporary or permanent basis, to manage dredged material prior to its ultimate reuse or disposal (e.g., barge unloading, stockpiling or storage, dewatering, processing or treatment, truck or train loading or unloading).

Isolated Vegetated Wetlands - Vegetated areas subject to jurisdiction under 33 U.S.C. 1251, *et seq*. that are not bordering vegetated wetlands subject to jurisdiction under M.G.L. c. 131, § 40 and 310 CMR 10.55(2).

Land Under Water - The land or surface area defined in 310 CMR 10.25(2) and 310 CMR 10.56(2).

Lot - An area of land in one ownership, with definite boundaries.

Low Energy Site - Locations in the open ocean where the average movement of water in contact with the bottom is less than 0.06 feet per second.

Low Permeability – means having a maximum hydraulic conductivity of $1x10^{-7}$ cm/sec.

Massachusetts Environmental Policy Act or MEPA - M.G.L. c. 30, §§ 61 through 62H and regulations at 301 CMR 11.00.

Massachusetts Oil and Hazardous Materials Release Prevention and Response Act or Chapter 21E – M.G.L. c. 21E Sections 1 through 18 as amended and implementing regulations at 310 CMR 40.0000, the Massachusetts Contingency Plan (MCP).

Mixing Zone - A mixing zone is the limited volume of resource water allowing for the initial dilution of a discharge, such as from dredging or disposal in waters.

Non-Invasive Sampling Activities – Sampling activities which include the collection of water, soil or sediment samples by techniques which will not significantly disturb existing wetland resources areas (e.g., hand-held augers).

Notice of Intent - The document described in 310 CMR 10.05(4).

Oil and Hazardous Material (OHM) – means the definitions included in 310 CMR 40.0000.

Outstanding Resource Water - Waters of the Commonwealth so designated in the Massachusetts Surface Water Quality Standards at 314 CMR 4.00.

Person - Any agency or political subdivision of the Commonwealth or the federal government, public or private corporation or authority, individual, partnership or association, or other entity, including any officer of a public or private agency or organization.

Qualified Environmental Professional (QEP) – An individual who is knowledgeable about the procedures and methods for characterizing dredged material and contaminated media; is familiar with Massachusetts and federal regulations applicable to the management of such materials; performs or oversees the management of sediment and/or contaminated soil as an integral part of his or her professional duties; and is professionally licensed or certified in a discipline related to environmental assessment (i.e., engineering, geology, soil science, or environmental science) by the state or recognized professional organization.

Rare and Endangered Species Habitat - Areas identified as habitat for rare or endangered species by the Massachusetts Division of Fisheries and Wildlife's Natural Heritage Program as published in the Massachusetts Natural Heritage Atlas.

Real Estate Subdivision - The division of a tract of land into two or more lots, including division where approval is required and where approval is not required under the Subdivision Control Law, M.G.L. c.41, §§ 81K through 81GG.

Reprofiling – A method of sediment management consisting of the movement of sediment from one location to a specific adjacent and deeper location, without removing the sediment from the water.

Salt Marsh - A coastal wetland as defined in M.G.L. c. 131, § 40 and 310 CMR 10.32(2).

Sediment – Means all detrital and inorganic or organic matter situated under :
(a) tidal waters below the mean high water line as defined in 310CMR 10.23; and
(b) below the upper boundary of a bank, as defined in 310 CMR 10.54 (2), which abuts and confines a water body.

Secretary - The Secretary of the Executive Office of Environmental Affairs.

Single and Complete Project - The total project proposed or accomplished by one or more persons, including any multiphased activity.

Special Aquatic Sites – Areas of aquatic ecosystems, including wetlands, salt marsh, mudflats, riffles and pools, and submerged aquatic vegetation.

Term – The period of time a Water Quality Certification is valid as specified by the Department.

Vernal Pool - A waterbody that has been certified by the Massachusetts Division of Fisheries and Wildlife as a vernal pool. In the event of a conflict of opinion or the lack of a clear boundary delineation certified by the Division of Fisheries and Wildlife or the Department, the applicant may submit an opinion certified by a registered professional engineer, supported by engineering calculations, as to the boundary of the vernal pool. The maximum extent of the waterbody shall be based upon the total volume of runoff from the drainage area contributing to the vernal pool and shall be further based upon a design storm of two and six tenths (2.6) inches of precipitation in 24 hours.

Waters of the United States within the Commonwealth - Navigable or interstate waters and their tributaries, adjacent wetlands, and other waters or wetlands within the borders of the Commonwealth where the use, degradation, or destruction could affect interstate or foreign commerce as determined by the Army Corps of Engineers. Bordering and isolated vegetated wetlands and land under water are waters of the United States within the Commonwealth when they meet the federal jurisdictional requirements defined at 33 CFR 328 through 329.

Water-dependent - Uses and facilities which require direct access to, or location in, marine, tidal or inland waters and which therefore cannot be located away from those waters, including any uses and facilities defined as water-dependent in 310 CMR 9.00.

401 Water Quality Certification or Certification - The document issued by the Department to the applicant and the appropriate federal agency under 33 U.S.C. 1251, *et seq.*, M.G.L. c. 21, § 27 and 314 CMR 9.00 certifying, conditioning, or denying an activity.

Wetlands Protection Act - M.G.L. c. 131, § 40 and regulations at 310 CMR 10.00.

9.03: Activities Not Requiring an Application

The activities identified in 314 CMR 9.03 (1) through (6) do not require an individual 401 Water Quality Certification application provided the specified conditions are met. The Department has certified these activities through its certification of the Corps of Engineers' Programmatic General Permit for Massachusetts effective March 1, 1995.

(1) Less than 5000 sq. ft. with an Order of Conditions. Activities conducted in compliance with the Wetlands Protection Act and receiving a Final Order of Conditions which meets all applicable performance standards under 310 CMR 10.00, provided that:

(a) the Final Order of Conditions permits work, which results in the loss of up to 5,000 square feet cumulatively of bordering and isolated vegetated wetlands and land under water. Both bordering and isolated vegetated wetlands must be delineated on the plans contained in the Notice of Intent and described on a form prescribed by the Department;

(b) except for those projects which qualify as "limited projects" as per 310 CMR 10.53 or for finger-like projections less than 500 square feet pursuant to 310 CMR 10.55(4)(c), the Final Order of Conditions includes conditions requiring at least 1:1 replacement of bordering vegetated wetlands under 310 CMR 10.55(4)(b); and

(c) the proposed work is not subject to 314 CMR 9.04.

(2) Beach Nourishment. Beach nourishment activities with a Final Order of Conditions issued under M.G.L. c. 131, § 40. The provisions of 314 CMR 9.04 do not apply.

(3) Dredging less than 100 c.y. Dredging and dredged material disposal of less than 100 cubic yards, provided that a Final Order of Conditions has been issued, the proposed work is not subject to 314 CMR 9.04 and the work qualifies for Category One of the Programatic General Permit (PGP). Dredged sediment generated from such activities shall be managed in accordance with the provisions of 314 CMR 9.07(9), (10), and (11) and may be used for beach nourishment

activities or reuse within the shoreline under a Final Order of Conditions issued under M.G.L. c.131, § 40.

(4) Agriculture or Aquaculture Exempt under the Wetlands Protection Act. Normal maintenance and improvement of land in agricultural or aquacultural use exempt from the Wetlands Protection Act, as defined and performed in accordance with 310 CMR 10.04 (Agriculture) including the alternatives analysis, as applicable, performed by the Natural Resources Conservation Service (formerly Soil Conservation Service) or 310 CMR 10.04 (Aquaculture). The provisions of 314 CMR 9.04 do not apply.

(5) Less than 5000 sq. ft. of Isolated Vegetated Wetlands. Any activity in an area not subject to jurisdiction of the Wetlands Protection Act which is subject to 33 U.S.C. 1251, *et seq*. (*i.e.*, isolated vegetated wetlands) which will result in the loss of up to 5000 square feet cumulatively of bordering and isolated vegetated wetlands and land under water, provided there is no discharge of dredged or fill material to any habitat for rare and endangered species or to any Outstanding Resource Water.

(6) Planning and Design Activities. Activities that are temporary in nature, have negligible impacts, and are necessary for planning and design purposes such as the installation of monitoring wells, exploratory borings, sediment sampling, and surveying. The applicant shall notify the Department and conservation commission at least ten days prior to commencing the activity. Notification is not required if a Final Negative Determination of Applicability has been issued for the work as described 310 CMR 10.05(3)(b). Notification shall include a description of the activity, the location of the proposed activity and measures to be taken to avoid or minimize impacts. The site shall be substantially restored to its condition prior to the activity. The provisions of 314 CMR 9.04 do not apply.

The Department will notify the persons to whom an Order of Conditions is issued not later than ten business days of its receipt by the Department that based on the information available to the Department the criteria of 314 CMR 9.03 have not been met. If the impacts to resource areas or the project size increases from the description filed with the Notice of Intent, or there are any inaccuracies therein, the applicant must notify the Department and request a determination that the criteria of 314 CMR 9.03 have been met before the activity begins.

9.04: Activities Requiring an Application

The activities identified in 314 CMR 9.04(1) through (14) require a 401 Water Quality Certification application and are subject to the Criteria for Evaluation of Applications for the Discharge of Dredged or Fill Material in 314 CMR 9.06:

(1) More than 5000 sq. ft. Any activity in an area subject to 310 CMR 10.00 which is also subject to 33 U.S.C. 1251, *et seq*. and will result in the loss of more than 5000 square feet cumulatively of bordering and isolated vegetated wetlands and land under water.

(2) Outstanding Resource Waters. Any activity resulting in any discharge of dredged or fill material to any Outstanding Resource Water.

(3) Real Estate Subdivision - Any discharge of dredged or fill material associated with the creation of a real estate subdivision, unless there is a recorded deed restriction providing notice to subsequent purchasers limiting the amount of fill for the single and complete project to less than 5000 square feet cumulatively of bordering and isolated vegetated wetlands and land under water and the discharge is not to an Outstanding Resource Water. Real estate subdivisions include divisions where approval is required and where approval is not required under the Subdivision Control Law, M.G.L. c. 41, §§ 81K through 81GG. Discharges of dredged or fill material to create the real estate subdivision include but are not limited to the construction of roads, drainage, sidewalks, sewer systems, buildings, septic systems, wells, and accessory structures.

(4) Activities Exempt under M.G.L. c. 131, § 40. Any activity not subject to M.G.L. c. 131, § 40 which is subject to 33 U.S.C. 1251, *et seq*. and will result in any discharge of dredged or fill material to bordering vegetated wetlands or land under water.

(5) Routine Maintenance. Routine maintenance of existing channels, such as mosquito control projects or road drainage maintenance, that will result in the annual loss of more than 5000 square feet cumulatively of bordering and isolated vegetated wetland and land under water will be evaluated under the criteria of 314 CMR 9.06. A single application may be submitted and a single certification may be issued for repeated routine maintenance activities on an annual or multi-year basis for a term not to exceed **ten** years.

(6) More than 5000 sq. ft. of Isolated Vegetated Wetlands. Any activity in an area not subject to jurisdiction of M.G.L. c. 131, § 40 which is subject to 33 U.S.C. 1251, *et seq*. (*i.e.*, isolated vegetated wetlands) which will result in the loss of more than 5000 square feet cumulatively of bordering and isolated vegetated wetlands and land under water.

(7) Rare and Endangered Species Habitat in Isolated Vegetated Wetlands. Any activity resulting in the discharge of dredged or fill material to an isolated vegetated wetland that has been identified as habitat for rare and endangered species.

(8) Salt Marsh. Any activity resulting in the discharge of dredged or fill material in any salt marsh.

(9) Individual 404 Permit. Any activity subject to an individual Section 404 permit by the Corps of Engineers.

(10) Agricultural Limited Project. Agricultural work, not exempt under M.G.L. c. 131, § 40, referenced in and performed in accordance with 310 CMR 10.53(5). Provided the activity does not result in any discharge of dredged or fill material to an Outstanding Resource Water, such work will be presumed to meet the criteria of 314 CMR 9.06 where a comparable alternatives analysis is performed by the Natural Resources Conservation Service (formerly Soil Conservation Service) and included in the Notice of Intent.

(11) Discretionary Authority. Any activity where the Department invokes discretionary authority to require an application based on cumulative effects of multiphased activities, cumulative effects from the discharge of dredged or fill material to bordering or isolated vegetated wetlands or land under water, or other impacts which may jeopardize water quality. The Department will issue a written notice of and statement of reasons for its determination to invoke this discretionary authority not later than ten business days after its receipt of an Order of Conditions.

(12) Dredging Greater than 100 c.y.. Any dredging or dredged material disposal of more than 100 cubic yards not meeting the requirements of 314 CMR 9.03(3) or any other dredging project.

(13) Any activity not listed in 314 CMR 9.04 which is also not listed in 314 CMR 9.03 is an activity requiring an application subject to the requirements of 314 CMR 9.05 and 9.06 through 9.13 as applicable.

(14) Demonstration or Pilot Projects. Any person who wishes to establish a demonstration or pilot sediment management project, related to activities within the direct jurisdiction of the 401 Certification, for the purpose of demonstrating the effectiveness and utility of an alternative or innovative management technology shall submit an application to the Department for a demonstration project permit and notify the board of health and conservation commission of the municipality where the project is proposed.

9.05: Submission of an Application

(1) Application Requirements. An applicant for 401 Water Quality Certification shall submit an application on the forms in the 401 Water Quality Certification application package currently available from the Department. The application shall be prepared in accordance with instructions contained in the Department's application package and submitted to the appropriate address. Failure to complete an application where required, to provide additional information when an application is deficient, to provide public notice in the form specified, to notify other agencies with jurisdiction where required, or to submit information for a single and complete project shall be grounds for denial of certification. The applicant has the burden of demonstrating that the criteria of 314 CMR 9.06, 9.07, or 9.08 have been met.

(2) Fee and Review Schedule. The fee and regulatory review schedule for actions by the Department in the review of a 401 Water Quality Certification application are set forth in the Timely Action Schedule and Fee Provisions at 310 CMR 4.00.

(3) Public Notice of an Application. A public notice of an application for 401 Water Quality Certification shall be published by the applicant within ten days of submitting an application at the applicant's expense in a newspaper of general circulation **within the area of the proposed dredging activity, intermediate facilities of the proposed activity and sediment placement site (upland or in-water unless managed under 314 CMR 9.07(10) or (11)).** The public notice shall contain:

(a) the name and address of the applicant and property owner;
(b) the location of the proposed activity;
(c) a brief description of the activity;

(d) the name and address of the person from whom additional information may be obtained;
(e) the 21 day time period within which the public may comment;
(f) the office and address within the Department to which comments should be addressed; and
(g) a statement that any ten persons of the Commonwealth, any aggrieved person, or any governmental body or private organization with a mandate to protect the environment that has submitted written comments may also appeal the Department's Certification and that failure to submit comments before the end of the public comment period may result in the waiver of any right to an adjudicatory hearing.

A person submitting an application for 401 Water Quality Certification who is also subject to 310 CMR 10.00 under M.G.L. c. 131, § 40, M.G.L. c. 91, or 310 CMR 9.00 may provide joint public notice by appending to the notice under 310 CMR 10.05(5) or 310 CMR 9.13 a statement that an application for 401 Water Quality Certification is pending before the Department, provided that the joint notice contains the information in 314 CMR 9.05(3)(a) through (g). A person submitting an application for a dredging project shall concurrently file a copy of this public notice with the Board(s) of Health in the community(ies) in which each of the dredging or dredged material management activities, sites, or facilities is to be located. A person submitting an application for the discharge of dredged or fill material to an Outstanding Resource Water or any application for dredging with aquatic disposal shall also publish a notice in the Environmental Monitor, and the 21 day time period within which the public may comment shall extend from the later of the date of publication of the newspaper or Environmental Monitor notice. All comments providing relevant information shall be considered.

(4) At the Department’s discretion a site visit may be conducted. If such a site visit is proposed, the Department will provide notice to the applicant, the conservation commission of the city or town where the activity will occur, and any persons or groups which have submitted written comments prior to the date the site visit is scheduled. If the Department has previously inspected the site prior to issuing a Superseding Order of Conditions, receives no public comments, or otherwise determines a site visit is not necessary or useful to its evaluation, it shall set forth its reasons in writing.

9.06: Applications for Discharge of Dredged or Fill Material

(1) No discharge of dredged or fill material shall be permitted if there is a practicable alternative to the proposed discharge which would have less adverse impact on the aquatic ecosystem.
(a) An alternative is practicable if it is available and capable of being implemented after taking into consideration; costs, existing technology and logistics in light of overall project purposes, and is permittable under existing federal and state statutes and regulation.
(b) Where the activity associated with the discharge does not require access or proximity to or siting within wetlands and waters to fulfill its basic purpose (*i.e.*, is not "water dependent"), practicable alternatives that do not involve the discharge of dredged or fill material are presumed to be available, unless clearly demonstrated otherwise. In addition, all practicable alternatives to the proposed

activity which do not involve a discharge are presumed to have less adverse impact on the aquatic ecosystem unless clearly demonstrated otherwise.

(c) The scope of alternatives to be considered shall be commensurate with the scale and purpose of the proposed activity, the impacts of the proposed activity, and the classification, designation and existing uses of the affected wetlands and waters in the Surface Water Quality Standards at 314 CMR 4.00.

1. For activities associated with access for one dwelling unit, the area under consideration for practicable alternatives will be limited to the lot. For activities associated with the creation of a real estate subdivision, the area under consideration will be limited to the subdivided lots and any adjacent lots the applicant formerly owned, presently owns, or can reasonably obtain an ownership interest.

2. For any activity resulting in the loss of more than one acre cumulatively of bordering and isolated vegetated wetlands and land under water, alternative sites not presently owned by the applicant which could reasonably be obtained, utilized, expanded or managed will be considered by the Department, but only if such information is required in an Environmental Impact Report or in an alternatives analysis conducted by the Corps of Engineers for an individuals 404 permit.

(2) No discharge of dredged or fill material shall be permitted unless appropriate and practicable steps have been taken which will minimize potential adverse impacts to the bordering or isolated vegetated wetlands, land under water or ocean, intertidal zone, special aquatic sites including a minimum of 1:1 restoration or replication of bordering or isolated vegetated wetlands**, unless the project qualifies as a "limited project" under either the coastal or inland wetlands regulations as per 310 CMR 10.24 and 10.53 respectively.** No dredging or discharge of dredged or fill material shall be permitted if there is a practicable alternative which would have less impact on the aquatic ecosystem.

(3) No discharge of dredged or fill material shall be permitted to Outstanding Resource Waters, except for the following activities specified in this paragraph, which remain subject to an alternatives analysis and other requirements of 314 CMR 9.06:

(a) Projects conducted or approved by public or private water suppliers in the performance of their responsibilities and duties to protect the quality of the water in the watersheds, or to maintain, operate and improve the waterworks system;

(b) Activities determined by the Department to be for the express purpose and intent of maintaining or enhancing the resource for its designated use, after consultation with the entity, if any, with direct control of the water resource or governing water use;

(c) Maintenance, repair, replacement or reconstruction but not substantial enlargement of existing and lawfully located structures or facilities including buildings, roads, railways, utilities and coastal engineering structures;

(d) Where the designation was for public water supply purposes, activities subject to the comprehensive public water supply protection program enacted by the legislature for the Ware, Quabbin, and Wachusett watersheds in the Watershed Protection Act, St. 1992 c. 36 and M.G.L. c. 92:

1. Any activity for which an applicant has been granted a variance by the Metropolitan District Commission pursuant to 350 CMR 11.06(3) or for a

discharge of dredged or fill material into a tributary that the Metropolitan District Commission has exempted pursuant to 350 CMR 11.06(4). A span or other bridging technique shall be considered an alternative in accordance with 314 CMR 9.06(3)(e) and the Department will consult with the Metropolitan District Commission in reviewing the alternatives.

(e) Access for the construction of dwelling units and associated utilities:

1. For the loss of more than 5,000 square feet cumulatively of bordering and isolated vegetated wetland and land under water for access to any number of dwelling units, a span or other bridging technique is presumed to be practicable;
2. For the loss of less than 5,000 square feet cumulatively of bordering and isolated vegetated wetland and land under water for access to three or fewer dwelling units, a span or other bridging alternative is presumed to not be practicable;
3. For the loss of less than 5,000 square feet cumulatively of bordering and isolated vegetated wetland and land under water for access to four to nine dwelling units, a span or other bridging technique may be required within the alternatives analysis depending on site conditions, the impact on the resource, and cost considerations; or
4. For the loss of less than 5,000 square feet cumulatively of bordering and isolated vegetated wetland and land under water for access to ten or more dwelling units, a span or other bridging technique is presumed to be practicable.

These presumptions may be overcome upon a showing of credible evidence that based on site considerations, impact on the resource, or cost considerations, a span or other bridging technique is or is not practicable.

(f) Construction of utilities, public or private roadways or other access except as specified in 314 CMR 9.06(3).

(g) Railroad track and rail beds and facilities directly related to their operation. These activities require use of a span or other bridging technique, unless the Department determines, based on information contained in a Department 401 alternatives analysis, a Corps of Engineers Section 404 alternatives analysis, or an Environmental Impact Report and the Secretary's certificate, that this alternative is not practicable, would not have less adverse impact on the aquatic ecosystem, or would have other significant adverse environmental consequences.

(h) Operations to clean up, prevent, assess, monitor, contain, or mitigate releases of oil or hazardous materials or wastes, including landfill closures under M.G.L. c.111 s.150A-150A1/2 and 310 CMR 16.00 and 19.000 and activities undertaken in accordance with M.G.L. c. 21E and 310 CMR 40.0000.

(i) Projects which have received a variance under 314 CMR 9.08 or under 310 CMR 10.36 or 310 CMR 10.58 where consideration has been given to the Outstanding Resource Water designation in the variance analysis.

(j) Access to land in agricultural or aquacultural use, of a nature suitable to the use as defined in 310 CMR 10.04 (Agriculture; Aquaculture).

(4) Discharge of dredged or fill material to an Outstanding Resource Water, specifically to certified vernal pools, or within 400 feet of a water supply reservoir, is prohibited as provided therein unless a variance is obtained under 314 CMR 9.08.

(5) No discharge of dredged or fill material is permitted for the impoundment or detention of stormwater for purposes of controlling sedimentation or other pollutant attenuation. Discharge of dredged or fill material may be permitted to manage stormwater for flood control purposes only where there is no practicable alternative and provided that best management practices are implemented to prevent sedimentation or other pollution. No discharge of dredged or fill material is permitted for the impoundment or detention of stormwater in Outstanding Resource Waters for any purpose.

(6) Stormwater discharges shall be provided with best management practices to attenuate pollutants and to provide a set back from the receiving water or wetland in accordance with applicable provisions of the Massachusetts Stormwater Management Policy. Stormwater discharges to Outstanding Resource Waters shall be removed or set back from the receiving water or wetland, and provided the highest and best practical method of treatment. All discharges of stormwater which meet the definition of "stormwater discharge", as defined at 314 CMR 3.04(2)(a)1. or (b), into Outstanding Resource Waters shall comply with 314 CMR 3.00 and 4.00.

(7) No discharge of dredged or fill material shall be permitted in the rare circumstances where the activity meets the criteria for evaluation but will result in substantial adverse impacts to the physical, chemical, or biological integrity of waters of the Commonwealth.

9.07: Applications for Dredging and Dredged Material Management

(1) General

(a) Dredging and dredged material management shall be conducted in a manner that ensures the protection of human health, public safety, public welfare and the environment.

(b) Applications submitted to the Department shall meet the criteria and performance standards of 314 CMR 9.07. If the project submitted by the applicant does not meet a particular provision of 314 CMR 9.07, the applicant shall demonstrate that the project will provide an equivalent level of environmental protection and meet the requirements of 314 CMR 9.07.

(c) Dredged material shall not be disposed if a feasible alternative exists that involves the reuse, recycling, or contaminant destruction and/or detoxification. An evaluation of whether such an alternative is feasible shall consider:

1. the volume and physical characteristics of the dredged material;

2. the levels of oil and/or hazardous materials present within the dredged material;
3. the relative public health and environmental impacts of management options; and
4. the relative costs of management options.

(d) The Department may consider any additional information submitted under MEPA or NEPA on impacts from the dredging activity, management of the dredged material, the options available for reuse or disposal techniques, alternative sites for the various management activities, or information related to other Department programs.

(e) Dredged material management activities or facilities subject to the 401 Water Quality Certification shall comply with the provisions of 314 CMR 9.00, the conditions of the Water Quality Certificate, but doesn't relieve the proponent from compliance with all other applicable federal and state statutes and regulations.

(f) Dredged material, including sediment, placed on or in the land at an upland location is subject to the release notification requirements and thresholds of 310 CMR 40.0300 and 40.1600 for soil, unless such placement is in accordance with the provisions of 310 CMR 40.0317(10) and 314 CMR 9.07 (4), (6), (9), (10), or (11).

(2) <u>Sampling and Analysis Requirements</u>. The applicant shall submit the results of all relevant sampling with the application, unless an alternative schedule is specifically authorized by the Department. As part of sampling and analysis, the applicant shall perform a "due diligence" review to determine the potential for the sediment proposed to be dredged to have concentrations of oil or hazardous materials (as defined in 310 CMR 40.0000). Such a review may include, but is not limited to, an analysis of records of the local Board of Health, Fire Department, and/or Department of Public Works, the Department's Bureau of Waste Site Cleanup, knowledge of historic land uses, information on prior dredging projects and discharges of pollutants in the project area watershed. Sampling that was conducted in accordance with the MCP as a part of site assessment activities or a remedial action shall be supplemented as necessary to comply with 314 CMR 9.07. Supplemental sampling, if necessary, shall be submitted with the application as results or as a sampling plan.

Applicants for dredging projects proposing unconfined open water disposal shall comply with the sampling, testing, and evaluation requirements and procedures of the U.S. Army Corps of Engineers and U.S. Environmental Protection Agency. A copy of the Determination of Suitability for unconfined disposal shall be provided to the Department.

Unless a project is specifically exempted by the Department from the requirement for chemical analyses, sampling and analysis for upland reuse or disposal of dredged material shall be carried out as follows:

(a) No chemical testing shall be required if the sediment to be dredged contains less than 10% by weight of particles passing the No.200 U.S.

Standard Series Testing Sieve (nominal opening 0.0029 inches), and if the required "due diligence" review demonstrates, to the Department's satisfaction, that the area is unlikely to contain anthropogenic concentrations of oil or hazardous materials.

(b) In all other instances, chemical and physical testing shall be conducted and the information provided to the Department. When characterizing dredged material, the applicant shall:

1. **Select sampling locations in a manner that ensures that representative information is obtained about the volume, potential contamination, grain-size distribution and total organic carbon of the sediment to be dredged.**
2. **Consider available analytical information from prior dredging projects conducted at, or proximate to, the area proposed to be dredged.**
3. **Evaluate and delineate areas of potentially elevated contamination, based on influences from outfalls, tributaries, industrial discharges or sources, boat-maintenance activities or historical spills of oil or hazardous materials. In such areas, samples shall not be composited but analyzed separately.**
4. **For projects up to 10,000 cubic yards, one core for every 1000 cubic yards of dredged material shall be collected. Up to three cores may be composited to create a single sample, provided:**

    a. The grain-size distribution and likelihood of contamination are similar based on depositional characteristics, spill history, and location of point source discharges;

    b. Cores are composited from the same reach; and

    c. Samples collected for volatile organic compound analyses are obtained from an individual core and not composited from multiple cores.

5. **For projects over 10,000 cubic yards, develop a project-specific sampling and analysis plan, taking into account the likely requirement for the option(s) being considered for management of the dredged materials. This plan shall be submitted in draft form to the Department for review and comment as part of the pre-application process.**

6. At a minimum, sediment shall be analyzed for the following parameters unless specifically exempted by the Department:

Parameter[1]	Reporting Limit Mg/kg (dry weight) – unless otherwise noted[2]
Arsenic	*0.5*
Cadmium	*0.1*
Chromium	*1.0*
Copper	*1.0*
Lead	*1.0*
Mercury	*0.02*
Nickel	*1.0*
Zinc	*1.0*
Polycyclic Aromatic Hydrocarbons (PAHs)	*0.02*
Polychlorinated Biphenyls (PCBs)-by NOAA Summation of Congeners	*0.01*
Extractable Petroleum Hydrocarbons [3]	*25*
Volatile Organic Compounds (VOC)[4]	*0.1*
Total Organic Carbon	*0.1%*
Percent Water	*1.0%*
Toxicity Characteristic Leaching Procedure[5]	*As applicable*
Grain Size Distribution – wet sieve (ASTM D422)	*Sieve Nos. 4, 10, 40, 60, 200*

[1]The applicant shall use the results of the due diligence review to determine whether additional parameters should also be analyzed.
[2]If one or more of the Reporting Limits could not be met, the applicant shall include a discussion of the reason(s) for the inability to achieve the reporting limit (e.g., matrix interference).
[3]Current method for the determination of Extractable Petroleum Hydrocarbons (EPH) MADEP
[4]Required for sediment to be reused or disposed of in the upland environment unless the due diligence review indicates that VOC contamination is unlikely to be present.
[5]Required to be performed when sediment is to be managed in the upland environment and if the total concentrations of metals or organic compounds are equal to or greater than the theoretical concentration at which TCLP criteria may be exceeded:
As > 100 mg/kg, Cd > 20 mg/kg, Cr > 100 mg/kg, Pb > 100 mg/kg, Hg > 4 mg/kg.

7. The Department will accept and may require, at its discretion, analyses for additional parameters not listed in 9.07(b)(6) when dredging is proposed to be performed in areas where current or historic uses indicate that such contaminants are likely to be present.

8. The chemical analyses of sediment, included as part of an application for dredging, shall have been performed within three years of the date of submission of the application.

9. At DEP's discretion, the project proponent for an aquatic disposal facility may be required to perform a biological assessment of the dredged materials to determine whether there is the potential for the inadvertent transfer of an "invasive species" from the dredging area to the disposal location.

(3) <u>Dredging Performance Standards</u>. Dredging shall be planned and conducted to minimize short-term, long-term, and cumulative impacts on the aquatic ecosystem and to provide protection to human health:

(a) The resuspension of silt, clay, oil and grease and other fine particulate matter shall be minimized to protect aquatic life and other existing and designated uses of waters of the Commonwealth.

(b) Improvement dredging activities shall minimize and, to the maximum extent possible, avoid affecting areas of ecological importance including vegetated wetlands, shellfish habitat, spawning habitat, habitat of state-listed rare wildlife, salt marsh, intertidal zone, riffles and pools, and vegetated shallows.

(c) Where feasible, a buffer zone of 25-feet shall remain unaltered between the edge of vegetated wetlands, saltmarsh or vegetated shallows, and the top of the slope of the dredging area.

(d) Dredging shall not be undertaken during migration, spawning or juvenile development periods of finfish, shellfish, crustaceans or merostomatans in locations where such organisms may be affected, except as specifically approved by the Department. Restricted time periods for dredging or in-water management will be established by the Department after consultation with Massachusetts Division of Marine Fisheries or Division of Fisheries and Wildlife. Any applicant proposing to dredge during the recommended restricted time period must demonstrate to the Department's satisfaction that measures taken to protect the resources (e.g., working in the dry, the use of silt curtains) will be effective.

(e) The Department may consider use of a mixing zone to achieve compliance with Ambient Water Quality Standards. Any mixing zone shall be as small as feasible, and site-specific conditions such as depth, currents, and the presence of resources will determine the mixing zone for any specific project. Within the mixing zone the minimum criteria for chronic toxicity may be exceeded; while the minimum criteria for acute toxicity shall not be exceeded. All water quality criteria apply at the boundary of the mixing zone. Mixing zones may be prohibited in order to provide a reasonable margin of safety for critical uses of waters, such as public water supply intakes, shellfish harvesting areas in Class SA and SB waters, wildlife sanctuaries, habitats of endangered species and species of special concern, or in Areas of Critical Environmental Concern (ACEC).

(f) In evaluating the potential effects of suspension of contaminated sediment on aquatic organisms, the Department may compare the bulk sediment chemistry with recognized guideline values (such as Long et al. (1995)).

(4) <u>Intermediate Facilities</u>. Placement of dredged material at an intermediate facility shall be governed by the 401 Water Quality Certification under 314 CMR 9.07(4) unless waived by the Department. The Department may impose specific conditions to ensure that activities at these facilities are conducted in compliance with these requirements:

(a) Dredged material shall be placed in a secure manner to minimize exposure to humans and the environment, and activities shall be carried out in a manner that does not create a nuisance or a threat to public health or the environment.

(b) All activities shall minimize run-off and soil loss through erosion. Any runoff or erosion that does occur shall be remediated and corrective action and/or additional controls shall be immediately implemented to prevent future occurrences.

(c) Unless approved by the Department, dredged material contaminated above S-1 criteria as defined in 310 CMR 40.0933 and 40.1600 stored for more than 24 hours at the site shall be placed in watertight containers or entirely on a base composed of an impermeable material, and shall be immediately covered with the same material or other suitable material so as to minimize the infiltration of precipitation, volatilization of contaminants, and erosion. Any cover material used shall be properly secured and possess the necessary physical strength to resist tearing by the wind. Any failure of materials or procedures used in the base layer or cover layer shall be immediately repaired, replaced, or re-secured so as to minimize precipitation infiltration, volatilization, and erosion or runoff of the dredged material.

(d) Intermediate Facilities shall not be located:

1. within a Current Drinking Water Source Area or a Potential Drinking Water Source Area as defined in 310 CMR 40.0006;

2. within a 500 foot radius of a Private Water Supply Well as defined in 310 CMR 40.0006;

3. less than 1/4 mile upgradient of a surface drinking water supply as defined by groundwater flow or surface water drainage;

4. less that 250 feet downgradient of a surface drinking water supply as defined by groundwater flow or surface water drainage;

5. within 500 feet of a health care facility, prison, elementary school, middle school or high schools or children's pre-school, licensed day care center, senior center or youth center, excluding equipment storage or maintenance structures;

6. where the Department determines that traffic impacts from the facility operation would constitute an unacceptable impact to the public, taking into consideration the following factors;

   a. traffic congestion,
   b. pedestrian and vehicular safety,
   c. road configurations,
   d. alternate routes, and
   e. vehicle emissions.

7. where it would have an adverse impact on; Endangered, Threatened, Special Concern Species listed by the Natural Heritage and Endangered Species Program of the Division of Fisheries and Wildlife, an Ecologically Significant Natural Community as documented by the Natural Heritage and Endangered Species Program, the wildlife habitat of any state Wildlife Management Area, or an ACEC;

8. in a location where the anticipated emissions from facility operations would not meet required state and federal air quality standards or criteria or the Department determines that it would otherwise constitute an unacceptable risk to the public health, safety or the environment, taking into consideration;

   a. the concentration and dispersion of emissions,
   b. the number and proximity of sensitive receptors, and
   c. the attainment status of the area.

(5) <u>Transportation</u>

(a) All dredged material when transported upon public roadways shall have no free liquid as determined by the Paint Filter Test or other suitably analogous methodology acceptable to the Department and be covered to minimize fugitive dust (unless transported in vehicles specifically designed to haul liquid materials).

(b) Truck tire and undercarriage washing (or equally effective mitigation measures) shall be employed to minimize tracking of sediment onto public roadways. Such activities shall be performed in a manner which avoids siltation into wetland resources.

(c) Dredged material shall be transported using a Dredged Material Tracking Form (DMTF) available from the Department. The Dredged Material Tracking Form, or reproduction, shall accompany each shipment of dredged material transported from the dredging site and shall be retained by the entity to whom the 401 Certification is issued for a minimum of five years. The Department reserves the right to impose additional requirements on the transportation of dredged material if the Department determines that such materials represent a hazard to health, safety, public welfare or the environment. The DMTF shall contain the following information:

1. the address or location of the area dredged and the address of any Intermediate Facilities where the dredged material was stockpiled, stored, treated and/or consolidated prior to transport;

2. the name, address and telephone number of the entity to whom the 401 Certification has been issued;

3. the name and address of the transporter;

4. the name and address of the receiving facility or location;

5. the volume of dredged material that will be shipped to the receiving facility;

6. the original dated signature of a Qualified Environmental Professional attesting that the dredge material as characterized, conforms with permitting and regulatory requirements for acceptance at the receiving facility or location;

7. the original dated signature of an authorized representative of the entity to whom the 401 Certification was issued certifying the accuracy and completeness of the shipping document;

8. upon completion of all shipping activities, the original dated signature of a representative of the receiving facility or location, attesting to the total volume or weight of dredged material received by the facility or location; and

9. any other information determined necessary by the Department.

(d) Use of a Dredged Material Tracking Form shall not be required when the dredged material requires shipment:

1. Using a Hazardous Waste Manifest pursuant to 310 CMR 30.000; or

2. Using a Bill of Lading under 310 CMR 40.0030.

(e) In the case where the dredged material is transported in whole, or in part, by barge, a Barge Tracking Form (available from the Department) shall also be required.

(f) Any barge used shall be the best reasonably available marine design and in good operating condition so that minimal discharge of sediment or water occurs during transport to the authorized disposal location(s). Deck barges shall not be used unless the barge has been modified to provide for complete containment of the sediments and approval has been obtained from the Department.

(6) <u>Beach Nourishment</u>. All beach or dune nourishment projects, utilizing dredged sediment as source material, shall be carried out in accordance with the Best Management Procedures for Beach or Dune Nourishment and any procedures developed by the Massachusetts Office of Coastal Zone Management. Right of public access shall be provided for beach nourishment projects on private beaches where public funds are utilized for the activities. Dredged material placed under this provision shall not be a solid waste and is not subject to 310 CMR 16.00 and 310 CMR 19.000.

(7) <u>Unconfined Open Water Disposal</u>. Applicants for dredging projects proposing unconfined open water disposal shall comply with sediment and water quality sampling, biological testing, and evaluation according to the requirements and procedures of the U.S. Army Corps of Engineers and U.S. Environmental Protection Agency. The Department may include specific

conditions related to time-of-year disposal restrictions to protect the Right Whale or other relevant requirements consistent with the Massachusetts Clean Water Act.

(8) Confined Disposal

(a) General

1. **Aquatic disposal of dredged sediment that is unsuitable for open ocean disposal shall include management techniques to isolate the sediment from the surrounding environment thereby minimizing potential adverse impacts to the benthic and pelagic communities. The principal methods to isolate the material are to cap it with a layer of "clean" material (Confined Aquatic Disposal) or use of a contaminant structure (Confined Disposal Facility). Capping may be required for both interim and final controls.**

2. **In determining the acceptability of a site for a confined disposal facility, the Department will consider all relevant factors including, but not limited to: shellfish; fisheries; wetland resources and special aquatic sites in proximity to the site; use of site as fishery nursery or farming; ACECs; recreational activities; hydrology and hydrodynamics of the site; existing sediment (physical and chemical quality) at and proximal to the site; and unique site factors and conditions.**

(b) Placement

1. **Sediment shall be placed into the facility in a manner that minimizes the escape and release of sediment to the environment.**

2. **Sediment placement shall occur only during specific periods of time authorized by the Department to provide maximum dilution but minimal dispersion and transport of fine contaminated sediment during placement operations. If an alternative technology is approved that allows the material to be placed directly in the disposal cell without passing through the water column, disposal may occur at any time.**

3. **Adequate time shall be provided to allow the sediment to properly consolidate prior to placement of the cap to minimize the escape of sediment from confinement during cap placement. Unless specifically approved by the Department, capping of any cell shall be completed within one month of the start of cap placement unless otherwise specified by the Department.**

4. **The applicant shall provide the Department with a schedule of activities related to initiation and completions of the capping phase.**

(c) Confined Aquatic Disposal (CAD)

1. Design Standards

a) The applicant shall take vessel traffic (e.g. passage of tugboats or deep draft vessels) into account during cell filling to minimize entrainment of sediment from prop-wash.

b) Unless specifically exempted by the Department, the applicant shall use a water quality model to assess compliance with water quality standards and to determine if restrictions on volume or timing of disposal events are required (e.g., tidal stage, tidal current, disposal volume, multiple disposal event timing, and proximity in time to expected vessel passage).

c) If project sequencing allows, the most contaminated material shall be placed at the bottom of cells to allow for the greatest level of sequestering.

d) The disposal cell cap shall be constructed and placed in a manner that minimizes disturbance of the dredged material in the disposal cells and provides the following:

1. **Documentation of the placement of the capping material including the amount and location of each load.**

2. **Documentation of the paths of the disposal vehicle to determine where the following load should be placed (if multiple loads are required) to keep the cap thickness as even as possible until the required thickness is achieved.**

3. **Surveys each capped cell to verify that the required areal coverage and vertical thickness is achieved.**

4. **Cap material shall be placed wet.**

5. **Tugs shall be used to move the deeper draft self-propelled vessels to minimize prop-wash effects.**

6. **There shall be no mechanical disturbance of the cap by a drag bar, clamshell bucket, barge spudding or other means, unless approved by the Department.**

7. **The applicant shall assure that at least 90% of the CAD surface area shall include a "clean layer" whose vertical thickness contains at least 70% sand or other approved capping material (layers less than 70% will**

be considered a "zone of mixed material" (interface layer) and will not be considered in the determination of capping compliance).

2. <u>Monitoring</u>

a) If subaqueous cells are utilized, bathymetric surveys shall be conducted: prior to cell excavation; after the cell is excavated and constructed; after the disposal of dredged material; and after the cap is placed.

b) Baseline conditions of general water quality (dissolved oxygen, suspended solids, turbidity) as well as specific contaminants of concern (those determined to be in the dredged material to be disposed) shall be assessed prior to the start of any dredging or dredged material placement activities.

c) Each disposal event shall be documented, including the date, time and source of dredged material; the time and location of disposal (including high accuracy location coupled with orientation of the disposal vessel); the equipment used to dredge and dispose of the material; the weather and sea conditions; and personnel on duty. In addition, an estimate of the volume of material disposed shall be provided. Detailed, step-by-step requirements for filling cells shall be developed and utilized.

d) The applicant shall obtain cores from a statistically valid number of disposal cells one year and five years after cells have been capped, selected according to a random distribution among all cells, to evaluate the cap thickness, interface layer, unless alternative times are specified by the Department, to determine the long-term integrity and thickness of the cap material and overlying sediment.

e) Recolonization of benthic species on the surface of the cell shall be assessed against background one year after completion of the project, unless an alternative time is specified by the Department.

(d) <u>Confined Disposal Facilities (CDF)</u>

1. <u>Design Standards</u>

a) The facility shall be designed and constructed to allow for stormwater controls and material dewatering and the applicant shall evaluate the need for leachate controls, including a liner system.

1. Stormwater controls shall prevent erosion, discharge of pollutants and protect the physical

integrity of the facility. The controls shall be designed to prevent flow onto the active portion of the facility and control the run-off from the active portion of the facility for at least the water volume resulting from a 24 hour, 25 year storm; the Department may require evaluation of a greater storm event due to the nature of the dredged material and/or potential discharge to sensitive receptors (such as ORWs, ACECs).

2. **The operator shall provide sufficient stormwater drainage controls and diversion structures to promote drainage off of the facility, minimize drainage onto the facility, and prevent ponding on or adjacent to the CDF area. Stormwater drainage structures shall be designed, constructed and maintained so as to ensure their integrity;**

3. **In a situation where significant settlement, ponding of water or erosion occurs during the operation, closure or the post-closure period, the operator or owner shall immediately institute corrective actions and mitigation.**

b) The operator shall prevent vermin, insects, dust, odors and other nuisance conditions from developing.

c) The operator of facilities located in proximity to airports shall operate and maintain the facility in a manner to ensure that the facility shall not pose a bird hazard to aircraft.

d) The operator shall provide sufficient fences or other barriers to prevent unauthorized access to the facility.

e) The facility shall include a final cover system, which shall: minimize the percolation of water through the final cover into the fill material; promote proper drainage of precipitation; minimize erosion of the final cover; facilitate the venting and control of gas (if applicable); ensure isolation of the sediment from the environment; and accommodate settling and subsidence of the facility so that the final cover system continues to operate as designed.

Unless authorized by the Department, the final cover system shall have a final top slope of not less than 5% and side slopes no greater than three horizontal to one vertical (3:1); be constructed so as to minimize erosion of all layers of the final cover by using terraces or other appropriate stormwater controls; be constructed so that the low permeability layer is protected from the adverse

affects of frost or freeze/thaw cycles; and be constructed to maintain slope stability.

f) The final facility cap shall be designed and constructed: to remain impervious for the expected life and post-closure period of the facility; have a minimum compacted thickness of 18 inches; be compacted to minimize void spaces; be capable of supporting the weight imposed by the post-closure use without excessive settling or causing or contributing to the failure of the low permeability layer; and be free of materials that, because of their physical, chemical or biological characteristics, may cause or contribute to an increase in the permeability of the low permeability layer or otherwise cause a failure of the low permeability layer.

g) An operation and maintenance plan shall be developed and implemented, including a narrative description of operation and maintenance requirements or activities proposed to be conducted during the life of the facility (including the post-closure period) and a proposed schedule for regular inspections and maintenance of the facility, including standard operating procedures.

h) The owner or operator shall hire an independent professional engineer, knowledgeable and experienced in matters of containment structures, who shall oversee the installation and construction of all components of the containment structures and certify all design and as-built plans for the facility.

2. <u>Siting Criteria</u>

CDFs shall not be located:

a) within 500 feet of an occupied residential dwelling, health care facility, prison, elementary school, middle school or high schools or children's pre-school, licensed day care center, senior center or youth center, excluding equipment storage or maintenance structures; provided, however, that the applicant may show a valid option to purchase the restricted area, the exercise of which shall be a condition of any Certification;

b) where traffic impacts from the facility operation would constitute an unacceptable risk to the public, taking into consideration the following factors;

1. traffic congestion,
2. pedestrian and vehicular safety,
3. road configurations,
4. alternate routes, and
5. vehicle emissions.

c) where it would have an adverse impact on; Endangered, Threatened, Special Concern Species listed by the Natural Heritage and Endangered Species Program of the Division of Fisheries and Wildlife, an Ecologically Significant Natural Community as documented by the Natural Heritage and Endangered Species Program, the wildlife habitat of any state Wildlife Management Area, or an ACEC;

d) in a location where the anticipated emissions from facility operations would not meet required state and federal air quality standards or criteria or the Department determines that it would otherwise constitute an unacceptable risk to the public, taking into consideration;

1. the concentration and dispersion of emissions,
2. the number and proximity of sensitive receptors, and
3. the attainment status of the area.

(9) Shoreline Placement and Upland Material Reuse Under a 401 Certification. In accordance with a 401 Certification pursuant to 314 CMR 9.07 the Department may permit:

(a) Shoreline Placement of dredged material at a location proximal to the dredging activity that lies within the greater of the 100-year floodplain or wetland resource buffer zone as defined in 310 CMR 10.00.

(b) <u>Upland Placement</u> of dredged material in any upland area as fill or for other reuse activities, provided the concentrations of oil and hazardous material in the dredged material are less than release notification thresholds for RCS-1 soils as specified in 310 CMR 40.0300 and 40.1600, that is not otherwise a hazardous waste and will not adversely affect an existing public or private potable water supply, provided that:

1. The material is not reused at a location(s) where the existing types of contaminants or concentration(s) of oil and hazardous material(s) in the soil at that location are significantly lower than the levels of those oil and/or hazardous material(s) present in the material;

2. The material is dewatered prior to transportation from the site of dredging and any Intermediate Facilities to the reuse location;

3. The material is managed, transported, and placed at the receiving location in compliance with the requirements of 314 CMR 9.07;

4. The Department has not determined in writing that either because of the nature of the proposed activity and/or the characteristics of the material that the material requires management as a solid waste subject to the provisions of 310 CMR 16.00 and/or 310 CMR 19.000; and

5. The applicant provides the following information with the 401 Water Quality Certification application;

a) for the property at which the dredge material is proposed to be reused:

1) the name and address of the owner of the property,

2) the name and address of the person proposing to reuse the material , if different than the owner of the property,

3) the address of the property, and
4) a United States Geological Survey Topographic Map showing the location of the property.

b) a description of the proposed reuse for the material, including but not limited to, the volumes and schedule for the activity;
c) a physical and chemical characterization of the material and the soil at the receiving location;
d) a statement signed by the applicant and the owner of the property at which the dredge material is proposed for reuse that the reuse of the material complies with the provisions of this section and 314 CMR 9.07; and
(e) Documentation that the Board of Health of the community(ies) within which the property(ies) are located that the dredged material is proposed for placement has been notified in writing of the proposal.

(c) <u>Dredged Material Reuse Decision</u> at any upland area not authorized under (a) or (b) above, provided a prior written approval of dredged material reuse is obtained from the Department, which complies with the following requirements and conditions.

1. <u>Submittal and Criteria Requirements</u>. An application for a Dredged Material Reuse Decision (DMRD) shall be submitted to the Department's Division of Wetlands and Waterways, and a copy of the application shall be filed with the board of health of jurisdiction, unless the Department determines that the proposed use is not limited to a specific location and therefore it is not practical to identify the board of health of jurisdiction. The application shall contain at least the information indicated below in a), b), c) and d); and the proposed reuse shall comply with the criteria and requirements in e), f), g), h) and i).

<u>Application Requirements</u>

a) chemical and physical characterization of the dredged material;
b) identification of the quantity, quality and source of the material;
c) the proposed method of handling and utilization of the material; and
d) such additional information as the Department deems necessary and appropriate to evaluate and permit the proposed processing and material reuse.

Criteria and Requirements

e) the proposed methods of handling, storing, treating and reuse of the material shall not adversely affect the public health, safety or the environment and/or result in a condition of significant risk;
f) the proposed project can be successfully completed and the identified material can be feasibly processed and reused under the proposal set forth in the application;

g) any mixing of different materials, if applicable, improves the usefulness of the material;
h) the proposed management and re-use of the material shall not cause a nuisance condition; and
i) adequate measures shall be in-place to control erosion and sediment transport.

Dredged material, when managed in accordance with provisions 314 CMR 9.07(9) (a), (b) or (c) above, shall not be considered solid waste for the purposes of 310 CMR 16.00 and 310 CMR 19.000 and its management shall not be considered disposal, unless the Department determines that due to the chemical or physical characteristics of the dredged material or the nature of the activity that the dredged material is a solid waste.

(10) <u>Management of Dredged Material at Disposal Sites Pursuant to M.G.L. c.21E and 310 CMR 40.0000, the Massachusetts Contingency Plan</u>

(a) The dredging, management, and placement of dredged material at a disposal site conducting response actions under 310 CMR 40.0000, the Massachusetts Contingency Plan, shall be performed pursuant to the provisions of 310 CMR 40.0000 and 314 CMR 9.00. A copy of the remedial action plan under 310 CMR 40.0000 (Immediate Release Abatement Plan, Release Abatement Measure Plan, Remediation Implementation Plan, etc.) in which the activity is being conducted and the associated Bureau of Waste Site Cleanup transmittal form shall be included with the application for the 401 Water Quality Certification, unless specifically exempted by the Department.

(b) The dredging, management at an Intermediate Facility, and placement at a Confined Disposal Facility or Confined Aquatic Disposal Facility of dredge material generated at a disposal site as part of a remedial action pursuant to 310 CMR 40.0000 shall also be subject to the provisions of 314 CMR 9.00 and a 401 Water Quality Certification. In addition, dredged material generated at a disposal site as part of remedial action under 310 CMR 40.0000 shall be managed in accordance with 310 CMR 40.0000, including but not limited to the provisions of 310 CMR 40.0030.

(c) Dredged material containing oil or waste oil or one or more hazardous materials at concentrations at or greater than a release notification threshold specified in 310 CMR 40.03000 and 40.1600, and that is not otherwise a hazardous waste may be brought from another location to a disposal site and utilized as part of a comprehensive remedial action pursuant to section 310 CMR 40.0800 of the Massachusetts Contingency Plan, provided that:

1. The material is dewatered prior to transportation to the disposal site;
2. The material is not reused at location(s) where the existing types of contaminants or concentration(s) of oil and hazardous material(s) in the soil at that location are significantly lower than the levels of those oil and/or hazardous material(s) present in the material;
3. It has been demonstrated that it is not feasible to reduce or approach the level of oil or hazardous material at the site of reuse to background;

4. The reuse of the material does not increase the footprint of contamination at the disposal site;
5. The reuse of the material does not result in a condition of Significant Risk;
6. The material substitutes for a material that is otherwise required for and integral to the remedial action at the disposal site; and
7. Unless otherwise directed by the Department in writing, the remedial action is conducted under a Phase IV – Remedy Implementation Plan that provides for the use of the material at the disposal site.

(11) Management of Dredged Material Under the Solid Waste Regulations Pursuant to 310 CMR 16.00 and 19.000.

Dredged material placed at upland locations other than under 314 CMR 9.07(6), (9) and (10) shall be managed subject to provisions of the Solid Waste Regulations at 310 CMR 16.00 and 19.000 and relevant Guidelines and Policies.

(12) Applicability of M.G.L. c.21C and 310 CMR 30.000, the Massachusetts Hazardous Waste Regulations

Dredged material managed in accordance with a 401 Certification pursuant to 314 CMR 9.07(4), (8) and (9) shall not be subject to regulation as a hazardous waste under 310 CMR 30.000, unless the Department determines that compliance with some or all of the provisions of 310 CMR 30.000 is required. Factors the Department shall consider in such determinations include, but are not limited to:

(a) the volume and toxicity of the dredged material;
(b) the nature of the proposed management activity;
(c) the potential impact of the proposed activity on the public health, safety, public welfare and the environment; and
(d) need for and types of long term management controls.

(13) Interstate Management

(a) Dredged Material from Out-of-State Waters

An applicant proposing to manage dredged material from out-of-state waters pursuant to permits issued for Massachusetts facilities which are proposed to handle dredged material shall file a notification on a form available from the Department. Any out-of-state applicant proposing to dispose, manage, or use dredged material in Massachusetts shall contact the Department to discuss the project prior to the submittal of permit applications.

(b) Dredged Material Going to Out-of-State Management Facilities
An applicant proposing to use or dispose of dredged material originating in Massachusetts at an out-of-state location shall demonstrate to the

Department that this option is approved by the receiving State. Documentation shall include:

1. **evidence that acceptance of the dredged material by the facility complies with the requirements of the receiving state, which may consist of either;**

    a) **letter from the appropriate regulatory agency of the receiving state approving receipt of the dredged material, or**

    b) **copies of the relevant portions of the facility's permit;**

2. **evidence that the dredged material has been characterized and meets the facility's acceptance criteria; and**

3. **documentation that the receiving facility has agreed to accept the dredged material.**

(14) Certification Requirements. The Department may incorporate into its certification requirements and conditions for each milestone in the dredging process, which shall be performed by the project proponent. Documentation of the fulfillment of the requirements and conditions for each milestone shall be prepared by a Qualified Environmental Professional and submitted to the Department (e.g., quality assurance/quality control plan, liner installation requirements, cap construction).

(15) Post-Closure Use. No person shall use a dredged material placement facility site permitted under 310 CMR 9.07(9) for any purpose other than that established in the 401 Certification after closure without first obtaining Department approval.

(16) Financial Responsibility for Closure, Post-Closure and Corrective Actions. The owner or operator of a dredged material placement or disposal facility may be required to establish or obtain, and continuously maintain, financial assurance that is adequate to assure the Department that the owner or operator is at all times financially capable of complying with the provisions of these regulations governing the closure of the facility and its post-closure maintenance.

9.08: Variance

The Commissioner may issue a variance of the criteria for evaluation of applications under 314 CMR 9.06 or 9.07 if the applicant demonstrates that:

(1) All reasonable measures have been proposed to avoid, minimize, and mitigate adverse effects on the environment; and

(2) The variance is justified by an overriding public interest or necessary to avoid a certification that so restricts the use of property as to constitute an unconstitutional taking without compensation.

The applicant may file an application for a variance with the Commissioner of the Department stating the proposed measures to avoid, minimize, and mitigate adverse effects and evidence of an overriding public interest or unconstitutional taking. If after public notice the Commissioner finds that the activity meets the variance criteria, the Commissioner shall specify which regulation(s) has been waived and what conditions must be met for certification. The Commissioner may consolidate variance decisions under 314 CMR 9.00, 310 CMR 10.36 and 10.58, and 310 CMR 9.21. Publication of the variance application in the Environmental Monitor shall constitute notice to the public and to agencies with acquisition authority of the Department's pending determination.

9.09: 401 Water Quality Certification

(1) The Department will certify in writing to the appropriate federal agency and to the applicant whether or not the proposed project will meet applicable water quality standards and minimize environmental impacts through compliance with 314 CMR 4.00 as implemented and supplemented by 314 CMR 9.00. Certification will be denied if the criteria of 314 CMR 9.06, 9.07, or 9.08 as applicable are not met. The Department shall send copies of the 401 Water Quality Certification or denial concurrently to the conservation commission, any person who submits written comments during the public comment period and any others who submit a written request. The certification or denial will contain:

(a) the name and address of the applicant, the address of the proposed activity, and the date of the Department's determination;

(b) the federal permit number, the 401 Water Quality Certification Transmittal Number and the Wetlands Protection Act File Number, if applicable and available;

(c) a statement that there is or is not reasonable assurance that the activity will be conducted in a manner which will not violate applicable Surface Water Quality Standards at 314 CMR 4.00 as implemented by 314 CMR 9.00 and a statement of reasons if certification is denied;

(d) any conditions deemed necessary by the Department to insure maintenance or attainment of water quality, minimization of any damage to the environment, which may result from the project, or compliance with any applicable provisions of Massachusetts law which the Department is authorized to administer. As a condition of certification of subdivisions or other phased activities, applicants may be required to record a deed restriction which would limit subsequent discharges of dredged or fill material to ensure that the criteria for the evaluation of applications have been applied to a single and complete project, including all components of multi-phased activities;

(e) the date the work may begin. No activity may begin prior to the expiration of the appeal period or until a final decision is issued by the Department if an appeal is filed;

(f) a statement that the certification does not relieve the applicant of the duty to comply with any other statutes or regulations;

(g) notification of the right to request an adjudicatory hearing as described in 314 CMR 9.10; and

(2) Applications may be made to amend existing 401 Water Quality Certifications and are subject to the Department's review and approval or denial.

9.10: Appeals

(1) Right to Appeal. Certain persons shall have a right to request an adjudicatory hearing concerning certifications by the Department when an application is required:

(a) the applicant or property owner;
(b) any person aggrieved by the decision who has submitted written comments during the public comment period;
(c) any ten persons of the Commonwealth pursuant to M.G.L. c. 30A where a group member has submitted written comments during the public comment period;
(d) any governmental body or private organization with a mandate to protect the environment which has submitted written comments during the public comment period.

Any person aggrieved, any ten persons of the Commonwealth, or a governmental body or private organization with a mandate to protect the environment may appeal without having submitted written comments during the public comment period only when the claim is based on new substantive issues arising from material changes to the scope or impact of the activity and not apparent at the time of public notice.

(2) Notice of Claim. Any notice of claim for an adjudicatory hearing must be accompanied by a filing fee as specified in 310 CMR 4.06 and be sent by certified mail or hand delivered to the Office of Administrative Appeals of the Department of Environmental Protection, postmarked within 21 days of the date of the certification.

(3) Contents of Claim. Any notice of claim for an adjudicatory hearing must include the following information:

(a) the 401 Certification Transmittal Number and Wetlands Protection Act Number, the name of the applicant and address of the project if applicable and obtainable;
(b) the complete name, address, and telephone number of the party filing the request; the name, address and telephone number of any authorized representative; and, if claiming to be a person aggrieved, the specific facts that demonstrate that the party satisfies the definition of "aggrieved person" found in 314 CMR 9.02;
(c) a clear statement that an adjudicatory hearing is being requested;
(d) a clear and concise statement of facts which are grounds for the proceeding, the specific objections to the Department's written certification, and the relief sought through the adjudicatory hearing, including specifically the changes desired in the final written certification; and

(e) a statement that a copy of the request has been sent by certified mail or hand delivered to:

1. the applicant;
2. for projects in Outstanding Resource Waters, the public or private water supplier where the project is located, the Department of Environmental Management for projects in Areas of Critical Environmental Concern, or other entity with responsibility for the resource;
3. the owner, if different from the applicant;
4. the appropriate regional office of the Department;
5. the conservation commission of the city or town where the activity will occur.

(4) Coordination of Appeals. The Department may coordinate adjudicatory appeals under 314 CMR 9.00, 310 CMR 10.00, 310 CMR 9.00 or other administrative appeals:

(a) If a final order has been issued pursuant to 310 CMR 10.00, the Department may exclude issues within the jurisdiction of 310 CMR 10.00 at an adjudicatory hearing held under 314 CMR 9.00.

(b) If an adjudicatory hearing has been requested under 314 CMR 9.00, 310 CMR 9.00, 310 CMR 10.00, or another administrative appeal, the Department may consolidate the proceedings.

9.11: Enforcement

Failure to comply with 314 CMR 9.00 or a 401 Water Quality Certification shall be enforced as provided in M.G.L. c. 21, §§ 42 and 44, M.G.L. c. 21A, §14 and 310 CMR 5.00.

The Department may issue such orders as it deems necessary to aid in the enforcement of 314 CMR 9.00. Such orders may require any person subject to 314 CMR 9.00 to cease any activity which is in violation of M.G.L. c.21, c.21A or 314 CMR 9.00, to carry out activities necessary to bring such person into compliance, or the Department may require the submittal of information deemed necessary to evaluate whether a person is subject to the provisions of M.G.L. c.21, c.21A or 314 CMR 9.00, where there is reasonable belief based upon industry practice and existing Department Policy.

9.12: Authorization of Emergency Action

In the rare situation where immediate action is essential to avoid or eliminate a serious and immediate threat to the public health or safety or to the environment, a person may act without a certification, provided that the person obtains prior approval of the Department or authorization under M.G.L. c. 131, § 40. The Corps of Engineers' emergency provisions for Section 404 permits are located at 33 CFR 325.2(e)(4).

(1) Any activity subject to the jurisdiction of 310 CMR 10.00 which has been certified as an emergency by a conservation commission conducted in accordance with 310 CMR 10.06, or by the Department under 310 CMR 10.06(5), and any oil or hazardous material "Immediate Response Action" undertaken in accordance with the provisions of 310 CMR 10.06(7), is also authorized under 314 CMR 9.00.

(2) Absent authorization under 310 CMR 10.00, a written request shall be submitted to the Department which describes the location, the work to be performed, and why the project is necessary for the protection of the environment

or the health or safety of the public. The applicant shall obtain a letter of support from the local Board of Health, Harbormaster, or Department of Public Works. If such written support is not included with the emergency request, the applicant shall document the actions taken to obtain such written support. Emergency approval shall be issued in writing and shall specify the limits of activities necessary to abate the emergency. When the necessity for undertaking the emergency action no longer exists, any emergency action shall cease until compliance with the provisions of 314 CMR 9.00. In any event, the time limit for performance of emergency work shall not exceed 30 days, unless a written extension is approved by the Department. The emergency authorization may require the submission of an application. No work may be undertaken without emergency authorization under M.G.L. c. 131, § 40, M.G.L. c. 91, and M.G.L. c.30, §§ 61 through 62H, where applicable.

(3) Any activity subject to the jurisdiction of 310 CMR 9.00 which is eligible for authorization by the Department under 310 CMR 9.20 may receive emergency authorization under 314 CMR 9.12, provided that the applicant submits sediment data or other information if requested by the Department.

(4) "Immediate Response Actions" not subject to the jurisdiction of 310 CMR 10.00, which receive oral approval from the Department pursuant to 310 CMR 40.0420(2), or are initiated 24 hours prior to notification and oral approval pursuant to 310 CMR 40.0420(7) and (8), may commence before a written request under 314 CMR 9.12(2) is submitted to the Department, provided the request is made within 24 hours after the Department's oral approval. Once a request for emergency certification has been made pursuant to 314 CMR 9.12(2), work that commenced prior to such filing may continue pending a decision on the request by the Department.

9.13: Effective Date, Transition Rule, and Severability

(1) Effective Date. The revisions to 314 CMR 9.00 shall take effect March 1, 1995. Any application submitted to the Department prior to March 1, 1995 shall be considered under the standards and criteria in effect prior to adopting these revisions.

(2) Transition Rule. When an applicant has filed a Notice of Intent under M.G.L. c. 131, § 40 prior to March 1, 1995 for which a Final Order is subsequently issued and the planning board approves a definitive subdivision plan pursuant to M.G.L. c. 41, §§ 81K through 81GG or determines that approval is not required based on plans that substantially conform to the Notice of Intent, activities related to a real estate subdivision shall be subject to the substantive standards as previously in effect under 314 CMR 9.00 dated December 31, 1983. Such activities shall be subject to the application provisions of the revised 314 CMR 9.00 effective March 1, 1995, but not including 314 CMR 9.06 through 9.10.

(3) Severability. If any provision of any part of 314 CMR 9.00, or the application thereof, is held to be invalid, such invalidity shall not affect any other provision of 314 CMR 9.00.

REGULATORY AUTHORITY
314 CMR 9.00: M.G.L. c. 21, §§ 26 through 53, M.G.L. c. 21A § 14; M.G.L. c.21C; M.G.L. c.21E; M.G.L. 21H; M.G.L. c. 91, §§ 52-56; and M.G.L. c. 111, §§ 150A-150A1/2

NEW ENGLAND DAM REMOVAL SEDIMENT MANAGEMENT WORKSHOP
WORKSHOP SUMMARY

October, 15 2001
Army Corps of Engineers (ACOE), New England Regional Office, Concord, MA

This workshop was one in a series of workshops planned to address issues in dam removal for ecological restoration in New England. Michael Merrill (MA Riverways Program) and Jim Turek (NOAA) prepared these workshop notes. Electronic or hard copies of the workshop Power Point presentations by the speakers are available on request.

Overview of Sediment Issues Related to Dam Removal- Jim Turek, NOAA:
The purpose of the meeting is to bring together individuals actively working on dam removals or potential projects as well as agency regulators involved in reviewing and approving sediment-related work activities to attempt to develop a region-wide process to improve on regulatory consistency and time and cost-effectiveness in dam removals. The process would be developed with input by each of the New England state regulatory agencies, U.S. Army Corps of Engineers, and federal resource agencies. A regional organization-released manual could be developed to help guide dam removal practitioners and regulators in following the agency-approved process by providing term definitions, explaining physical sedimentation processes, sediment characteristics, general work approaches, standard operating procedures, significance of contamination, regulatory requirements, and examples of project involving sediment management.

Q: Cost-benefit analysis of leaving dam in place and maintain sediment and putting in a fish-way? Often, the repair is considerably costlier, but when contaminated sediment is present, it can be expensive. Also, fishway technology is moving forward, yet may still be costly.

Q: Why has there been a trend been toward removal versus repair? Is there a historical basis for this trend? There seems to be a general consensus building by state and federal agencies as well as the public that dam removal is a more holistic approach to riverine restoration and means for better ensuring public health and safety from dam failure and exposure to contaminated soil and sediment. People are learning to better appreciate the benefits of free-flowing rivers. Anadromous fish restoration has really pushed dam removal as an alternative. However, many people are still reluctant to change. Dam removal comes down to cost versus benefits. Two issues generally arise: contaminated sediment with the high costs of off-site removal and disposal, and the fact that many people have grown accustomed with their local impoundment. Many communities also do not like to deal with the liability.

Q: Is maintenance of a dam really a viable solution to a contaminated impoundment? Leaving it in place is still a potential problem because of potential ecological impacts and human health risk, as well as chronic contaminant releases. Risk assessment can be used to evaluate these project alternatives. In some cases, it may be better to keep the contaminants wet and anoxic.

Site Sediment Screening- USGS' Approach in Massachusetts- Marc Zimmerman, Rob Breault, USGS:
Dr. Zimmerman discussed USGS' cost-effective approach to completing sediment screening for Massachusetts test sites. This project resulted from cooperation and funding from MADEP, MADEM, and MA Riverways. The purpose of the project was to develop a screening method so that future projects would include cost-effective sampling and analysis, especially organic contaminants.

He suggested protocols can be developed to address:
1. Regulatory agencies data needs: Provide information they will need to base decisions
2. Regulatory Standards: Biological effects, disposal standards; Recognize possible disparity between standards
3. Decisions as to number of cores and samples, including quality assurance samples

4. constituents
5. Money: Define funds needed and identify sources of funding

Two types of projects were assessed: Perryville Pond, French River, an impoundment with known contamination and two sites with no known contamination– two small impoundments on Yokum Brook in Becket, MA.

Sampling plan began with consultation with state and federal agencies to address concerns, analytes, and number of samples. Looked to the Town Brook project in Plymouth as a starting point, and also consulted with MADEP (Steve Lipman) which suggested a standard due diligence approach to look at historical documents and studies pertaining to the sites. Due diligence for the Perryville Pond site included 21 E sites database, EPA permitted wastewater treatment discharges, EPA – 1987 EIA for French River clean-up that included some sediment grab samples and revealed trace element contamination –metals, PAH's; although no standards exceeded at that time. Sediment map published in 1980s showed where sediment mass is located and helped guide sampling plan. Deepest sediment is 8 to10 feet deep near dam.

Other issues associated with the subject study sites: Perryville Pond: recreational- fishing, canoeing; the impoundment is immediately upstream of CT border; chronic interim repair of dam embankment to prevent dam failure which would release sediment to CT
Yokum Brook: Atlantic salmon spawning and nursery habitat; school needs fire protection system with water storage, and there are other fire pond needs

Cores were sub-sampled by collecting from surface, middle, and bottom strata.

Dr. Zimmerman discussed analytical methods to measure amino acid analytes using colorimetric techniques. The analytical method termed, ELISA is supplied by Strategic Diagnostics (Go to: www.SDIX.com). Analytes are extracted with methanol and added are coloring reagents. It is a competitive reaction for binding sites, and antibodies are used to target specific compounds. Spectrophotometry is applied to estimate target organic contaminant concentrations (ELISA method does not work for metals). Calibration curves are then used to estimate concentrations. Sediment samples need to consist of a minimum 70% solid material. Only a 10-gram sediment sample is needed that is allowing to air dry, thus minimizing potential error due to volatilization, a problem with oven drying technique.

Results included: Total chromium: 550 mg/kg – Perryville, 250-300 mg/kg - Becket
PAHs: 10,000 ppm in Perryville sediment – comparable to previous studies in Charles River samples; considerably lower in relatively pristine Becket sediment (100s ppm)
PCBs: 6 detections at Perryville; none at Becket
Total Chlordane: Significant number of detections and levels at Perryville; one at Becket

Rob Breault suggested that much more information is needed on sediment quality behind impoundments, statewide. In MA, there are 1500 dams with little or no sediment quality data. He proposes a statewide survey to add information to the dam database so that the dam removal constraints would be better defined, or data would help to inform the public on what contaminants were released, should an accidental breach occur.

This study included ~45 samples with 4 different analytes costing a total of ~$8,000 (~$180/sample suite; $45/sample). The normal cost for analyzing this suite would be ~$2,000 a sample suite. For QA/QC, samples with a range of concentrations were also sent to other analytical lab to verify results of the ELISA technique.

Purpose of screening? Results should help to understand general distribution within the natural river environment. We should apply field-sampling techniques used for remediation work. Most deal with upland contaminant sites. Also, human contact contaminant thresholds are for upland soils. Aquatic sites may open up different pathways for negative human or ecological impacts.

Can contaminant levels be correlated to grain size? Sampling can be conducted to obtain a grain size distribution analysis with focused sampling efforts. Sometimes the grain size-contaminant correlation may not hold true.

How were sample location and number of samples determined? For the Perryville site, a base map and knowledge of deposition patterns was applied. One protocol might be to first use ground-penetrating radar (GPR) to project sediment thickness and general grain size conditions. With this reconnaissance information, it is then possible to decide where to sample and how samples will be collected.

Still need to know how to determine: What is an appropriate number of samples? Where do we sample spatially (and vertical).

Overview of Sediment Transport and Sedimentation Processes- Jim MacBroom, Milone & MacBroom, Inc.

Sediment yield and transport fate are the two primary components to evaluate. Channel sediment transport occurs primarily as pulses associated with storm events. East Coast rivers typically have relatively low bedload values, almost always <100 mg/l. Sediment bars may result from an unlikely source such as a storm water outfall discharging to the river. The sampling strategy may need to include up and downstream samples to adequately evaluate the magnitude of these sources.

Northeast sediment yields: *Low rate: 30 tons/ square mile/yr*
Mean rate: 250 tons/ square mile/ yr
High rate: 1200 tons/square mile/yr

Sediment deposition in the impoundment can be understood by investigating sediment strata characteristics, recognizing bottom set beds, fore set beds and top set beds. Bottom set beds initially deposited and may be uniformly spread throughout the impoundment. Fore set beds develop at the head of the basin, transgressing sequentially downstream over time in the form of a series of delta leads. Top set beds fill in uniformly downstream of the fore set beds, filling in the remainder of the impoundment.

Mr. MacBroom recommends contouring impoundment sediment thickness before completing a sampling program.
Levels of transport analyses: (1) Sediment Budget- grain size proportionality to channel geometry including channel slope, width, and depth; and (2) Sediment Continuity- change in volume of sediment Q of inflow - Q outflow.

Various models are available to assess sediment transport (e.g., HEC-6, GSTARS, BRIGHTSTARS, FLUVIAL, RMA-2). The type of model applied is often dependent on the genral grain size of the river system. The Einstein model is the most broad-reaching but is also the most difficult to use. Two or 3-dimensional models may provide more conclusive results but have higher costs due to greater survey needs. The grid or mesh formation for the model involves the use of three model equations and may take several months to converge. The RMA-2 model is nearly always used in tidal environments.

Panel Discussion: Status of Sampling and Analytical Requirements
Jim Turek, NOAA, moderator
Steve Lipman, MADEP ; Grace Levergood, NHDES ; Rob Breault, USGS

Massachusetts (Steve Lipman)

Steve Lipman passed out 2 documents for review. MADEP is in the process of revising and updating the state WQ 401 regulations. Why? Regulations were outdated and need to look at all possible uses of dredged materials (314 CMR 9.00). Materials passed out at the workshop:

1. Matrix and schematic chart of management alternatives and guidance for dredged materials; review chart to see the activities and see what the regs apply to the activity; proposed changes have been in works for last 3 last years and have been working with the interim guidelines. These revisions will formalize the interim guidance.
2. Example pages from the sampling and analysis requirements from the Draft regulations
3. Upland management of dredged material and soil
4. Flow charts that describe solid waster management activities

Due diligence review is now incorporated: Look at all databases that exist relating to the site of interest. Do as much work up front to develop sampling plan, contaminants of concern, and management alternatives. There are a number of existing databases. Conduct pre-application meeting to discuss 401 WQ regulation requirements and other related MADEP regulations (e.g., Chapter 91 licenses; wetlands protection act; and solid and hazardous waste regulations). Get as much information to assist with the sampling and analysis plan development. Coordinate with state (DEP, DMF) and federal agencies (ACOE, EPA, NMFS) that can offer advice on sampling plan. MA has a state environmental review program called MEPA process to get public and agency comments and review on projects – a key element to the review process and activity.

Mr. Lipman suggested that nearly all dam decommissioning activities involve a mandatory Environmental Impact Report (EIR) with a more in-depth review. Extensive coordination is required, and the 401 WQ program is the "gatekeeper" for the process and then coordinate the other permits in MADEP. MADEP may send applicants to other players and/or invite other entities. Mr. Lipman supports a two stage plan to conduct initial sampling and analysis, with possible follow-up sampling to save money and get a better sampling design.

Mr. Lipman suggests first understanding the probable end point for sediment management. This will dictate some of the analyses needed depending on how the sediment will be handled; often the management of the sediment is the biggest issue, not the dredging activities. Look at disposal alternatives to determine the sampling and chemical data needs. For example, lined landfill sites, gross analyses may be adequate to obtain approval. Compost or direct human reuse will different issue and more data needs to be obtained.

How does MADEP WQ view sediment behind dams? If you keep them in place and do not dredge, do you need to go through the 401 WQ certification? If no dredging is proposed, then you do not enter certification process. However, if breaching the dam and allowing sediment to move downstream, then certification for ‘filling’ activities is required.

Comment: We worked with a dam removal in western MA and the sediment sampling which was required cost over $40,000; we did a lot of testing and did not find contamination. We felt we did not get the greatest bang for the buck because of the costs involved. It is good that MADEP reduced the required magnitude of sampling for coarse-grain sediment because of the costs involved.

Comment: Looking at the parameters asking to be tested as a matter of course in Number 6 of the draft regulations, PAHs are common in most watersheds receiving road runoff. Unless there is a specific industrial discharge upstream, does it make sense to test every single location for PAHs?
Lipman: PAHs are of particular concern to MADEP because of the risks to human health; some of them have very high risks at really low concentrations (carcinogenic). These are important when consider in a

management plan. We always require testing for PAHs because of the potential risks. We may phase things, such as the USGS suggested screening methods, but would require more detail if they are found in higher levels.

Q: Will it be easier to get access to available data? Some data were not available to us to as part of the due diligence process. There was some EPA data that had not been released yet. Lipman: This is often a problem in enforcement cases, too. We try to take this into consideration and hope we can work together to get access to all the available data.

Q: In my experience it is rarely, if ever, practical to look at off-site disposal because of the cost. Often, on-site containment is a fairly universal solution and one that the current regulations do not address. Also, the ubiquitous nature of PAHs does make it sense to test for these. Lipman: On-site containment is addressed in the shoreline management scenario – if the placement or containment of material in the 100-year flood zone or the wetland resource buffer zone, then the 401 Program controls the material management of the project.

New Hampshire (Grace Levergood)
River Restoration Task Force is a collaboration of state and federal agencies and non-profit organizations.

Dam removal application regulations are combined Dam Bureau and Wetlands Bureau. Engineering is handled in NHDES with assistance from USFWS and NRCS. NH Historical Commission plays a big role in the dam removal process. A sediment protocol does not exist.

Recent case projects: 1. McGoldrick dam – felt no need to sample because minimal sediment, except large sized material at this run-of-the-river site.
2. Ashuelot River – USFWS sampled, EPA lab doing analysis, with composite sampling with a dredge, low TOC, mostly sand and gravel – no further testing required.
3. Homestead dam – USFWS sampled, mostly sandy gravel, used ponar dredge, PCBs, PAHs, Metals for analysis; did not find any significant contaminant levels, no coring done, no sampling below the dam

Task force needs to develop protocols; seeks guidance, and presently uses EPA protocol in the NHDES. They also mention the Corps' Inland Testing Manual

Maine
The state has no specific protocols for sampling sediment. Through Natural Resources Protection Act, dam removal are exempt from full permitting process by simple rule, but the Department has discretion to make it go through full review. Existing procedure:

Confer with state to conduct due diligence
Sample for grain size, and limit chemical analyses to one or two compounds
Look at historic uses (e.g., arsenic- agricultural uses (pesticides), lead-runoff, chromium from tanneries

Case projects: Edward Dam – sampling done by ACOE during the EIS process. Run-of-river conditions resulted in minimal sediment present

Smelt Hill Dam was gravelly, but required testing for Dioxins (paper mill). ACOE could not find sediment to sample, steep and narrow channel with high flow velocities.

Comments: Rob Breault, USGS
Outlook on improving on protocols: Can develop cooperative agreement with states and develop protocol. If dredging is removal technique, sediment will be mixed anyway, so compositing samples should be acceptable. If redistribution without dredging is proposed, what are the protocols? He suggests two-tiered sediment sampling strategy: First, sediment thickness, grain-size analysis applying GPR; pick

appropriate number of samples per volume sediment. Tier II: more intensive protocols: coring technique – number, some composites and some individual strata; Use ELISA for organic analysis: inexpensive, so you can do more testing if required. Use detailed testing for certain statistical fractions. Metals are cheap; organics are expensive (e.g., individual PCB congeners). Get a top 20 to 100 list of dams and sample these using screening methods. The results will help define baseline conditions within the state or region.

Panel Discussion: Assessing and Evaluating Results
Matt Liebman, EPA, moderator
Ken Finkelstein, NOAA
Jim MacBroom, Milone & MacBroom, Inc.

Matt Liebman: EPA is compiling a Regional Sediment Inventory that will supplement the National Sediment Inventory. Please send him sediment data.

Ken Finkelstein: Sediment Quality Guidelines (SQG) should only be used as screening numbers, not regulatory numbers, and not clean-up numbers. The main purpose is to be able to realize when a potential problem exists and needs biological testing. He emphasizes that there are no such SQG that can act as sediment clean-up numbers that are based solely on chemistry and concentrations in sediment.
Background information:
Two-types of SQG:

Theoretically derived methods (e.g., portioning (organics) and ABS (metals)

Empirically derived methods (e.g., effects range Low and Median (ERL, ERM), Threshold Effects Levels (TEL)

These methods look at acute and chronic effects of the 7-28 day variety and are not used to assess bioaccumulation. Newer approach uses logistic regression where many tests run at various concentrations and run model for best fit.

Jim MacBroom: His experiences as consultant has been to generally take composite cores in the impoundment and if 'hot spots' are determined, test further. Also, test upstream of the impoundment and downstream of dam can be completed to get a better understanding of 'background' levels in the system. Actually, finding that contaminant levels in areas outside the impoundment are often just as high as in the impoundment. A lot of the contaminants are ubiquitous in the stream systems. Also, many of the dams he has worked on were run-of-river dams, and therefore, fine-grained sediment was not found in these basins.

Examples: 1. Platts Mill Dam, CT- Some contamination, so left a portion of the dam to keep sediment in place. Removed a section to allow free flowing conditions and fish passage. Installed a rock vortex weir that acted as a riffle and kept sediment behind it. Wanted to avoid surge of sediment and some sediment is washed out slowly.
2. Union City Dam, CT- Took out entire length of the dam. Found contaminants and dredged and disposed of first 100 feet river length of sediment. The rest of the sediment had similar levels as downstream. The design was to result in a gradual release of sediment, not big wave to bury downstream substrate.
3. Freight Street Dam, CT- Small dam (~3ft height). Low level contaminants and excavated to create a distinct thalweg to make a more stable and passable stream channel. Used as bank material, planted and stabilized sediment, on site.
4. Anaconda Dam, CT- Partial breach with just the spillway removed. There was an island that had contaminated sediment and had planned to remove to excavate fines. Before removal occurred, a storm breached the dam and sediment were released. No obvious adverse effects have been recorded.
5. Leesville Dam, CT- Lowered from 18 ft. to 9 ft height and installed a fishway. This lowered the dam to the sediment levels to keep it in place. However, a 500-year flood went through and scoured out

practically all the sediment and deposited it downstream. These had to be dredged out of the riverbed. Have not seen adverse effects from contamination downstream.
6. Mill Pond Dam, CT- Basically a small tidal pool. Dredged the top 3 feet because of elevated mercury levels (which were only in the first 6 inches). Disposed at a landfill.

Conclusions: Managing the volume of sediment released (so downstream habitats would not be buried) was often more important than the sediment contamination issues. On-site containment worked well in areas where potential human exposure to the 'high and dry' sediment was not possible. If accessible by public then other options need to be explored. The sediment transport models available are good at predicting scouring and sediment movement in post-construction and can be used to predict the concentrations downstream. Need policies that will allow us to estimate post-construction contaminant concentrations based on mixing and sediment volumes. For example, one site had approximately 500 cubic yards of contaminated sediment, yet the sediment load that the river moved in one year was 5000 cubic yards. This is a 10 to 1 volume ratio and may have been enough to fall below thresholds and have acceptable ecological risks associated with the natural redistribution.

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