Malden River Ecosystem Restoration
Detailed Project Report

APPENDIX F

WATER QUALITY & SEDIMENT QUALITY DATA

US Army Corps
of Engineers®
New England District

TABLE OF CONTENTS

SECTION **PAGE**

HYDROLOGY **F-1**

EXISTING WATER QUALITY AND USE **F-3**

DESIGNATED WATER USE SUPPORT IN THE MALDEN RIVER **F-5**

EXISTING SEDIMENT QUALITY **F-11**

LIST OF FIGURES

NUMBER

Figure F-1 WATER DEPTHS.....
Figure F-2 WATER DEPTHS RANGES.....
Figure F-3 HISTORIC SAMPLE LOCATIONS: 1996-2000.....
Figure F-4 APPROXIMATE SAMPLE LOCATIONS .....
Figure F-5 SUB-AREA 1 DETAIL.....
Figure F-6 SUB-AREA 2 DETAIL.....
Figure F-7 SUB-AREA 3 DETAIL.....
Figure F-8 SUB-AREA 4 DETAIL.....
Figure F-9 SUB-AREA 5 DETAIL.....

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Hydrology

No recent or systematic hydrologic study of the Malden River was identified during Phase I and the completion of such a study is likely to be complicated due to the urbanized nature of the watershed as well as the flow and elevation changes dictated by the operations at the Amelia Earhart dam. The following provides a brief overview of three important hydrological features of the Malden River watershed – the Malden River's source at Spot Pond, the confluence with the Lower Mystic River and the changes caused by the presence and operation of the downstream Amelia Earhart Dam.

Spot Pond and Upper Watershed

The Malden River originates from Spot Pond, in the Middlesex Fells Reservation in Stoneham, MA. The surface area of Spot Pond is approximately 298 acres, the largest pond in the Mystic River watershed. The natural watershed of Spot Pond was historically 1,175 acres. However, due to a series of drainage diversions for flood control of surrounding areas, the actual drainage area of the pond (including the pond surface area) is approximately 369 acres (CDM, 2002). Spot Pond discharges into Spot Pond Brook, where it flows for approximately 1 mile in a channel before entering culverts. Spot Pond Brook becomes Malden River within the culvert system, and remains underground for approximately 3 miles until it emerges in the Malden River Federal channel.

Spot Pond was historically used as potable water conveyance in the MWRA system. Since 1997, the pond has been taken off line, and is now used to receive flows from the distribution system, either as part of a flushing event or a system failure and as an extreme emergency source, if there is a loss of suction from other facilities in the system or a transmission failure. If needed as an emergency drinking water supply, the water will be passed through a disinfection process and will require boiling before consumption. MWRA currently operates the pond such that an 8-day emergency water supply is available at all times. For this reason, releases of water from the pond can be restricted.

Lower Mystic Lake and Influence of Amelia Earhart Dam

Historically, the Malden River and Lower Mystic River were tidal estuaries supporting brackish aquatic biota. Saltwater intrusion in the rivers led to saline stratification in the Lower Mystic Lake, first observed in 1860 and consistently present until its reduction in the 1980s. The presence of the saline stratification caused the saltwater to be trapped in the deep pools of the lake, and prevented biannual turnover and complete mixing. At times (during the right combination of strong winds and low lake levels), there were releases of hydrogen sulfide (H2S) from Lower Mystic Lake, causing public nuisance conditions and possible health hazards. Following a 1965 release, a major kill of alewives and barnacle growth on boats and pilings were observed.

The installation of the Craddock Dam in 1908 (on the Mystic River approximately 3 miles downstream of the lake) did not isolate the lake, and periodic excursions of saltwater into the lake occurred when the locks were open. The Amelia Earhart Dam was completed in 1966 (approximately 5 miles downstream of the lake, below the confluence of the Mystic and Malden Rivers) with flood control (i.e., protection from storm surge) as its primary function. The dam maintains the lake level about 3 feet above mean low water, which prevents intrusion of tidal seawater and negates the possibility of reintroduction of saline stratification into the Lower Mystic Lakes. However, this effectively eliminates tidal flow into and flushing of the Mystic and Malden Rivers, and the elimination of saltwater quickly changed the ecosystem from its natural brackish state to freshwater. For this reason, runoff and flushing by upgradient freshwater flows now dominates the system. Due to its urbanized nature, much of this recharge consists of non-point source stormwater runoff, which is being addressed through complementary water quality programs and represents an objective to be addressed by this NER plan. As supported by the basic water quality information compiled within this study and its presence on the Massachusetts 303(d) list for waters not meeting state water quality standards, the present rate of flushing appears directly related to the inability to maintain good water quality in the Malden River.

In the late 1970s, the Lower Mystic Lake Saltwater Removal Project (MDC, 1994) was designed and implemented by MDC and EPA to reduce the volume of saltwater trapped in the deep holes

of the lake, as well as the potential for H2S releases. A combination of pumping (removing 8.47 million cubic feet) and a large storm event (removing 16.09 million cubic feet) resulted in the removal of approximately 90% of the saltwater from the holes in the Lower Mystic Lake. This removal led to a larger lake volume available for freshwater habitat and elimination of H2S releases due to the larger depth of freshwater overlying the remaining salt water and a smaller reservoir of sulfide-laden water.

The current operation of the Earhart Dam permits the passage of small volumes of salt water when the locks open. This small volume tends to sink into the deep hole located just upstream of the dam, and does not make its way up the rivers. This water is periodically pumped to the seaward side of the dams during efforts to lower the upstream water level.

Due to the persistent water quality problems in the lake and the extensive effort expended to address these issues, there is considerable concern that any alteration in the operation of the Earhart Dam that allowed more salt water inflow could result in a reintroduction of saline stratification in the Lower Mystic Lake. This concern is driven by historical experience and the fact that there is very little elevation change between the dam and the lake, indicating that the tidal salt water will likely migrate to the lake.

Existing Water Quality and Use

Water quality in the Malden River is generally considered degraded, owing to several sources of contamination, (i.e., contaminated sediments, stormwater, historic releases of OHM) and, in particular, poor flushing and mixing. Several focused studies (e.g. NCA, 2000b) indicate degraded water quality conditions in the river; primarily due to poor mixing and stormwater run-off contributions. In addition, detailed inspections of the river system (Harris 2000) have revealed extensive accumulations of solid waste and debris.

The Mystic River Watershed Association (MyRWA) has been regularly collecting data throughout the Mystic River Watershed since 1999, including one station above the Amelia Earhart Dam. At this location, they collected continuous dissolved oxygen (DO) data during the summer months of 2002 and 2003. The DO sensor was located in 3-6 feet of water, in the lower portion of the water column. In 2002, a dry year, there were 3-4 weeks in July when the DO fell

below 5.0 mg/L (the Class B water quality standard). In 2003, a wet year, there were only a few periods in July when DO fell below this water quality standard. These data indicate that low DO conditions are likely seasonally dependent and occur on an annual basis. However, as described below, DO conditions within the river system appear to vary spatially as well as temporally due to a variety of influences such as depth of water column, ambient temperature, sediment quality and proximity to the main recharge areas for the river system.

In August of 1999, baseline DO measurements were performed at fifteen (15) sampling locations along the centerline of the Malden River by Nangle Consultants Associates, Inc. (NCA). In general, DO concentrations ranged from 0.11 to 4.65 mg/l in the lower depths of the Malden River. In contrast, substantially higher DO levels ranging from 9.55 to 15.46 mg/l were measured in shallow water, alluding to the poor mixing attributable to ongoing surface water management practices. In this regard, during various summertime sampling events, reportedly distinct observations of varied zones of surface water transport were evidenced in the form of velocity separation between upper (1± foot) and lower depths of the river. Point measurements of DO collected by MyRWA throughout the watershed on 10/28/03 also indicate that DO in the central reach of the Malden River is considerably lower than at other locations in the Malden or Mystic Rivers.

MyRWA has also performed a focused study to characterize bacteria concentrations and potential sources along the Malden River to complement the baseline data collected monthly (MyRWA, 2002). This effort included the sampling of several locations along the river and pipe discharge on May 28, 2002. Baseline data collected at the Medford Street Bridge indicated a fecal coliform geometric mean of 265/100 ml. Sixty-four percent of the samples violated the primary contact standard (swimming) of 200/100 ml and 23% violated the secondary contact standard (boating) of 1000/100 ml. Three samples from this May 2002 sampling event violated the primary contact standard, while and two violated the secondary contact standard. The two violations of the secondary contact standard both occurred inside the culvert at the upper or northern end of the Malden River channel. MRWA hypothesized that the high level of fecal coliform observed at this location may be attributable to the infiltration or mixing of sewage contamination within the distribution system. Wet weather stormwater quality information has

also been provided for Little Creek (NCA, 2000b), which shows a significant variations and degradation of water quality due to fecal coliform and other stormwater constituents.

As part of a remedial investigation associated with the former General Electric site, one of the properties along the easterly banks of the Malden River, several surface water samples were collected and analyzed in 1989 and 1993 (Eckenfelder/Brown and Caldwell, 1999). VOCs, SVOCs and TPHs were either not detected or were detected in low concentrations. Several metals, including cadmium, lead, mercury, and zinc, were detected in one or more of the samples. The authors concluded that these contaminants did not appear to originate in groundwater near the investigation.

Designated Water Use Support in the Malden River

The Malden River is classified by the State of Massachusetts as Class B waters, designated as a habitat for fish, other aquatic life and wildlife, required to meet swimming and boating standards, suitable for irrigation, agricultural and industrial uses and have "consistently good aesthetic value." However, water quality results indicate that the river does not support its designated uses and, as such, it is included on the Massachusetts 303(d) list for organic enrichment/low DO, pathogens, oil and grease, taste, odor, color, suspended solids, and "objectionable deposits." Poor water quality in the Malden River is attributed to the impact of a variety of sources related in large part to historic conditions and ongoing infrastructure, as well as contaminated sediments, stormwater, atmospheric deposition and ongoing transfer of residuals associated with OHM releases that have occurred. As described previously, a primary causal factor is the poor flushing of the river system, due to the shift from an historic tidal estuary to a poorly flushed "freshwater impoundment." Because of the small, highly impervious nature of the watershed, there is little freshwater base flow into the Malden River for extended periods, and groundwater inflow that does occur may be of degraded quality.

The Malden River Federal channel is on average 6 feet deep by 100 to 150 feet wide from the Medford Street Bridge in Malden to its confluence with the Mystic River, approximately 2 miles (Fort Point Associates, 2003). In locations outside of the channel, water depths have been observed to be as shallow as 2 feet (D. Klinch, pers. observation). Spot depth elevations

compiled during river assessment studies and corresponding bathymetric profiles for the river system may be referenced in Figures F-1 and F-2, respectively. The Malden River has an estimated surface area of 54 acres (from the stormwater culvert to the confluence with the Mystic River) and an approximated volume of 14,700,000 ft3 (110 million gallons), based on preliminary provisional USGS bathymetric data.

Existing Sediment Quality

A general description of site history and sources of sediment contamination is provided in Appendix B, while a summary of thickness and types of sediments, together with corresponding pollutant concentrations may be referenced from Section 4.0 of this report. This Appendix, together with Appendix E, provides a more detailed discussion of the relationship between sediment quality and the selected components of the NER Plan.

SOURCES OF SEDIMENT CONTAMINATION

The Malden River was originally an extensive tidal wetlands area bisected by a sinuous, meandering channel. Beginning in the 1800's the wetland areas were filled, the path of the river straightened, and the main stem of the river dredged at various times (i.e., 1840's, 1890's, 1930's and 1970's) with additional spot dredging to access specific shoreline properties. Eventually tidal influences were eliminated by installation of flood control structures. With the last of the dredging in the 1970's, sediments have had the opportunity to accumulate undisturbed in the river. Accumulated sediments are underlain by light yellow to blue clay (often referred to as Boston blue clay).

Intensive use of the land along and dependent upon the Malden River began in the mid-1800s as industrial expansion proceeded north from the City of Boston. As described in Appendix B, dredging and realignment of the once meandering Malden River served as the catalyst to a period of unprecedented economic growth and industrial activity which included numerous chemical, rubber products, manufactured gas, asphalt pharmaceutical, foundry and technological initiatives. Following several periods of wartime support, a majority of these facilities relocated to more modern facilities during the mid-1900s. Industries that probably had the greatest impact

Insert Figure F-1 Water Depths

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on sediment quality include manufactured gas plant operations, several asphalt and tar companies, tanneries, metal working plants, and chemical companies (NCA, 1996; 1997; 2000a). Potential sources of pollutants impacting the sediments are primarily related to residuals associated with historic industrial waste deposition practices, with a significant reduction in upland source contributions occurring over the past few decades. In general, current sediment quality in the Malden River is impacted by the following:

- Historic conditions – Historic activities that have impacted sediments include releases of OHM directly to the River, releases of OHM to soil and groundwater, fill deposition and land alteration practices. Because these releases occurred during periods when the river was tidal and being maintained for navigation, pollutants are present in both shallow and deeper sediment layers. Profiles showing vertical variations in sediment covers are described in Appendix D of the Phase I study. Also described in Appendix B is the extensive filling of former tidelands a long the Malden to support the uses described above. Due to the nature of then existing roadway networks, a majority of the fill material appeared to have been generated as a consequence of nearby industrial activities and include a predominance of razed building materials, consisting of concrete, rubber, wood and metal debris, as well as discrete industrial waste products. Historically, pollutants from these fill materials may have seeped directly into the river or dissolved in groundwater then migrated into the river, although current groundwater contributions to adverse sediment quality within the river system appear to be minor. The exception to this behavior may exist at the confluence of the Malden River and Little Creek. While former seeps of non-aqueous phase liquids into culverts and ultimately into the river have occurred, efforts to address specific source areas have been completed by several responsible parties within the river system.

- Current Conditions – Current conditions that continue to influence sediment quality include the mixing of OHM residuals from historic land use practices, particularly cola gasification and metalworking activities, stormwater runoff and atmospheric deposition. Extensive remedial activities have been undertaken within the study area by numerous parties and at this time residuals within sediments, rather than ongoing sources or release appear to represent the most significant unresolved conditions. As described in further

detail within the following sections of this Appendix, the nature of sediment quality at the confluence of Little Creek and the Malden River is a primary area of environmental concern, which will be addressed in part by recommended elements of the NER Plan. The Malden River receives stormwater runoff from an extensive urban area and efforts are also ongoing to reduce the influence from stormwater runoff. Metals from coal burning power plants and other sources may accumulate in river sediments via atmospheric deposition.

LOCATION OF SEDIMENT CONTAMINATION

Sediment depths and characteristics have been characterized for major portions of the Malden River study area A cross section depicting sediment in the upper section of the river (from Malden River Culvert Outfall to Medford Street Bridge) is provided in Appendix D of the Phase I study (Haley & Aldrich, 2001). As shown, the depth of water in the upper section is 5 feet or less and sediments consist of organic silt, sands, clayey organic silts and clay. The depth of sediments (defined as the depth to clay) reportedly varies from 2 feet to over ten feet in the upper section of the river. Generally, the thickness of sediment increases with distance from the culvert outfall at the northern end of the river. The top layer of sediment is identified as primarily sand at the culvert outfall and immediately to the south, with the top layer of sediment consisting primarily of organic silt further south.

A profile depicting sediment in the River's Edge section (from Medford Street to Revere Beach Parkway) is also provided in Appendix D of the Phase I study (NCA, 2003a). The depth of water within the portion of the river system, defined for discussion purposes as River's Edge section is five to ten feet. The depth of water generally increases from north to south. The thickness of sediment in the River's Edge section ranges from approximately 7 to 18 feet. The sediment layer has been measured as being thickest along the banks immediately south of the Medford Street Bridge and the confluence of the River and Little Creek. The top layer of sediment is primarily loose or unstable organic silts and benthic material and generally underlain by the first zone of historic sediment contamination. Contaminant distribution with depth is typically stratified according to variations in the underlying layer of silts, sands, peat and/or clay.

POLLUTANT CONCENTRATIONS IN SEDIMENT

Data on sediment quality is available from a variety of sources (TRC, 1985; Haley and Aldrich, 2001, NCA, 2003a; 2003b). River sediments have been sampled for metals, cyanide, volatile organic compounds (VOCs), PCBs, petroleum hydrocarbon fractions, and pesticides. The primary pollutants of concern in the Malden River are semi-volatile organic compounds (SVOCs) and metals. During the Phase I study, that portion of the River system extending southerly from the Medford Street Bridge to the Revere Beach Parkway was identified as having the highest potential for meeting the objectives of this restoration plan. Accordingly, sediment quality within this portion of the river, referred to as Sub-Areas 1 through 5 has been evaluated in greater detail. To assist in the review of the following environmental data and information, a summary of sediment sampling locations identified to the north of the Medford Street Bridge during the Phase I study is provided as Figure F-3 and a sketch plan of site depicting the approximate location of surface water and sediment samples between the Medford Street Bridge and Revere Beach Parkway has been presented as Figure F-4.

A general summary of the pollutants detected, ranges of concentrations, and average concentration is provided in Tables F-1 to F-4. Included in the tables are generic soil criteria from the MCP, as well as the ecological benchmarks. Generally, the three MCP soil categories (S-1, S-2, S-3), together with Upper Concentration Limits (UCLs), though not applicable to sediments, do provide a benchmark in terms of relative magnitude of contamination present. While presented for comparative purposes only, reference to Table F-1 UCLs for several SVOCs were exceeded at one sampling location VC-23. SVOCs significantly in excess of ecological benchmark screening criteria and UCLs are found in both upper and mid range deeper sediments. The highest levels of SVOCs were found in a mid range sample from VC-23, S-5 (NCA, 2003a), which was collected from 53 to 57 inches below the surface of the sediments. The concentrations of pollutants detected at this location suggest the presence of separate phase wastes. For example, the total concentration of SVOCs in sample VC-23, S-5 was 71,000 mg/kg (i.e., 7.1% of the sample was semi-volatile compounds). Although there is no set standard for determining the concentration of pollutants in soil or sediments that indicate the presence of a separate phase waste, 10,000 mg//kg is used as a guideline by some agencies (RIDEM, 1996). Potential sources for SVOCs, in descending order of contribution, are historic discharges directly

to the river (no longer occurring), seeps from sources near the river (efforts to mitigate these sources have been completed and are ongoing), and stormwater runoff (minor contributions).

UCL exceedances for arsenic have been identified at two (2) locations (Table F-2) and the highest levels of arsenic were present at the confluence of Little Creek and the Malden River. Elevated levels (over 1,000 mg/kg) of lead and zinc were also found at various locations in the river. The average concentrations of arsenic, cadmium, chromium, copper, lead, mercury, nickel, and zinc in sediments all exceed the Threshold Effect Concentrations or TEC benchmark values cited on Table F-2. As described in Appendix E and subsequent portions of this appendix, approaches for evaluation of potential ecological risks associated with sediment chemistry have been developed by MacDonald and Ingersol, et. al. Levels of VOCs in sediments (Table F-3), with the exception of naphthalene (also evaluated as a SVOC), are generally low. PCB data available are somewhat limited and, as shown in Table F-4, the highest PCB result was 8.5 mg/kg. PCBs have not been identified as a contaminant of concern within the Malden River Corridor. Sediments upstream of the Medford Street Bridge contain elevated levels of SVOCs,

VOCs, and metals. A summary of data in this area is provided in Appendix D. SVOCs exceed 100 mg/kg in several locations and exceed the UCL for benzo(a)pyrene in at least one location. The primary VOC of concern is benzene, which has been detected at levels up to 120 mg/kg.

As described in Section 4.1, at this time, several independent studies for portions of the river have been undertaken, however, human health risk issues have not been fully characterized for the entire river system. In general, potential risks that may exist include exposure to contaminants in the surface water or sediments due to skin contact or fish consumption. There is no evidence that contact recreation (swimming, wading) is conducted at the Malden River on a regular basis, so it is expected that any current potential exposure to surface water or sediments would be incidental and slight. Consumption of fish is a potential human health risk but is likely limited by the lack of public access and the poor state of the Malden River fishery. A human health risk assessment has been conducted for the upper Malden River north of the Medford Street Bridge (Haley and Aldrich, 2001). The risk assessment concluded a condition of No Significant Risk for recreational contact with surface water (child receptor) but could not demonstrate this condition for ingestion of fish caught in the Malden River.

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Human health risk issues in the lower reaches of the Malden River are currently being studied by the MVDC through their consultant NCA and others as a part of ongoing Brownfields and MCP compliance programs. While the evaluation of these risks is the subject of several complementary and ongoing studies referenced within this NER plan, development of recommendations pertaining to human health risks is not within the scope of this study. However, consideration of potential risks to benthic organisms and those habitat populations which serve as the objective of the NER plan is required. Accordingly, the following overview of Malden River sediment quality has been prepared.

Sediment chemistry is often regarded as a primary indicator of potential sediment toxicity, however, USEPA guidance confirms that the use of numerical standards as a measure of sediment chemistry alone is not sufficient to adequately assess the actual toxicity that may be present. More specifically, it has been recommended that measurements of sediment chemistry, toxicity, benthic community structure and tissue chemistry would be preferred for the determination of sediment quality. Although a database has been developed, which describes general sediment chemistry and a limited benthic inventory was completed as a part of this study, the cost and efforts required to complete the above approach to ecological risk characterization are significant and beyond the scope of this current project. Data usability constraints have been offset, however, in part through advances in the development of Sediment Quality Guidelines (SQGs) which have increased reliance that may be given to the use of sediment chemistry in the evaluation of ecological risks.

As described in Appendix E, a greater degree of reliability for predictive indicators of sediment toxicity has been developed through a consensus-based approach by MacDonald and Ingersol, et al. involving the use of Threshold Effects Concentrations (TECs) and Probable Effects Concentrations (PECs). The development of consensus-based values has been achieved by MacDonald by estimating the geometric mean for acceptable SQGs pertaining to threshold limits for sediment toxicity that have been established within the industry.

As stated previously, TEC values are intended to provide a numerical threshold below which no adverse effects to benthic organisms, principally amphipods and midge (*Hyalella azteca* and *Chironomus tentans*, respectively) will occur. PEC SQGs represent an upper threshold where

harmful effects were likely, each of these SQGs is a consensus based standard developed from published guidance criteria in an effort to normalize high and low discrepancies through the use of geometric means for the suitable database. A summary of PAH and metals contaminants exceeding their respective PEC values within each of the five Sub-Areas is provided on Tables F-5 through F-14.

It is to be noted that MDEP has recently adopted the use of PEC concentrations as benchmark values for the completion of a Stage I Environmental Screening (310 CMR 40.0995(3). To facilitate the review of environmental data and information presented within this section, detailed sketch plans of site depicting each sub-area within the stretch of the Malden River associated with the River's Edge project have been prepared as Figures F-5 through F-9, respectively. Also shown on Figures F-5 through F-9 are the maximum and minimum PEC value exceedances for metals within each of the sub-areas. A review of this information reveals that a majority of metal and PAH compounds greatly exceed their corresponding PEC values within each of the sub-areas for the River's Edge portion of the Malden River.

To reduce the level of uncertainty that arises from reliance upon numerical standards for discrete compounds contained within complex mixtures of site contaminants, MacDonald, et al. reasoned during the development of consensus based SQGs that the predictive ability of sediment assessment is likely to increase when SQGs are used in combination to classify the toxicity of sediments. Essentially, the occurrence of harmful effects was correlated with mean PEC quotient values for each sample in the database wherein quotient values are obtained by dividing the concentration value of each chemical within the sample by its corresponding PEC. Mean PEC quotients of 0.1, 0.5, 1.0 and 5.0 were then correlated with the incidence of toxicity in several tests resulting in a distinct correlation between increasing mean quotient values and sediment toxicity.

Essentially, this approach is intended to address the following goals:

- Evaluating values between TEC and PEC benchmark levels
- Used for predicting toxicity of contaminant mixtures (i.e., PAHs and metals)
- Provide a more definitive prediction of the probability of sediment toxicity

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Based upon empiric studies, it was generally determined that the incidence of toxicity increased with increasing mean quotient values, with a consistent occurrence of toxicity at mean values greater than 0.5. Accordingly, to further the understanding of potential risks to benthic organisms associated with site sediments, mean PEC quotient values were also developed for each of the samples collected the Malden River system, within Sub-Areas 1 through 5, as presented as Tables F-10 through F-14.

A review of Tables F-10 through F-14 reveals that the geometric mean threshold value of 0.5, above which consistent occurrences of toxicity are likely to occur is exceeded by a factor of 2 within all subareas for copper, lead, zinc and cadmium (Sub-Area 1, 0.99). Indications of elevated arsenic levels were highest in Sub-Areas 1, 3 and 4 and, in general, lead was identified as the metal exhibiting the greatest degree of toxicity potential in each sub-area. This is followed arsenic, zinc and copper, although weighting to the magnitude of contaminant concentrations results in variations of this trend within portions of the river. In this regard, it is to be noted that the contaminant concentrations reported for the River's Edge portion of Malden River sediments reflect, for the most part, targeted or worst case concentration values that were obtained through the evaluation of the physical and semi-quantitative characteristics of sediment quality at the time sample collection. Specifically, sample designations for the purposes of analytical quantification were based upon field screening measurements and the visual inspection of both sediment quality and general geologic stratification of sediment columns obtained during vibra-core and conventional split spoon sampling techniques.

The development of an average PEC quotient value by parameter provides a normalized concentration value for each of the sub-areas, simply for discussion and comparative purposes. To demonstrate the sensitivity of data points with respect to potential sediment toxicity, average metal PEC quotient values by sampling location are also provided on Tables F-10 through F-14 using the approach recommended by MacDonald et.al. without the inclusion of mercury data due to the lack of sufficient toxicity data to support the use of this PEC value. Specifically, given its bioaccumulation potential, mercury has a very low default threshold and toxicity projections based upon this metal are more accurately reflected through the completion of more comprehensive analytical and ecosystem function evaluations.

The quotient value approach has also been expanded by Ingersol et. al. to include commingled or multiple mixtures of contaminants (PCBs, PAHs and metals) wherein an average quotient value for each parameter was determined and an overall mean PEC quotient value for the commingled mixture was then obtained for the sum of each of the parameters.

However, as evidenced from a review of site characterization information, the primary indicators of sediment chemistry concerns involve only metals and PAHs. Accordingly, for PAHs it has been recommended a total PAH PEC value (22.8) be used in the development of a mean value for each sample location to avoid the dominance of certain compounds and account for "double-dipping." For the database corresponding to the evaluation presented within this section, a minimum of 17 PAH compounds were utilized in the calculation of mean quotient values. It is to be noted that USEPA is presently reviewing guidance that would require the use of 18 primary and 16 secondary compounds in this evaluation. However, the effect of this would be to increase or more conservatively exhibit potential sediment toxicity. As evidence from a review of tables F-15 through F-19, it is seen that the normalized PAH PEC values determined the River's Edge portion of the Malden River system already exceed stated toxicity threshold values of concern by several magnitudes of order.

Immediately apparent from a review of the information summarized on Tables F-15 through F-19 is the dominance of single sampling results at discrete locations such as: VP-23 (Area 1); B-8, B-16, VC-1, VC-2, VC-3, VC-15, VC-18, VC-25 and SPD-3D (Area 3); and VC-5 through VC-7 (Area 4) both horizontally across the river bottom and with depth. With consideration of the targeted sampling protocols described above, of equal note are the lower indications of significant PAH accumulations within sediment layers characterized in Areas 2 and 5. This contaminant distribution within site sediments is an important consideration with respect to habitat quality improvements that may be achieved and sustained through the implementation of recommended NER Plan component involving targeted sediment removal and capping strategies.

While benthic activity is typically afforded the highest concern within the upper contact layer (0 – 12 inch depth interval), actual projections of potential contaminant toxicity must consider the physical characteristics and transport pathways that exist within the specific sediment unit under consideration. While once tidally influenced transport of industrial wastes has resulted in the

distribution of stratified sediment contamination containing elevated levels of PAHs, this condition varies within the river in response to more recent influences upon historic contaminant deposition. Typically, the upper (0 – 3 foot) layer of sediments within the River's Edge portion of the Malden River has typically been observed to consist of loose and unstable material that is subject to the desorption of contaminants due to disturbances by prop wash from motorboats and a lowering of the Malden River through Dam alterations. During these activities and significant storm events, the opportunity arises for mixing and contact to sediments below the upper 1-foot layer by both benthic and marine life as well as potential users of the river. This potential is of particular concern within Sub-Area 3 or the formerly tidal confluence of the Malden River and Little Creek, as reflected by summary of PEC values for PAHs corresponding to 0 – 3 foot depth interval shown on Figure F-10. In contrast to the River's Edge and more northern portions of the Malden River where sediment quality appears to be attributable to discrete OHM releases for which response actions subject to the provisions of the MCP are ongoing, only limited data (four sediment samples) were identified for the Malden River below the Revere Beach Parkway. However, a review of historic documentation has identified the presence of phthalates attributable to former industrial activity for which MCP response actions were performed.

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TABLE F-1 MALDEN RIVER SEDIMENT QUALITY (Semivolatile Organic Compounds) (ALL DATA IN PARTS PER MILLION)

				MaDEP Soil Criteria*				Ecological		
Compound	**Range**	**No. of Samples**	**Average**	**S-2**	**S-3**	**UCLs**	**Qualitative HH Assessment**	**TECs**	**Qualitative Eco Assessment**	**Changes with Depth?**
Acenaphthene	ND-5,300	38	187	2,500	4,000	10,000	over S-2, 1 location			
Fluoranthene	ND-3,100	42	170	3,000	5,000	10,000	over S-2, 1 location	0.423	possible concern	
Naphthalene	ND-12,000	41	342	1,000	3,000	10,000	**over UCL, 1 location**	0.176	possible concern	highest levels deep
Benzo(a)Anthracene	ND-1500	64	88	40	300	3000		0.108	possible concern	highest levels deep
Benzo(a)Pyrene	ND-1,000	25	60	4	30	300	**over UCL, 1 location**	0.15	possible concern	highest levels deep
Benzo(b)Fluoranthene	ND-94	22	25	40	300	3000	over S-2			
Benzo(k)Fluoranthene	ND-120	25	22	400	3000	10000	not a major contributor			
Chrysene	ND-1700	22	90	10	40	400	**over UCL, 1 location**	0.166	possible concern	highest levels deep
Acenaphthylene	ND-1,500	22	52	1000	1000	10,000	not a major contributor			
Anthracene	ND-3,300	22	146	2,500	5,000	10,000	over S-2	0.0572	possible concern	
Benzo(g,h,I)perylene	ND-76	65	18	2,500	2,500	10,000	not a major contributor			
Fluorene	ND-3,300	65	138	2,000	4,000	10,000	over S-2, 1 location	0.0774	possible concern	
Phenanthrene	ND-10,000	65	420	100	100	10,000	**over UCL, 1 location**	0.204	possible concern	highest levels deep
Dibenzo(a,h)anthracene	ND-41.659	65	6	4	30	300	over S-3, 1 location	0.033	possible concern	
Indeno(1,2,3-cd) Pyrene	ND-88	65	20	40	300	300	over S-2			
Pyrene	ND-4,000	65	226	3,000	5,000	10,000	over S-2, 1 location	0.195	possible concern	
Benzo(e)pyrene	ND-54	4	17							
Biphenyl	ND-1,200	4	393							
Perylene	ND-3.1	4	0.8							
1-Methyl Napthalene	ND-11,000	53	407							
2-Methyl Napthalene	ND-13,000	57	440	1,000	1,000	10,000	**over UCL, one location**			highest levels deep
Carbazole	ND-3,200	4	800							
bis (2-ethyl hexyl) phthalate	ND-3500	41	426	300	500	10000				

* these standards are presented for comparison only, soil criteria are not applicable to sediments

ND = not detected

S-2 = MaDEP direct contact criteria for potentially accessible soils

S-3 = MaDEP direct contact criteria for isolated soils

UCL = MaDEP Upper Concentration Limit

TECs = Threshold Effects Levels

TABLE F-2 MALDEN RIVER SEDIMENT QUALITY (Metals) (ALL DATA IN PARTS PER MILLION)

				MaDEP Soil Criteria*				Ecological		
Metal	**Range**	**No. of Samples**	**Average**	**S-2**	**S-3**	**UCLs**	**Qualitative HH Assessment**	**TECs**	**Qualitative Eco Assessment**	**Changes with Depth?**
Antimony	ND-14	12	5	30	30	300	not a major contributor			
Arsenic	2.7-250	65	49	20	20	200	**over UCL, 2 locations**	9.79	possible concern	
Barium	9-169	33	85	3000	5,000	10,000	not a major contributor			
Beryllium	ND-1.4	36	0.7	0.8	3	30	not a major contributor			
Cadmium	ND-14	65	5	30	30	300	not a major contributor	0.99	possible concern	
Chromium	9-2,140	58	139	200	200	2000	not a major contributor	43.4	possible concern	
Copper	42-482	42	231	NS	NS	NS	not a major contributor	31.6	possible concern	
Lead	ND-1970	65	592	300	300	3,000		35.8	possible concern	still over 1,000 at depth
Mercury	ND-15.1	57	2	30	30	300	not a major contributor	0.18	possible concern	
Nickel	3-295	42	42	700	700	7,000	not a major contributor	22.7	possible concern	
Selenium	ND-3.1	57	0.8	800	800	8,000	not a major contributor			
Silver	ND-2.7	64	0.3	200	200	2,000	not a major contributor			
Thallium	ND	N/A	Detection Limit	60	80	800	not a major contributor			
Zinc	72-3610**	42	1160	3000	5,000	10,000	possible concern	121	possible concern	

* These standards are presented for comparison only, soil standards are not applicable to sediments
** zinc concentration of 26,200 ppm recorded at culvert to Little Creek
ND = not detected

S-2 = MaDEP direct contact criteria for potentially accessible soils
S-3 = MaDEP direct contact criteria for isolated soils
UCL = MaDEP Upper Concentration Limit
TECs = Threshold Effects Levels

TABLE F-3 MALDEN RIVER SEDIMENT QUALITY (Volatile Organic Compounds) (ALL DATA IN PARTS PER MILLION)

				Post-Dredging		MaDEP Soil Criteria*				
Compound	**Range**	**No. of Samples**	**Average**	**Range**	**Average**	**S-2**	**S-3**	**UCLs**	**Qualitative Assessment**	**Changes with Depth?**
Benzene	ND-0.08	7	0.019	ND-0.025	0.013	200	900	9000		
2-Butanone	0.44-1.8	4	1.2	1.3	1.3	40	40	10000		
Chlorobenzene	ND-1.2	7	0.3	ND-0.36	0.18	100	100	10000		
1,2 Dichlorobenzene	ND-5.5	4	1.4	5.5	5.5	300	300	10000		
1,3 Dichlorobenzene	ND-0.4	4	0.1	0.4	0.4	500	500	5000		
1,4 Dichlorobenzene	ND-7.4	4	1.9	7.4	7.4	300	2000	10000		
Ethylbenzene	ND-89	16	9	ND-1.75	0.9	500	500	10000		
Isopropylbenzene	ND-22	13	3	ND	Detection Limit					
p-Isopropyltoluene	ND-21	13	4	ND	Detection Limit					
Naphthalene	ND-2600	13	380	1.1	1.1	1000	3000	10000	1 sample over S-2	highest levels deep
n-Propylbenzene	ND-5.6	13	0.5	ND	Detection Limit					
1,2,3 Trichlorobenzene	ND-0.6	4	0.16	0.64	0.64					
1,2,4 Trichlorobenzene	ND-3.4	4	0.9	3.4	3.4	900	900	9000		
1,2,4 Trimethylbenzene	ND-140	13	19	ND	Detection Limit					
1,3,5 Trimethylbenzene	ND-23	13	2	ND	Detection Limit					
o-Xylene	ND-1.6	4	0.7	ND	Detection Limit					
p-m-Xylene	ND-1.9	4	0.9	ND	Detection Limit					
Toluene	ND-32	12	3	0.075	0.075	1000	1000	10000		
n-Butylbenzene	ND-7.4	8	1	NA	0					

* These standards are presented for comparison only, these standards are not applicable to sediments
ND = not detected

S-2 = MaDEP direct contact criteria for potentially accessible soils
S-3 = MaDEP direct contact criteria for isolated soils
UCL = MaDEP Upper Concentration Limit
TECs = Threshold Effects Levels

TABLE F-4 MALDEN RIVER SEDIMENT QUALITY (PCBs) (ALL DATA IN PARTS PER MILLION)

				MaDEP Soil Criteria*					
Compound	**Range**	**No. of Samples**	**Average**	**S-2**	**S-3**	**UCLs**	**Qualitative Assessment**	**Ecological TECs**	**Qualitative Ecological Assessment**
total PCBs	ND-8.5	21	0.67826	2	2	100	2 samples over S-2	0.0598	possible concern

* These standards are presented for comparison only, these standards are not applicable to sediments

ND = not detected

S-2 = MaDEP direct contact criteria for potentially accessible soils

S-3 = MaDEP direct contact criteria for isolated soils

UCL = MaDEP Upper Concentration Limit

TECs = Threshold Effects Levels

Table F-5 Area 1 PEC Exceedances – PAHs (mg/kg)

Parameter	PEC	Minimum Concentration Exceeding PEC	Maximum Concentration Exceeding PEC
Anthracene	0.845	**18** (VC-21 S-1)	**3300** (VC-23 S-5)
Benzo (a) Anthracene	1.05	**28**j (B-12 S-3)	**1500** (VC-23 S-5)
Benzo (a) Pyrene	1.45	**16**j (B-12 S-3)	**1000** (VC-23 S-5)
Chrysene	1.29	**29**j (B-12 S-3)	**1700** (VC-23 S-5)
Fluoranthene	2.23	**54**j (B-12 S-3)	**3100** (VC-23 S-5)
Fluorene	0.536	**11** (VC-21 S-1)	**3300** (VC-23 S-5)
Naphthalene	0.561	**11** (VC-21 S-1)	**12,000** (VC-23 S-5)
Phenanthrene	1.17	**73** (VC-21 S-1)	**10,000** (VC-23 S-5)
Pyrene	1.52	**75**j (B-12 S-3)	**4000** (VC-23 S-5)
Acenaphthene	0.089	**9.8** (VC-21 S-1)	**5,300** (VC-23 S-5)
Acenaphthylene	0.128	**8.9** (VC-21 S-1)	**1,500** (VC-23 S-5)
Benzo (b) Fluoranthene	13.4	**21j** (B-12 S-3)	**ND (405)** (VC-23 S-5)
Benzo (k) Fluoranthene	13.4	**20** (VC-21 S-1)	**ND (405)** (VC-23 S-5)
Benzo (g,h,i) perylene	3.2	**ND (15)** (B-12)	**ND (405)** (VC-23 S-5)
Dibenzo(a,h) Anthracene	0.135	**5.5** (VC-21 S-1)	**ND (405)** (VC-23 S-5)
Indeno (1,2,3) Pyrene	3.2	**ND (15)** (B-12)	**ND (405)** (VC-23 S-5)
2-Methylnaphthalene	0.201	**5.7** (VC-21 S-1)	**13,000** (VC-23 S-5)

Table F-6 Area 2 PEC Exceedances – PAHs (mg/kg)

Parameter	PEC	Minimum Concentration Exceeding PEC	Maximum Concentration Exceeding PEC
Anthracene	0.845	**0.89** (B-11 S-5)	**27j** (B-10 S-2)
Benzo (a) Anthracene	1.05	**1.5** (B-11 S-5)	**27** (B-11 S-3)
Benzo (a) Pyrene	1.45	**17.5** (B-10 S-2/B-13 S-3)	**20** (B-11 S-3)
Chrysene	1.29	**1.3** (B-11 S-5)	**23.j** (B-10 S-2)
Fluoranthene	2.23	**18**j (B-13 S-3)	**43**j (B-10 S-2)
Fluorene	0.536	**17.5** (B-13 S-3)	**25**j (B-10 S-2)
Naphthalene	0.561	**15** (B-13 S-3)	**43**j (B-10 S-2)
Phenanthrene	1.17	**1.3** (B-11 S-5)	**83**j (B-10 S-2)
Pyrene	1.52	**3.5** (B-11 S-5)	**54**j (B-10 S-2)
Acenaphthene	0.089	**ND (15)** (B-13 S-3)	**35.0j**(B-10 S-3)
Acenaphthylene	0.128	**0.41** (B-11 S-5)	**ND (17.5)** ((B-10 S-2,B-13 S-3)
Benzo (b) Fluoranthene	13.4	**16** (B-10 S-2)	**21** (B-11 S-3)
Benzo (k) Fluoranthene	13.4	**15** (B-11 S-3)	**ND (20)** (B-10 S-2,B-13 S-3)
Benzo (g,h,i) perylene	3.2	**6.6** (B-11 S-3)	**ND (15)** (B-10 S-2,B-13 S-3)
Dibenzo(a,h) Anthracene	0.135	**ND (0.5)** (B-11 S-3)	**ND (17.5)** (B-10 S-2,B-13 S-3)
Indeno (1,2,3) Pyrene	3.2	**6.3** (B-11 S-3)	**ND (15)** (B-10 S-2,B-13 S-3)
2-Methylnaphthalene	0.201	**9.5** (B-11 S-3)	**33.0j** (B-10 S-2)

Table F-7 Area 3 PEC Exceedances – PAHs (mg/kg)

Parameter	PEC	Minimum Concentration Exceeding PEC	Maximum Concentration Exceeding PEC
Anthracene	0.845	**3.2** (VC-24 S-2)	**430** (B-8 S-1A)
Benzo (a) Anthracene	1.05	**1.2** (VC-24 S-2)	**270** (B-8 S-1A)
Benzo (a) Pyrene	1.45	**0.86** (VC-24 S-2)	**210** (B-8 S-1A)
Chrysene	1.29	**14** (VC-2 S-6) dup	**250** (B-8 S-1A)
Fluoranthene	2.23	**3** (VC-24 S-2)	**650** (VC-20 S-3)
Fluorene	0.536	**0.96** (VC-24 S-2)	**430** (VC-20 S-3)
Naphthalene	0.561	**2.2** (VC-2 S-2)	**770** (B-8 S-1A)
Phenanthrene	1.17	**2.9** (VC-24 S-2)	**1300** (B-8 S-1A)
Pyrene	1.52	**2.6** (VC-24 S-2)	**820** (B-8 S-1A)
Acenaphthene	0.089	**0.83** (VC-24 S-2)	**610** (B-8 S-1A)
Acenaphthylene	0.128	**0.48** (VC-24 S-2)	**54** (VC-1 S-5)
Benzo (b) Fluoranthene	13.4	**15** (VC-25 S-2)	**65** (VC-20 S-3)
Benzo (k) Fluoranthene	13.4	**14** (VC-25 S-2)	**90** (B-8 S-1A)
Benzo (g,h,i) perylene	3.2	**4.4** (VC-2 S-6 dup)	**43** (B-8 S-1A)
Dibenzo(a,h) Anthracene	0.135	**0.16** (VC-24 S-2)	**ND (35)** (B-6 S-1B, B-8 S-1A)
Indeno (1,2,3) Pyrene	3.2	**4.7** (VC-2 S-6 dup)	**44j** (B-8 S-1A)
2-Methylnaphthalene	0.201	**1.4** (VC-2 S-6 dup)	**790** (B-8 S-1A)

Table F-8 Area 4 PEC Exceedances – PAHs (mg/kg)

Parameter	PEC	Minimum Concentration Exceeding PEC	Maximum Concentration Exceeding PEC
Anthracene	0.845	**17** (VC-12 S-2)	**210** (VC-5 S-3)
Benzo (a) Anthracene	1.05	**1.2** (VC-12 S-1)	**140** (VC-5 S-3)
Benzo (a) Pyrene	1.45	**13** (VC-12 S-2)	**87** (VC-5 S-3)
Chrysene	1.29	**1.4** (VC-12 S-1)	**160** (VC-5 S-3)
Fluoranthene	2.23	**2.5** (VC-12 S-1)	**270** (VC-5 S-3)
Fluorene	0.536	**0.87** (VC-12 S-2)	**170** (VC-5 S-3)
Naphthalene	0.561	**2.3** (VC-12 S-2)	**190** (VC-5 S-3)
Phenanthrene	1.17	**1.2** (VC-12 S-1)	**600** (VC-5 S-3)
Pyrene	1.52	**2.4** (VC-12 S-1)	**340** (VC-5 S-3)
Acenaphthene	0.089	**0.11** (VC-12 S-1)	**140** (VC-5 S-3)
Acenaphthylene	0.128	**0.41** (VC-12 S-1)	**92** (VC-6 S-3)
Benzo (b) Fluoranthene	13.4	**17** (VC-7 S-5)	**46** (VC-5 S-3)
Benzo (k) Fluoranthene	13.4	**17** (VC-12 S-1)	**59** (VC-5 S-3)
Benzo (g,h,i) perylene	3.2	**6.5** (VC-12 S-2)	**43** (VC-5 S-3)
Dibenzo(a,h) Anthracene	0.135	**0.21** (VC-12 S-1)	**14** (VC-5 S-3)
Indeno (1,2,3) Pyrene	3.2	**7** (VC-12 S-2)	**48** (VC-5 S-3)
2-Methylnaphthalene	0.201	**0.4** (VC-12 S-1)	**250** (VC-5 S-3)

Table F-9 Area 5 PEC Exceedances – PAHs (mg/kg)

Parameter	PEC	Minimum Concentration Exceeding PEC	Maximum Concentration Exceeding PEC
Anthracene	0.845	**0.875** (B-1 S-2A)	**35** (B-5 S-2A)
Benzo (a) Anthracene	1.05	**7.8** j (B-5 S-3B)	**35** (B-5 S-2A)
Benzo (a) Pyrene	1.45	**8.75** (B-5 S-3B)	**35** (B-5 S-2A)
Chrysene	1.29	**8.2** j (B-5 S-3B)	**35** (B-5 S-2A)
Fluoranthene	2.23	**13**j (B-3 S-2A)	**25**j (B-5 S-2A)
Fluorene	0.536	**0.875** (B-1 S-2A)	**35** (B-5 S-2A)
Naphthalene	0.561	**0.75** (B-1 S-2A)	**330** (B-5 S-2A)
Phenanthrene	1.17	**5.5**j (B-5 S-3A)	**40**j (B-5 S-2A)
Pyrene	1.52	**17.5** (B-2 S-2A/B-14 S-2)	**27**j (B-5 S-2A)
Acenaphthene	0.089	**ND (30)** (B-1 S-2A)	**ND (0.75)**(B-5 S-2A)
Acenaphthylene	0.128	**ND (0.875)** (B-1 S-2A)	**ND (35)** (B-5 S-2A)
Benzo (b) Fluoranthene	13.4	**16.0j** (B-4 S-2A)	**ND (40)** (B-5 S-2A)
Benzo (k) Fluoranthene	13.4	**ND (20)** (B-2 S-2A, B-3 S-2A, B-4 S-2, B14 S-2)	**ND (40)** (B-5 S-2A)
Benzo (g,h,i) perylene	3.2	**ND (7.5)** (B-5 S-3B)	**ND (30)** (B-5 S-2A)
Dibenzo(a,h) Anthracene	0.135	**ND (0.875)** (B-1 S-2A)	**ND (35)** (B-5 S-2A)
Indeno (1,2,3) Pyrene	3.2	**ND (75)** (B-1 S-2A)	**ND (30)** (B-5 S-2A)
2-Methylnaphthalene	0.201	**ND (0.875)** (B-1 S-2A)	**30.0j** (B-5 S-2A)

Table F-10 Malden River Sediment Quality Evaluation - Metals

Area 1

Consensus-Based Probable Effects Concentration (PEC)[1]

Location	Depth (feet)	Date	Results (mg/kg)							
			Arsenic	Cadmium	Chromium	Copper	Lead	Nickel	Zinc	Average PEC Quotient Value By location
B-12 S-3	4.7-6.7	08/24/99	36.7	6	98	242	1780	36	1018	
PEC Quotient			**1.11**	**1.20**	**0.88**	**1.62**	**13.91**	**0.74**	**2.22**	**3.1**
VC-21 S-1	0-0.3	6/5/03	8.9	1.9	39	120	360	18	360	
PEC Quotient			**0.27**	**0.38**	**0.35**	**0.81**	**2.81**	**0.37**	**0.78**	**0.82**
VC-21 S-2	0.6-0.9		35	12	78	310	1100	32	1100	
PEC Quotient			**1.06**	**2.41**	**0.70**	**2.08**	**8.59**	**0.66**	**2.40**	**2.56**
VC-21 S-4	2.4-2.8		17	1.1	45	63	170	27	190	
PEC Quotient			**0.52**	**0.22**	**0.41**	**0.42**	**1.33**	**0.56**	**0.41**	**0.55**
VC-22 S-1	0.0-0.3		16	4.4	71	220	760	43	740	
PEC Quotient			**0.48**	**0.88**	**0.64**	**1.48**	**5.94**	**0.88**	**1.61**	**1.7**
VC-23 S-4B	4.2-4.4		120	4.6	150	320	780	17	1400	
PEC Quotient			**3.64**	**0.92**	**1.35**	**2.15**	**6.09**	**0.35**	**3.05**	**2.51**
VC-23 S-4Bdup	4.2-4.4		120	4.5	150	310	780	17	1400	
PEC Quotient			**3.64**	**0.90**	**1.35**	**2.08**	**6.09**	**0.35**	**3.05**	**2.49**
Total Concentration			**353.6**	**34.5**	**631**	**1585**	**5730**	**190**	**6208**	
PEC			**33**	**4.98**	**111**	**149**	**128**	**48.6**	**459**	
Average PEC Quotient Value			**1.53**	**0.99**	**0.81**	**1.52**	**6.40**	**0.56**	**1.93**	

[1]"Prediction of Sediment Toxicity Using Consensus-Based Freshwater Sediment Guidelines," EPA 905/R-00/007, June 2000.

Table F-11 Malden River Sediment Quality Evaluation - Metals

Area 2

Consensus-Based Probable Effects Concentration (PEC)[1]

Location	Depth (feet)	Date	Results (mg/kg)							Average PEC Quotient Value By location
			Arsenic	Cadmium	Chromium	Copper	Lead	Nickel	Zinc	
B-10 S-2	2.5-4.3	08/24/99	18.8	8	121	-	1290	-	-	
PEC Quotient			**0.57**	**1.61**	**1.09**		**10.08**			**3.34**
B-11 S-3	5-7		26.0	14	122	262	530	55	1201	
PEC Quotient			**0.79**	**2.81**	**1.10**	**1.76**	**4.14**	**1.13**	**2.62**	**2.62**
B-11 S-5	7.3-9.3		18.1	4	32	-	80	-	-	
PEC Quotient			**0.55**	**0.80**	**0.29**		**0.63**			**0.56**
B-13 S-2	2.5-4.3		15.7	7	88	320	780	44	1038	
PEC Quotient			**0.48**	**1.41**	**0.79**	**2.15**	**6.09**	**0.91**	**2.26**	**2.01**
B-13 S-3	4.8-.68		36.5	7	136	277	610	34	1092	
PEC Quotient			**1.11**	**1.41**	**1.23**	**1.86**	**4.77**	**0.70**	**2.38**	**1.92**
B-13C	0-5.3'		27.5	11	116	343	1970	56	2838	
PEC Quotient			**0.83**	**2.21**	**1.05**	**2.30**	**15.39**	**1.15**	**6.18**	**4.16**
Total Concentration			**142.6**	**51**	**615**	**1202**	**5260**	**189**	**6169**	
PEC			**33**	**4.98**	**111**	**149**	**128**	**48.6**	**459**	
Average PEC Quotient Value			**0.62**	**1.46**	**0.79**	**1.15**	**5.87**	**0.56**	**1.92**	

[1]"Prediction of Sediment Toxicity Using Consensus-Based Freshwater Sediment Guidelines," EPA 905/R-00/007, June 2000.

Table F-12 Malden River Sediment Quality Evaluation – Metals - Area 3
Consensus-Based Probable Effects Concentration (PEC) [1]

Location	Depth (feet)	Date	Results (mg/kg)							Average PEC Quotient Value By Location
			Arsenic	Cadmium	Chromium	Copper	Lead	Nickel	Zinc	
B-6 S-1B	1-2	8/23 1999	36.6	7	151	230	550	41	1390	
PEC Quotient			**1.11**	**1.41**	**1.36**	**1.54**	**4.30**	**0.84**	**3.0**	**1.94**
B-106 S-1B	1-2		31.4	5	120	177	410	35	1046	
PEC Quotient			**0.95**	**1.00**	**1.08**	**1.19**	**3.2**	**0.72**	**2.28**	**1.49**
B-6 S-2B	3.8-4.8		40.0	7	152	-	570	-	-	
PEC Quotient			**1.21**	**1.41**	**1.37**		**4.45**			**2.11**
B-7 S-2A	1.6-2.4		14.7	1	21	54	110	13	367	
PEC Quotient			**0.45**	**0.20**	**0.19**	**0.36**	**0.86**	**0.27**	**0.80**	**0.45**
B-8 S-1A	0-1		234.2	3	242	-	680	-	-	
PEC Quotient			**7.10**	**0.60**	**2.18**		**5.31**			**3.80**
B-8 S-2A	2.3-3		12.7	2	32	-	190	-	-	
PEC Quotient			**0.38**	**0.40**	**0.29**		**1.48**			**0.64**
B-9 S-1	0-1.2		28.6	6	106	467	1120	47	1440	
PEC Quotient			**0.87**	**1.20**	**0.95**	**3.13**	**8.75**	**0.97**	**3.14**	**2.72**
B-9 S-2B	4.5-5.5		30.9	5	103	172	540	30	746	
PEC Quotient			**0.94**	**1.00**	**0.93**	**1.15**	**4.22**	**0.62**	**1.63**	**1.5**
B-15 S-1	0-2		21.8	7	98	230	1090	47	2300	
PEC Quotient			**0.66**	**1.41**	**0.88**	**1.54**	**8.52**	**0.97**	**5.01**	**2.71**
B-15 S-2A	3.2-4.2		19.3	7	79	233	650	48	1450	
PEC Quotient			**0.58**	**1.41**	**0.71**	**1.56**	**5.08**	**0.99**	**3.16**	**1.93**
B-16 S-1B	1.3-2		32.0	7	179	209	900	20	591	
PEC Quotient			**0.97**	**1.41**	**1.61**	**1.40**	**7.03**	**0.41**	**1.29**	**2.02**
B-16 S-2C	4-4.3		35.4	12	217	286	780	20	863	
PEC Quotient			**1.07**	**2.41**	**1.95**	**1.92**	**6.09**	**0.41**	**1.88**	**2.25**
B-16 S-3C	5.9-6.5		188.2	8	242	482	990	20	1450	
PEC Quotient			**5.70**	**1.61**	**2.18**	**3.23**	**7.73**	**0.41**	**3.16**	**3.43**
B-16C-A	0-2.6		42.3	7	190	260	700	25	732	
PEC Quotient			**1.28**	**1.41**	**1.71**	**1.74**	**5.47**	**0.51**	**1.59**	**1.96**
VC-1 S-1	0-0.5	6/3 2003	55	4.5	160	300	460	23	590	
PEC Quotient			**1.67**	**0.9**	**1.44**	**2.01**	**3.59**	**0.47**	**1.29**	**1.62**
VC-2 S-1	0-1		30	7.0	140		590			
PEC Quotient			**0.91**	**1.41**	**1.26**		**4.61**			**2.05**
VC-3 S-4	1.9-2.2		210	4.5	160	400	560	15	1100	
PEC Quotient			**6.36**	**0.90**	**1.44**	**2.68**	**4.38**	**0.31**	**2.40**	**2.64**
VC-15 S-1	0-0.3	6/4 2003	32	5.1	93		450			
PEC Quotient			**0.66**	**1.41**	**0.88**		**8.52**			**1.59**
VC-18 S-4	6.6-6.8		48	4.0	120		410			
PEC Quotient			**1.45**	**0.8**	**1.08**		**3.2**			**1.64**
VC-20 S-3	1.7-2	6/5 2003	50	2.8	87		500			
PEC Quotient			**1.52**	**0.56**	**0.78**		**3.91**			**1.69**
VC-24 S-2	0.7-0.8		7.2	ND	10		9.6			
PEC Quotient			**0.22**	**0.05**	**0.09**		**0.08**			**0.11**
VC-25 S-1	0-0.3		70	2.6	98		430			
PEC Quotient			**2.12**	**0.52**	**0.88**		**3.36**			**1.72**
VC-25 S-2	0.3-0.5		70	2.2	93		490			
PEC Quotient			**2.12**	**0.44**	**0.84**		**3.83**			**1.81**
Total Concentration			**1340.3**	**116.97**	**2893**	**3500**	**13179.6**	**384**	**14065**	
PEC			**33**	**4.98**	**111**	**149**	**128**	**48.6**	**459**	
Average PEC Quotient Value			**1.77**	**1.02**	**1.13**	**1.81**	**4.48**	**0.61**	**2.36**	

[1] "Prediction of Sediment Toxicity Using Consensus-Based Freshwater Sediment Guidelines," EPA 905/R-00/007, June 2000.

Table F-13 Malden River Sediment Quality Evaluation - Metals

Area 4

Consensus-Based Probable Effects Concentration (PEC)[1]

Location	Depth ± (feet)	Date	Results (mg/kg)							Average PEC Quotient Value by Location
			Arsenic	Cadmium	Chromium	Copper	Lead	Nickel	Zinc	
VC-4 S-2	4.2-4.5	6/3 2003	79	3.4	120		500			
PEC Quotient			**2.39**	**0.68**	**1.08**		**3.91**			**2.02**
VC-5 S-3	2.3-2.6		96	3.5	120		550			
PEC Quotient			**2.91**	**0.7**	**1.08**		**4.3**			**2.25**
VC-6 S-3	2.1-2.4		87	3.4	130		530			
PEC Quotient			**2.64**	**0.68**	**1.17**		**4.14**			**2.16**
VC-7 S-3	2.1-2.4		69	2.4	87		380			
PEC Quotient			**2.09**	**0.48**	**0.78**		**2.97**			**1.58**
VC-10 S-3	1.2-1.5	6/4 2003	8.6	ND(0.39)	29		8.4			
PEC Quotient			**0.26**	**0.08**	**0.26**		**0.07**			**0.17**
VC-11 S-1	0-0.3		26	5.0	94	220	410	46	1100	
PEC Quotient			**0.79**	**1.0**	**0.85**	**1.48**	**3.2**	**0.95**	**2.40**	**1.52**
VC-12 S-1	0-0.3		4.6	1.4	9.4	49	170	10	210	
PEC Quotient			**0.14**	**0.28**	**0.08**	**0.33**	**1.33**	**0.21**	**0.46**	**0.4**
VC-12 S-2	0.5-0.8		240	7.0	140		800			
PEC Quotient			**7.27**	**1.41**	**1.26**		**6.25**			**4.05**
VC-12 S-2dup	0.5-0.8		250	7.3	140		850			
PEC Quotient			**7.58**	**1.47**	**1.26**		**6.64**			**4.24**
VC-13 S-3	1.5-2.9		50	3.2	120		360			
PEC Quotient			**1.52**	**0.64**	**1.08**		**2.81**			**1.51**
Total Concentration			**910.2**	**36.99**	**989.40**	**269**	**4558.4**	**56**	**1310**	
PEC			**33**	**4.98**	**111**	**149**	**128**	**48.6**	**459**	
Average PEC Quotient Value			**2.76**	**0.74**	**0.89**	**0.90**	**3.56**	**0.57**	**1.42**	

[1]"Prediction of Sediment Toxicity Using Consensus-Based Freshwater Sediment Guidelines," EPA 905/R-00/007, June 2000.

Table F-14 Malden River Sediment Quality Evaluation - Metals

Area 5

Consensus-Based Probable Effects Concentration (PEC)[1]

Location	Depth (feet)	Date	Results (mg/kg)							Average PEC Quotient Value By Location
			Arsenic	Cadmium	Chromium	Copper	Lead	Nickel	Zinc	
B-1 S-2A	3.7-4.5	8/19 1999	8.8	ND (0.5)	28	42	20	15	72	
PEC Quotient			**0.27**	**0.1**	**0.25**	**0.28**	**0.16**	**0.31**	**0.16**	**0.22**
B-2 S-1	0-1		26.8	6	148	264	670	64	1250	
PEC Quotient			**0.81**	**1.20**	**1.33**	**1.77**	**5.23**	**1.32**	**2.72**	**2.05**
B-3 S-1	0-2	8/20 1999	29.4	9	155	275	850	63	2810	
PEC Quotient			**0.81**	**1.81**	**1.40**	**1.85**	**6.64**	**1.30**	**6.12**	**2.85**
B-3 S-2A	3.5-5		41.0	7	166	206	590	38	813	
PEC Quotient			**1.24**	**1.41**	**1.50**	**1.38**	**4.61**	**0.78**	**1.77**	**1.81**
B-3 S-3A	6-7		2.7	ND (0.5)	9	-	ND (0.5)	-	-	
PEC Quotient			**0.08**	**0.1**	**0.08**		**0**			**0.06**
B-4 S-2	7.6-9.6		30.0	6	188	200	440	31	551	
PEC Quotient			**0.91**	**1.20**	**1.69**	**1.34**	**3.44**	**0.64**	**1.2**	**1.43**
B-104 S-2	7.6-9.6		34.4	8	344	-	730	-	-	
PEC Quotient			**1.04**	**1.61**	**3.10**		**5.7**			**2.86**
B-5 S-2A	2.5-3.5		36.6	8	155	218	480	3	759	
PEC Quotient			**1.11**	**1.61**	**1.40**	**1.46**	**3.78**	**0.06**	**1.65**	**1.58**
B-5 S-3B	6-6.6		8.0	1	58	-	80	-	-	
PEC Quotient			**0.24**	**0.2**	**0.52**		**0.63**			**0.40**
B-14 S-2	2.4-4.4	8/25 1999	43.2	10	191	257	900	61	3610	
PEC Quotient			**1.31**	**2.01**	**1.72**	**1.72**	**7.03**	**1.26**	**7.86**	**3.27**
SP-2	0-7.2	8/24 1999	25.6	14	536	254	1100	295	3280	
PEC Quotient			**0.78**	**2.81**	**4.83**	**1.70**	**8.59**	**6.07**	**7.15**	**4.56**
Total Concentration			**286**	**70**	**1978**	**1716**	**5860.5**	**570**	**13145**	
PEC			**33**	**4.98**	**111**	**149**	**128**	**48.6**	**459**	
Average Pec Quotient VALUE			**0.78**	**1.27**	**1.62**	**1.44**	**4.16**	**1.46**	**3.58**	

[1]"Prediction of Sediment Toxicity Using Consensus-Based Freshwater Sediment Guidelines," EPA 905/R-00/007, June 2000.

Table F-15 Polynuclear Aromatic Hydrocarbon (PAH)-PEC Values – Area 1

Sample Location	B-12	B-12	VC-21	VC-21	VC-21	VC-22	VC-22	VC-23	VC-23	VC-23
Sample Designation	S-3	S-6A	S-1	S-2	S-4	S-4B	S-5	S-4B	S-4B dup	S-5
Sample Depth	56-80"	128-148"	0-4”	7-11”	29-33”	49-53”	71-75”	50-53"		53-57”
Date	8/24/1999		6/5/2003							
SVOCs (mg/kg)										
2-Methyl Naphthalene	92	55.0 j	5.7	150	100	400	930	3800	3600	13,000
Acenaphthene	38.0 j	61.0 j	9.8	220	70	240	440	1400	1200	5,300
Acenaphthylene	ND (17.5)	ND (17.5)	8.9	65	18	64	120	380	370	1,500
Anthracene	26.0 j	46.0 j	18	190	68	190	360	910	830	3,300
Benzo (a) Anthracene	28.0 j	39.0 j	40	170	56	140	220	400	830	1,500
Benzo (a) Pyrene	16.0 j	30.0 j	34	120	40	120	130	250	400	1,000
Benzo (b) Fluoranthene	21.0 j	25.0 j	27	73	23	66	57	ND (100)	230	ND (405)
Benzo (g,h,i) Perylene	ND (15.0)	ND (15.0)	22	69	22	62	56	ND (100)	-	ND (405)
Benzo (k) Fluoranthene	ND (20.0)	10.0 j	20	74	22	62	64	ND (220)	76	ND (405)
Chrysene	29.0 j	32.0 j	40	160	54	130	200	440	400	1,700
Dibenzo (a.h) Anthracene	ND (17.5)	ND (17.5)	5.5	20	5.9	14	19	ND (100)	29	ND (405)
Fluoranthene	54.0 j	70.0 j	96	350	110	330	420	800	780	3,100
Fluorene	26.0 j	40.0 j	11	190	62	190	360	900	900	3,300
Indeno (1,2,3-cd) Pyrene	ND (15.0)	ND (15.0)	25	79	25	65	65	ND (100)	88	ND (405)
Naphthalene	250	130	11	420	120	520	770	2700	2400	12,000
Phenanthrene	79	150	73	570	190	560	980	2800	2300	10,000
Pyrene	75.0 j	100	85	370	120	390	520	1100	1100	4,000
Total SVOCs	819.00	853.00	531.90	3290.00	1105.90	3543.00	5711.00	16500.00	15533.00	61725.00
PEC	22.80	22.80	22.80	22.80	22.80	22.80	22.80	22.80	22.80	22.80
Total PAH PEC Value	**35.92**	**37.41**	**23.33**	**144.30**	**48.50**	**155.39**	**250.48**	**723.68**	**681.27**	**2707.24**

- Not Tested
ND - Not Detected
J - Estimated results, value is below the calibration/detection limit.

Table F-16 Polynuclear Aromatic Hydrocarbon (PAH)-PEC Values – Area 2

Sample Location	B-10	B-11	B-11	B-13
Sample Designation	S-2	S-3	S-5	S-3
Sample Depth	30-52"	60-84"	88-112"	52-76"
Date	8/24/1999			
SVOCs (mg/kg)				
2-Methyl Naphthalene	33.0 j	9.5	0.1 j	ND (17.5)
Acenaphthene	35.0 j	16	0.1 j	ND (15.0)
Acenaphthylene	ND (17.5)	9.3	0.41	ND (17.5)
Anthracene	27.0 j	15	0.89	ND (17.5)
Benzo (a) Anthracene	ND (17.5)	27	1.5	ND (17.5)
Benzo (a) Pyrene	ND (17.5)	20	1.2	ND (17.5)
Benzo (b) Fluoranthene	16	21	0.92	ND (20.0)
Benzo (g,h,i) Perylene	ND (15.0)	6.6	0.26	ND (15.0)
Benzo (k) Fluoranthene	ND (20.0)	15	0.31	ND (20.0)
Chrysene	23.0 j	24	1.3	ND (17.5)
Dibenzo (a.h) Anthracene	ND (17.5)	ND (0.5)	0.1 j	ND (17.5)
Fluoranthene	43.0 j	39	2.1	18.0 j
Fluorene	25.0 j	18	0.1 j	ND (17.5)
Indeno (1,2,3-cd) Pyrene	ND (15.0)	6.3	0.3 j	ND (15.0)
Naphthalene	43.0 j	50	0.1 j	ND (15.0)
Phenanthrene	83.0 j	41	1.3	30.0 j
Pyrene	54.0 j	53	3.5	28.0 j
Total SVOCs	502.00	371.20	14.47	316.00
PEC	22.80	22.80	22.80	22.80
Total PAH PEC Value	**22.02**	**16.28**	**0.63**	**13.86**

- Not Tested
ND - Not Detected
J - Estimated results, value is below the calibration/detection limit.

Table F-17 Polynuclear Aromatic Hydrocarbon (PAH)-PEC Values – Area 3

Sample Location	B-6	B-6	B-8	B-8	B-9	B-9	B-109	B-15	B-16	B-16
Sample Designation	S-1B	S-2B	S-1A	S-2A	S-2B	S-4B	S-2B	S-2A	S-3C	C-A
Sample Depth	13-24"	46-58"	0-12"	28-36"	54-66"	105-117"	54-66"	38-50"	71-78"	0-38"
Date	8/23/1999									
SVOCs (mg/kg)										
2-Methyl Naphthalene	ND (35.0)	25.0 j	790	26.0 j	62.0 j	110	35.0 j	ND (17.5)	130	30
Acenaphthene	ND (30.0)	22.0 j	610	21.0 j	53.0 j	90	43.0 j	ND (15.0)	140.0 j	110
Acenaphthylene	ND (35.0)	ND (17.5)	49.0 j	9.5 j	ND (17.5)	9	ND (17.5)	ND (17.5)	27.8 j	13
Anthracene	ND (35.0)	19.0 j	430	40.0 j	50.0 j	54	37.0 j	ND (17.5)	140	100
Benzo (a) Anthracene	ND (35.0)	ND (17.5)	270	38.0 j	35.0 j	42	33.0 j	28.0 j	84	71
Benzo (a) Pyrene	ND (35.0)	ND (17.5)	210	25.0 j	23.0 j	28	17.0 j	ND (17.5)	50.0 j	48
Benzo (b) Fluoranthene	ND (40.0)	ND (20.0)	15.0 j	29.0 j	25.0 j	28	21.0 j	26.0 j	45.0 j	63
Benzo (g,h,i) Perylene	ND (30.0)	ND (15.0)	43.0 j	12.0 j	10.0 j	11	ND (15.0)	ND (15.0)	18.0 j	26
Benzo (k) Fluoranthene	ND (40.0)	ND (20.0)	90	13.0 j	ND (20.0)	13	14.0 j	ND (20.0)	21.0 j	34
Chrysene	ND (35.0)	ND (17.5)	250	35.0 j	34	40	30.0 j	36.0 j	80	85
Dibenzo (a.h) Anthracene	ND (35.0)	ND (17.5)	ND (35.0)	ND (17.5)	ND (17.5)	2.6	ND (17.5)	ND (17.5)	ND (17.5)	6.6
Fluoranthene	ND (35.0)	31.0 j	500	85	76	110	65.0 j	60.0 j	130	210
Fluorene	ND (35.0)	18.0 j	390	28.0 j	40.0 j	78	38.0 j	ND (17.5)	110	100
Indeno (1,2,3-cd) Pyrene	ND (30.0)	ND (15.0)	44J	14.0 j	12.0 j	12	10.0 j	ND (15.0)	20.0 j	25
Naphthalene	ND (35.0)	93	770	90	110	310	84	ND (15.0)	68	190
Phenanthrene	41.0 j	55.0 j	1300	95	150	220	110	58.0 j	390	340
Pyrene	32.0 j	33.0 j	820	81	83	100	80	73.0 j	240	240
Total SVOCs	593.00	453.50	6572.00	659.00	818.00	1257.60	667.00	466.00	1711.33	1691.60
PEC	22.80	22.80	22.80	22.80	22.80	22.80	22.80	22.80	22.80	22.80
Total PAH PEC Value	**26.01**	**19.89**	**288.25**	**28.90**	**35.88**	**55.16**	**29.25**	**20.44**	**75.06**	**74.19**

- Not Tested

J - Estimated results, value is below the calibration/detection limit.

ND - Not Detected

Table F-17 Polynuclear Aromatic Hydrocarbon (PAH)-PEC Values – Area 3

Sample Location	VC-1	VC-1	VC-2	VC-2	VC-2	VC-3	VC-3	VC-15	VC-15	VC-15	VC-18	VC-20	VC-24	VC-25	VC-25	SP-3D
Sample Designation	S-3	S-5	S-2	S-6	S-6 dup	S-4	S-4 dup	S-2	S-4	S-6	S-4	S-3	S-2	S-2	S-5	
Sample Depth	24-28”	57-61”	19-23”	93-96”	93-96”	23-26”	23-26”	5-9"	22-26”	52-56”	79-82”	20-24”	7-10"	4-6”	34-37”	0-24"
Date	6/4/2003															
SVOCs (mg/kg)																
2-Methyl Naphthalene	23	230	1	1.8	1.4	17	19	21	240	110	220	ND (3.6)	0.15	ND (1.9)	330	24.0 j
Acenaphthene	24	160	1.3	2.5	2.2	23	26	290	190	82	140	380	0.83	6.3	270	23.0 j
Acenaphthylene	34	54	9.4	8.3	5.6	18	25	50	19	37	22	37	0.48	9.6	ND (12.5)	ND (17.5)
Anthracene	57	180	8	14	9.5	63	68	280	170	120	120	380	3.2	21	210	30.0 j
Benzo (a) Anthracene	67	120	16	18	13	57	65	190	90	86	69	190	1.2	22	120	17.0 j
Benzo (a) Pyrene	46	71	11	13	10	36	42	120	48	53	40	100	0.86	18	100	13.0 j
Benzo (b) Fluoranthene	35	30	7	5.6	3.5	18	20	71	35	29	29	65	0.67	15	48	13.0 j
Benzo (g,h,i) Perylene	24	28	7	6.2	4.4	16	16	61	24	22	19	50	0.51	10	46	ND (15.0)
Benzo (k) Fluoranthene	34	42	7.3	6.1	1.3	20	27	73	27	27	24	61	0.67	14	69	ND (20.0)
Chrysene	72	110	18	18	14	58	65	180	82	84	62	180	1	27	120	23.0 j
Dibenzo (a.h) Anthracene	8	9.2	2	1.9	1.4	4.8	5.4	18	6.9	7.7	5.8	15	0.16	3.4	ND (12.5)	ND (17.5)
Fluoranthene	140	240	35	32	22	100	120	470	300	170	230	650	3	48	270	43.0 j
Fluorene	23	150	0.86	4.6	2.8	32	36	270	200	85	140	430	0.96	ND (1.2)	180	20.0 j
Indeno (1,2,3-cd) Pyrene	28	32	8	6.6	4.7	17	20	70	28	25	24	57	0.58	9.1	38	ND (15.0)
Naphthalene	17	120	2.2	2.4	2.8	14	15	120	590	82	570	39	0.18	3	280	24.0 j
Phenanthrene	120	460	3.6	29	17	140	150	810	530	290	370	1100	2.9	6.6	620	78.0 j
Pyrene	150	310	36	41	28	120	140	480	250	200	200	550	2.6	48	360	56.0 j
Total SVOCs	902.00	2346.20	173.66	211.00	143.60	753.80	859.40	3574.00	2829.90	1509.70	2284.80	4287.60	19.95	264.10	3086.00	449.00
PEC	22.80	22.80	22.80	22.80	22.80	22.80	22.80	22.80	22.80	22.80	22.80	22.80	22.80	22.80	22.80	22.80
Total PAH PEC Value	**39.56**	**102.90**	**7.62**	**9.25**	**6.30**	**33.06**	**37.69**	**156.75**	**124.12**	**66.21**	**100.21**	**188.05**	**0.88**	**11.58**	**135.35**	**19.69**

- Not Tested

ND - Not Detected

Table F-18 Polynuclear Aromatic Hydrocarbon (PAH)-PEC Values – Area 4

Sample Location	VC-4	VC-5	VC-6	VC-7	VC-7	VC-8	VC-11	VC-12	VC-12
Sample Designation	S-2	S-3	S-3	S-3	S-5	S-3	S-4	S-1	S-2
Sample Depth	24-26”	28-31”	25-29”	25-29”	46-50”	20-24”	32-35”	0-3”	6-9”
Date	6/3/2003						6/4/2003		
SVOCs (mg/kg)									
2-Methyl Naphthalene	57	250	31	16	41	7.3	3.4	0.46	0.84
Acenaphthene	46	140	61	86	40	35	14	0.11	7.3
Acenaphthylene	70	76	92	55	26	38	8.3	0.41	11
Anthracene	94	210	130	120	57	75	22	0.43	17
Benzo (a) Anthracene	76	140	95	100	46	68	24	1.2	18
Benzo (a) Pyrene	49	87	60	70	31	45	17	1.1	13
Benzo (b) Fluoranthene	33	46	38	38	17	33	12	0.97	6.8
Benzo (g,h,i) Perylene	27	43	29	34	13	24	9.6	0.89	6.5
Benzo (k) Fluoranthene	33	59	35	45	17	30	12	0.8	6.4
Chrysene	88	160	110	110	43	77	25	1.4	17
Dibenzo (a.h) Anthracene	9.1	14	9.2	10	4.7	8.2	2.7	0.21	1.8
Fluoranthene	180	270	210	220	93	140	63	2.5	36
Fluorene	69	170	90	110	39	38	13	0.14	0.87
Indeno (1,2,3-cd) Pyrene	31	48	34	40	15	28	11	0.98	7
Naphthalene	28	190	96	96	33	64	13	0.085	2.3
Phenanthrene	260	600	350	370	150	170	29	1.2	2.6
Pyrene	210	340	270	250	110	160	57	2.4	45
Total SVOCs	1360.10	2843.00	1740.20	1770.00	775.70	1040.50	336.00	15.29	199.41
PEC	22.8	22.8	22.8	22.8	22.8	22.8	22.8	22.8	22.8
Total PAH PEC Value	**59.65**	**124.69**	**76.32**	**77.63**	**34.02**	**45.64**	**14.74**	**0.67**	**8.75**

- Not Tested

ND - Not Detected

J - Estimated results, value is below the calibration/detection limit.

Table F-19 Polynuclear Aromatic Hydrocarbon (PAH)-PEC Values – Area 5

Sample Location	B-1	B-2	B-3	B-3	B-4	B-5	B-5	B-14
Sample Designation	S-2A	S-2A	S-2A	S-3A	S-2	S-2A	S-3B	S-2
Sample Depth	44-54"	24-36"	40-60"	72-84"	91-115"	32-44"	72-79"	29-53"
Date	8/19/1999							8/24/1999
SVOCs (mg/kg)								
2-Methyl Naphthalene	ND (0.875)	ND (17.5)	ND (17.5)	ND (0.008)	ND (17.5)	30.0 j	ND (8.750)	ND (17.5)
Acenaphthene	ND (0.750)	ND (15.0)	ND (15.0)	ND (0.008)	ND (15.0)	ND (30.0)	ND (7.50)	ND (15.0)
Acenaphthylene	ND (0.875)	ND (17.5)	ND (17.5)	ND (0.008)	ND (17.5)	ND (35.0)	ND (7.50)	ND (17.5)
Anthracene	ND (0.875)	ND (17.5)	ND (17.5)	0.007	ND (17.5)	ND (35.0)	8.3 j	ND (17.5)
Benzo (a) Anthracene	ND (0.875)	ND (17.5)	ND (17.5)	ND (0.003)	14.0 j	ND (35.0)	7.8 j	ND (17.5)
Benzo (a) Pyrene	ND (0.875)	ND (17.5)	ND (17.5)	ND (0.003)	12.0 j	ND (35.0)	ND (8.750)	ND (17.5)
Benzo (b) Fluoranthene	ND (1.0)	ND (20.0)	ND (20.0)	ND (0.003)	16.0 j	ND (40.0)	5.1 j	ND (20.0)
Benzo (g,h,i) Perylene	ND (0.750)	ND (15.0)	ND (15.0)	ND (0.003)	ND (15.0)	ND (30.0)	ND (7.50)	ND (15.0)
Benzo (k) Fluoranthene	ND (1.0)	ND (20.0)	ND (20.0)	ND (0.003)	ND (20.0)	ND (40.0)	ND (10.00)	ND (20.0)
Chrysene	ND (0.875)	ND (17.5)	ND (17.5)	ND (0.003)	17.0 j	ND (35.0)	8.2 j	ND (17.5)
Dibenzo (a.h) Anthracene	ND (0.875)	ND (17.5)	ND (17.5)	ND (0.005)	ND (17.5)	ND (35.0)	ND (8.750)	ND (17.5)
Fluoranthene	0.4 j	ND (17.5)	13.0 j	0.012	16.0 j	25.0 j	19.0 j	ND (17.5)
Fluorene	ND (0.875)	ND (17.5)	ND (17.5)	ND (0.005)	ND (15.0)	ND (35.0)	ND (8.750)	ND (17.5)
Indeno (1,2,3-cd) Pyrene	ND (0.750)	ND (15.0)	ND (15.0)	ND (0.003)	ND (15.0)	ND (30.0)	ND (7.50)	ND (15.0)
Naphthalene	ND (0.750)	ND (15.0)	ND (15.0)	ND (0.008)	ND (15.0)	ND (30.0)	ND (7.50)	ND (15.0)
Phenanthrene	ND (0.875)	ND (17.5)	ND (17.5)	0.008 j	ND (17.5)	45.0 j	5.5 j	ND (17.5)
Pyrene	0.58J	ND (17.5)	18.0 j	0.014	25.0 j	27.0 j	19.0 j	ND (17.5)
Total SVOCs	13.30	292.50	288.50	0.10	282.50	572.00	155.40	292.50
PEC	22.8	22.8	22.8	22.8	22.8	22.8	22.8	22.8
Total PAH PEC Value	**0.58**	**12.83**	**12.65**	**0.00**	**12.39**	**25.09**	**6.82**	**12.83**

\- Not Tested
ND - Not Detected
J - Estimated results, value is below the calibration/detection limit.

ENSR INTERNATIONAL

Memorandum

To:	Dave Mitchell	**Date:**	3 Nov 2003
From:	Marcia Greenblatt	**File:**	
RE:	Malden River - Spot Pond	**CC:**	Mark Gerath

Emergency Distribution Reservoir Management Study Task 5.2 Spot Pond Reservoir Final Management Plan (including Appendices). Completed by CDM, May, 2002 for MWRA (ENSR has these reports in House). The project included a field program, including water quality measurements, bathymetry and a structures survey, were performed. A summary of the hydraulics and hydrology of Spot pond is provided below.

Spot Pond was historically used as conveyance in the MWRA system. Since 1997, the pond has been taken off line, and is now used to receive flows from the distribution system, either as part of a flushing event or a system failure and as an extreme emergency source, if there is a loss of suction form other facilities in the system or a transmission failure. If needed as an emergency drinking water supply, the water will be passed through a disinfection process and will require boiling before consumption.

Spot Pond has a volume of 2235 million gallons and a surface area of 298 acres at 164' BCB. The maximum depth is 47' and the average depth is 23' at this elevation. The natural area of the watershed is 1175 acres, including the pond surface. However, due to drainage diversions and blocked pipes, the actual watershed is 369 acres, not much bigger than the pond area. Because of this small actual watershed, the water level in the pond is controlled primarily by groundwater flows.

There are 11 dams, two pump stations, a spillway and 2 sluice gates on Spot Pond. There are also many drains around the perimeter of the pond, in varying conditions of functionality. The elevation of the spillway, which drains into Spot Brook, is 161.83'. There is a single stoplog above the spillway, raising the elevation to 162.16'. There has been no flow over the spillway in the past 40 years.

At the East Gatehouse, the Gills Pump Station can move water at 60 mgd into the North High Service Area, if needed in an emergency. The city of Winchester maintains a pump station, and they periodically pump water, either to supplement their supply or to maintain the desired water levels in the pond, and the request of the MWRA.

The operational goals of the MWRA are:

- Maintain a minimum water level sufficient to supply water in an extreme emergency.
- Maintain a maximum water level to provide flood storage, sustain dam safety and avoid unregulated overflows.
- Minimize the need to supplement water in the pond.
- Control downstream releases to avoid exacerbating flooding.

The MWRA wants at least a 5 day supply of water in the pond, or ~328 million gallons (plus any additional volume necessary to maintain pump suction). Based on the stage-volume curve, this is equivalent to a water elevation of 157.5 in the pond.

CDM developed and applied a water budget model to establish operating guidelines based on the needs of MWRA. Because the pond is controlled primarily by groundwater flow, there is negligible inflow in the summer and early fall, and a slow response to precipitation events. Based on historical data, CDM developed a dry, average and wet year to model, with the following results:

Scenario	Net volume of water at the end of the year
Dry	-156 mg
Average	-0.16 mg
Wet	169 mg

Overall, there is a predicted net loss of water from Spot Pond.

CDM recommended an operating range of 157.6' – 160.5'. These recommendations take into account the 500-year design storm and aesthetics. The banks of the pond are heavily rip-rapped at least several feet below 160.5', and CDM recommended a water level sufficient to cover these banks as much as possible, as the pond is highly used as a recreational area.

If water needs to be released from Spot Pond, it can be spilled from the low-level outlet into Spot Pond Brook, pumped into the Winchester Reservoir or withdrawn into the MWRA distribution system.

CDM performed a downstream impact analysis for Spot Pond Brook, encompassing 3000' downstream from the pond. Water flows out of spot pond along the eastern shore through a 24" low-level outlet with a design capacity of 25 cfs. From this outlet, water is piped 1000' and discharges by gravity to form the headwaters of Spot Pond Brook. The Brook flows for 1500' through the Middlesex Fells Reservation and down a steep ravine. Below the ravine, the Brook flows through a small ponded area south of Pond Street and into a 4' x 4' box culvert that contains a broad crested weir. Between the weir and Pond Street, there is a 50' wide open grassy area that could provide storage during a large release. The stream enters 200' long pipe, and exits via a 9' x 3' outlet. The Brook parallels Philips Street, and enters a second culvert under Wyoming Ave. Below this culvert is a 30" MDC culvert, the downstream limit of the impact analysis. This culvert was deemed the control point due to its small cross-sectional area, and the flow capacity of this culvert was determined to be 22 cfs.

Based on the above, water can be released at 21 cfs with no downstream flooding. At this rate, 18.1 mg (the 500-year design storm) can be released over 32 hours.

MWRA has decided to operate the pond at 159-160.5', which maintains aesthetics and provides an 8 day (at 60 mgd) emergency water supply. An official procedure for lowering the pond, including verifying the available conveyance in the downstream path and notifying some of the communities downstream, has been developed by MWRA.

The option to supplement water supply and increase flushing in the Malden River with "excess" water from Spot Pond is not a viable option. On an annual basis, there is no excess water to spill during the dry months of late summer and early fall, when increased freshwater inflow would be most needed in the Malden River. On a long-term basis, Spot Pond is losing overall, and there would not be excess water in even an average rainfall year. Additionally, there would be water quality concerns associated with periodically spilling water into the culverts, channels and streambeds of Spot Pond Brook. **This option will not be considered further in the evaluation of restoration alternatives for the Malden River.**

ENSR INTERNATIONAL

Memorandum

To:	Dave Mitchell	**Date:**	7 Nov 2003
From:	Marcia Greenblatt	**File:**	
RE:	Malden River - Volume	**CC:**	Mark Gerath

We calculated the volume of the Malden River, based on USGS bathymetric mapping. We calculated the volume 2 ways:

1. We assumed that the highest contour in the USGS mapping represented the water surface elevation, and
2. Last week we were surveying bathymetry in the Mystic River, and our surveyor indicated that the water level varied between 106' and 106.4' while he was out there. We used a value of 106.2', but do not have the channel cross-sectional area above 105.8. Therefore we assumed vertical banks. This is probably not that far off. These calculations indicate a surface area of 54 acres for the River.

These values are consistent with an engineering study conducted in 1962 by Charles A. Maguire and Associates. In this report, a stage-volume curve for the Malden River is presented. Based on this curve, a water elevation of 106' results in a volume of approximately 14.7 million cubic feet.

Water Surface Elevation (ft, MDC datum)	Volume (ft3)	Volume (MG)
105.8	14,737,221	110
106.2*	15,670,611	117

*Does not account for additional channel width between 105.8 contour and 106.2 (I.e., assumes straight banks)

ENSR INTERNATIONAL

Memorandum

To:	Dave Mitchell	**Date:**	3 Nov 2003
From:	Marcia Greenblatt	**File:**	
RE:	Malden River – Tidal Exchange at the Earhart Dam	**CC:**	Mark Gerath

I have reviewed the information provided by the MDC regarding water quality issues and the saltwater removal project in Lower Mystic Lake. The objective of this review was to assess the feasibility of going forward with an evaluation of introducing salt water flushing at the AE dam. As we have discussed, allowing tidal may provide significant improvement in water quality, leading to improved fish habitat, restoration of the historically tidal wetlands, and possibly improvements in sediment quality with increased flows in the river. Thus, the reintroduction of tidal flows into the Malden River addresses the three core goals of the Malden River restoration project, and merits a proper evaluation before dismissing the alternative.

The following documents provided the summary information presented here:

MDC. 1994. Lower Mystic Lake Salt Water Removal Project

Ludlam, S.D. and B. Duval. 2001. Natural and Management-Induced Redution in Monomolimnetic Volume and Stability in a Coastal, Merimictic Lake.Lake and Reserv. Manage. 17(2):71-81.

From the above documents, the following is a summary of the issues pertaining to the reintroduction of tidal flushing at the AE dam:

- Historically, the Malden River and Lower Mystic River were tidal estuaries supporting brackish aquatic biota.
- Chemical stratification in the Lower Mystic Lake due to saltwater intrusion was first observed in 1860, and has been consistently present.
- Saltwater intrusion into the Lake may have occurred primarily during large storm events.
- The presence of the chemical stratification causes the saltwater to be trapped in the deep pools of the Lake, and prevents biannual turnover and complete mixing.
- At times (during the right combination of strong winds and low lake levels), there have been releases of H_2S from Lower Mystic Lake, causing public nuisance conditions and possible health hazards. Following a 1965 release, a major kill of alewives and barnacle growth on boats and pilings were observed.
- The installation of the Cradock Dam in 1908 (~3 mi downstream of the lake) allowed periodic excursions of saltwater into the lake when the locks were open.
- The AE dam was completed in 1966 (~5 mi downstream) and maintains the lake level ~1 m above mean low water, eliminating tidal flow into the Mystic and Malden Rivers.
- The elimination of saltwater changed the ecosystem from brackish to freshwater, however there does not appear to be adequate freshwater flow to support a healthy freshwater ecosystem.
- A combination of pumping (removing 240,000 m^3) and a large storm event (removing 456,000 m^3) has removed ~90% of the saltwater from the deep holes in the Lower Mystic Lake. This removal led to a larger lake volume available for freshwater habitat and elimination of H_2S releases due to the larger depth of freshwater overlying the remaining salt water.
-

The negative impacts of saltwater in the Lower Mystic Lakes that persisted long after the closure of the Earhart dam are understood, and the effort that was required to rectify the situation is appreciated. It would be important to ensure that any change in operation of the dam did not result in any significant increase in the saltwater residing in Lower Mystic Lake, which could lead to H_2S releases and degradation of fish habitat. However, the information presented here does not fully demonstrate that there is no way to operate the dam to provide flood protection while allowing for limited tidal exchange. There may be a mode of operation that provides for flushing on lower portions of the Malden River, restoring a brackish marsh habitat, without allowing saltwater excursions into Lower Mystic Lake.

Because of the high stakes of the project, an evaluation of tidal exchange as a means to rehabilitate wetlands, encourage a healthy fishery and improve sediment quality is warranted. The goal of this evaluation is to review available data to fully understand the situation, historically and presently, including lock operation, conditions that cause saltwater intrusion and volume of flushing required to improve water quality. At the completion of this review, it is anticipated that a meeting with DCR will be set up to discuss our ideas. At that time, we can decide if this alternative deems further consideration.

ENSR INTERNATIONAL

Memorandum

To:	Dave Mitchell	**Date:**	3 Dec 03
From:	Marcia Greenblatt	**File:**	
RE:	Malden River - Aeration	**CC:**	

In order to improve water quality in the Malden River, aeration was proposed as an alternative to provide circulation and increase DO in the river. A brief review of aeration application in the Malden River was performed to assess the feasibility of aeration as a water quality improvement alternative.

Artificial improvement of DO concentration in the water column can be achieved by aeration or artificial circulation. Aeration is generally aimed at DO improvements in the hypolimnium. There are three general classes of hypolimnium aeration: mechanical agitation, where water is removed, treated and returned; injection of pure oxygen and injection of air (Cooke et al 1993). These methods are generally applied in at least 12-15 m of water, where it apparatus is situated 1-2 m above the bottom, and can extend up to 10 m into the water column. Artificial circulation, achieved by pumps, jets or bubbled air, can also be implemented to increase DO in the water column. Diffuser pipes are located near the bottom of the water column, and discharge compressed air upwards. The induced vertical circulation of water serves to introduce oxygen into the oxygen-depleted water circulated up from the lower portion of the water column.

An artificial circulation system in the Malden River would serve to increase DO locally. It would provide the most benefit in any areas where stratification has been observed. Although water column profiles have not been collected, it is not believed that significant stratification develops in the Malden River due to the shallow water depths (<6 ft). Additionally, It would be most practical to install such a system at a location identified for other fish habitat improvements, such as placement of substrate. A specific location that would be feasible in the Malden River has not been identified.

Any form of aeration in the Malden River would be a challenge due to shallow water depths. The placement of any apparatus on the bottom may result in sediment scour. An apparatus on the bottom in such shallow water depths could impede with recreational uses of the river. Additionally, any sort of mechanical system requires initial capital expenditure followed by annual O&M costs.

The Mystic River Watershed Association has collected dissolved oxygen data continuously during the summer months at several stations in the Mystic River Watershed, including one station at the Amelia Earhart dam. Figure 2 and Figure 3 present the DO data for 2002 and 2003, respectively. The DO sensor was located in 3-6 feet of water. In 2002, a dry year, there were 3-4 weeks in July where the DO fell below 5.0 mg/L (the water quality standard). In 2003, a wet year, there were only a few excursions in July where DO fell below the water quality standard. These data indicate that low dissolved oxygen is present at this location, likely on an annual basis. However, the low DO condition does not appear to persist throughout the summer season. Nor does stormwater inflow appear to drive low DO at this location. It is possible that low DO persists further upstream in the Malden River, where there is no influence from the Mystic River. Figure 3 presents point measurements of DO collected throughout the watershed on 10/28/03. These observations indicate that DO in the mid section of the Malden River is considerably lower that at other locations in the Malden River and the Mystic River. Additional field measurements would be required to fully characterize the spatial and temporal extent of oxygen deficiencies in the Malden River

In summary, the implementation of artificial circulation is not likely to result in significant water quality improvement in the Malden River. The data do not indicate that low DO concentrations are a persistent water quality issue in the Malden River, and it is unlikely that significant stratification develops in the summer and fall months due to shallow water depths. Finally, shallow water depths make the installation of such a system problematic at best.

Figure 1 Continuous Dissolved Oxygen at the Amelia Earhart Dam, 2002

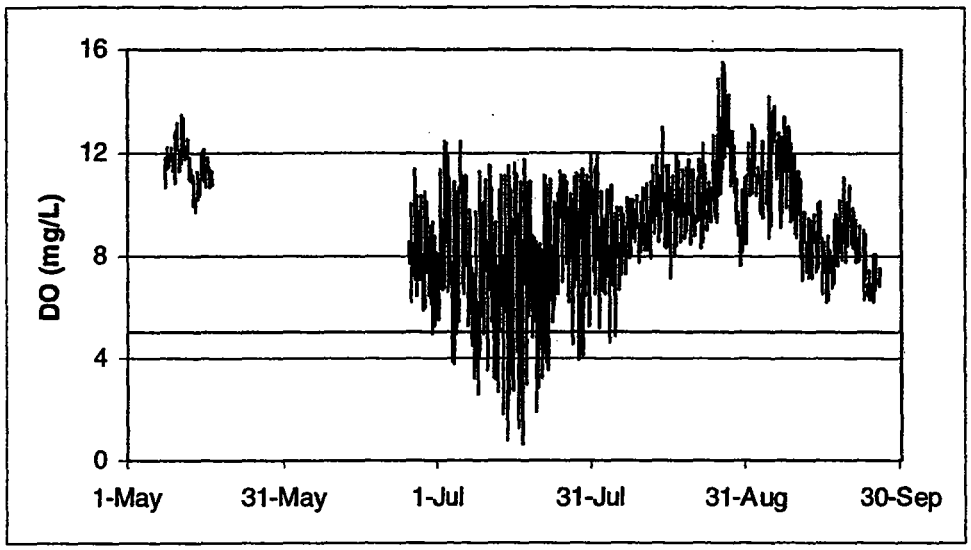


Figure 2 Continuous Dissolved Oxygen at the Amelia Earhart Dam, 2003

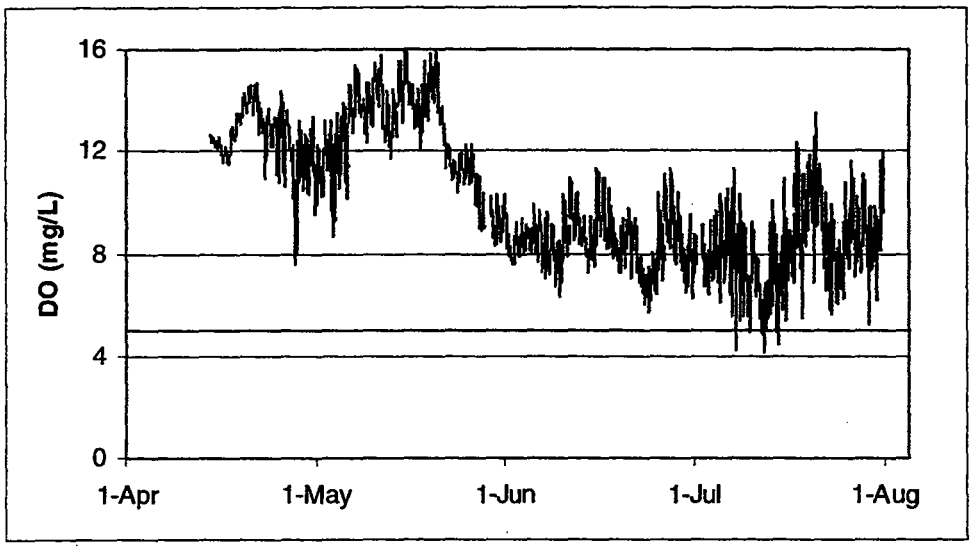
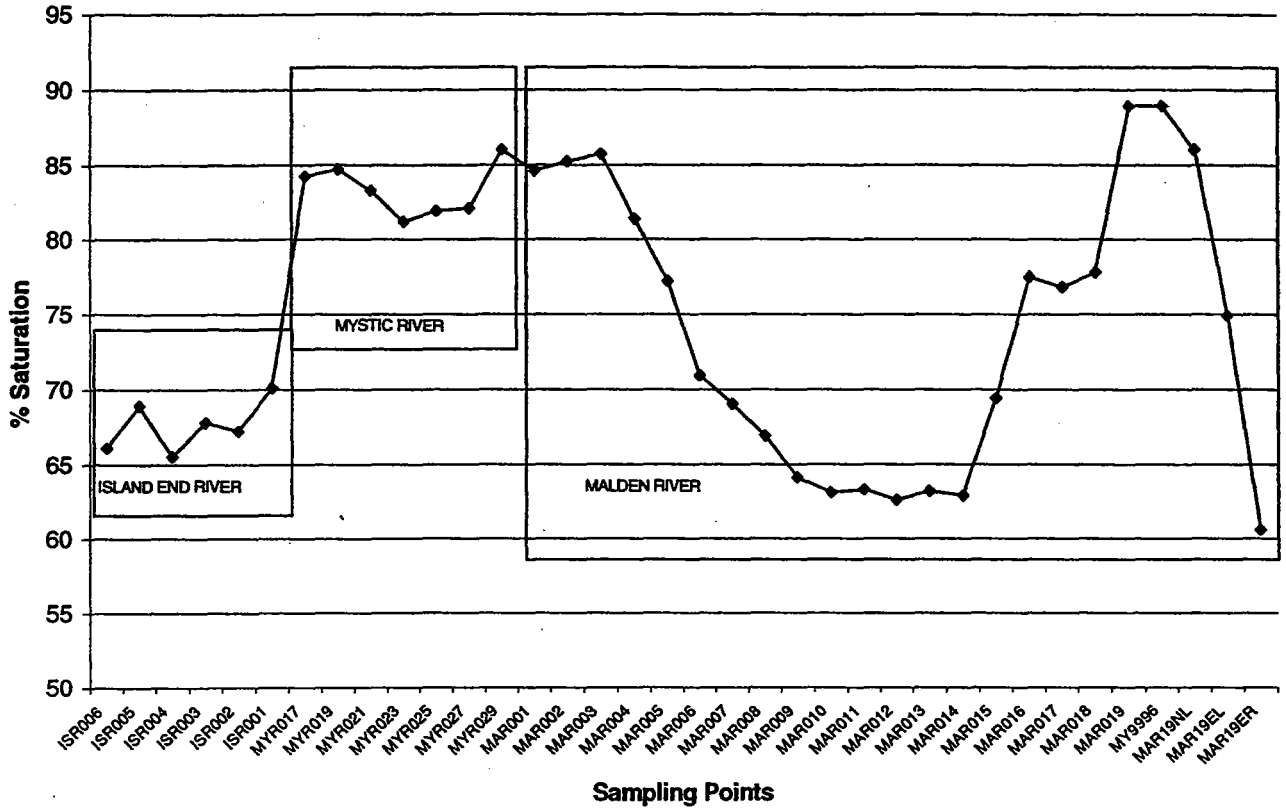


Figure 3 DO on 10/28/03



ENSR INTERNATIONAL

Memorandum

To:	Mike Tuttle, CENAE	**Date:**	January 5, 2004
From:	David F. Mitchell	**File:**	09000-328-140
RE:	Identification of Fish Passage Issues at Amelia Earhart Dam	**CC:**	Ginny Lombardo EPA/MVDC; Marcia Greenblatt, Dave Klinch, and Dave Nyman / ENSR

Dear Mike,
This memorandum is in response to your email of 1/5/04, where you indicated the need to follow-up on the fish passage component of Alternative "J" plan and, in particular, solicit input from NOAA, US F&WS & MDC. You noted that if sufficient new concerns were expressed, a meeting could be scheduled to discuss these issues.

I thought it might be useful to review the steps that ENSR has already taken or will undertake to fully address potential regulatory concerns regarding fish passage at the Amelia Earhart Dam.

- ENSR contacted Dick Quinn (U.S. Fish & Wildlife Service) in 10/03 regarding fish and wildlife habitat in the Malden River;
- ENSR contacted Brad Chase (MA Department of Marine Fisheries) on 10/31/03 to discuss the fish passage issues on the Mystic/Malden Rivers;
- ENSR visited DCR offices (formerly MDC) on 11/6/03 and met with Mike Galvin and Paul DiPetro regarding dam structural characteristics and dam operations;
- ENSR contacted Eric Hutchins (National Marine Fishery Service (NMFS)) on 1/05/04 to discuss any concerns regarding fish passage in the Malden River; and
- ENSR will contact NOAA in the next day or so to see if NOAA has concerns regarding fish passage in the Malden River.

Based on these conversations and available information regarding the Malden River, an estimate of the range of positive outcomes (i.e., benefits) will be made. Similarly, based on evaluation of the dam and existing structural characteristics, the available hydrologic gradient and flows involved, and the ecological requirements of the anadromous fish of interest (alewives, smelt), ENSR will estimate approximate potential costs for the three options:

1.) operational changes to the lock system,
2.) improvement of the existing fish passage sluice structure, and
3.) design and implementation of a new fish passage structure.

This level of cost-benefit comparison will allow evaluation of this alternative restoration plan in a comparable manner to the other 4 alternative plans.

Based on this level of input from the fisheries stakeholder agencies and the need for sufficient information for objective evaluation at the Phase I level, ENSR does not consider it necessary to convene an additional meeting to discuss these items, unless additional issues or strong stakeholder agency interests are identified.

ENSR INTERNATIONAL

Telephone Call Summary Sheet

By: Marcia Greenblatt

Talked With: Brad Chase

Of: Mass Marine Fisheries

Telephone Number: 617-727-3336 ext 111

Date: 31 October 2003

Project Number:

Project Name: Malden River

Subject: Fisheries in the Malden River

I spoke with Brad regarding the current and potential fishery in the Malden River. He was more familiar with the Mystic, and said that he has never seen much spawning habitat in the Malden, primarily due to the culverts. He said that the system is not functioning as a marine fishery due to lack of tidal exchange, and that he would be a strong supporter to opening the system up to even modest tidal exchange. He feels that the elimination of tidal exchange resulted in an ecological disaster in the Mystic River, especially for rainbow smelt. They spawn earlier in the season (when there is not much boat traffic) and at night, and so were not seen by the lock operators, and could not get up river. He said limited access, combined with loss of spawning substrate, led to the end of the rainbow smelt population in the watershed within ~3 years of the installation of the AE dam.

He said that there is a strong culture at the AE dam for the lock operators to let in the Alewives, that the are easy to see, come up during the late spring, and they are well liked, and that the lock operators due a good job passing them.

He said that the fish ladder on the AE dam was a "hopeless design" and that it was never effective at passing fish, and no longer operational.

He says there are potential spawning areas in downtown Medford (fast flowing riffles) that, with some substrate rehabilitation, would be ideal for rainbow smelt. However he is aware that this location is outside of the project area.

From his perspective (marine) there is little value in the Malden River as a fishery without tidal exchange. Even with tidal exchange, he is not sure there is any potential for spawning habitat, as the river is slow moving, and subject to too much stormwater inflow. I asked him about the possibility of habitat in the tribs, if we could perform some restoration activities there, but he wasn't optimistic that a fast moving stream could be maintained since the tribs are fed primarily by stormwater.

Signature

Distribution:	(1)	(2)	(3)
	(4)	(5)	(6)
	(7)	(8)	(9)

ENSR INTERNATIONAL

Memorandum

To:	Dave Mitchell	**Date:**	7 Nov 2003
From:	Marcia Greenblatt	**File:**	
RE:	Malden River - DCR visit	**CC:**	Mark Gerath

On Thursday afternoon, 6 Nov 2003, I went into the Boston office of DCR (formerly MDC) flood control office to gather available information on the Earhart Dam. While I was there, I chatted informally with Mike Galvin and Paul DiPietro about flows and operations in the Malden and Mystic River watershed.

I reviewed several old (1904-1965) reports discussing water quality in the Mystic River basin, and presenting studies and designs to improve water quality in the basin. Water quality has been a concern in the basin as early as the mid 1800s. Included in the reports were proposed designs for the Earhart Dam, and accompanying hydrologic studies and computer model results. I was not able to obtain the final plans for the Dam, although they do exist at the DCR, and could be obtained if necessary. I was able to ask about the Dam, and found that the final design appears to closely follow the latest design study that I reviewed.

I learned that water is pumped out of the lower pool above the dam prior to and during large storms, maybe once every 2 years.

Mike said that he gets calls from folks along Spot Pond Brook (he thinks along Pond St. in Melrose and/or Stoneham) who say that their backyards flood periodically. This was not addressed in the CDM downstream analysis of Spot Pond, and this area is not under the jurisdiction of the DCR.

Paul provided some additional information on Spot Pond as well as a copy of the MDC Mystic Lake Salt Removal Project report. He mentioned that he feels that the goals of the Malden River restoration project are not well defined, and that objectives (backed by data) should be clearly stated prior to going forward with the project. He told me that he had written the letter regarding the proposal to open up the dam to tidal flushing, and that he was of the strong opinion that this idea is not worth pursuing. He said that the lower pool, immediately above the dam, was very deep, and that small volumes of salt water that may come through the locks will settle to the bottom and not move upstream. However, if the volume of salt water was sufficient to fill this pool, salt water would then extend right up to Lower Mystic Lake due to the low gradient of the Lower Mystic River.

I copied the following pieces of reports:

- Summary and results of a modeling study predicting water levels above the dam and in Mystic Lake under various
- Summary of the proposed dam design, including lock configuration and dimensions
- Pumping operation at AE Dam during large storms in 1996, 1998 and 2001.

1. **Operational changes to the lock system**

This alternative consists of expanding the periods of operation of one or more of the locks, to provide more effective passage of fish. In particular, the operation would be modified to attain greater transfer of Atlantic rainbow smelt. This would require operating the locks not only during daytime periods (which has proved reasonably effective for alewives), but also during evening and early morning hours during the smelt migration period.

The alternative includes the following measures:

- Installation of portable or permanent lighting near the freshwater end of the lock, to employ for attracting fish into the structure during operation;
- Development of a protocol for lock operation to address the transfer of migrating fish, consistent with the prevention of excessive saltwater intrusion into the freshwater basin (locking of fish must be coordinated with tide levels lower than the freshwater basin level);
- Staffing the lock during the anticipated spring fish migration period (March, April, May). This element is assumed to require an evening and a morning shift, each of four hours, staffed by two operators.
- During the first year of modified operation, the operating cycle would be periodically monitored to assess fish capture and transfer. Based on this monitoring, the operating protocol would be modified, if necessary.

2. **Retrofit one of smaller locks to provide a fish passage structure**

This option comprises using one of the locks to develop a fish passage structure, without requiring significant modifications to other elements of the existing dam.

To accomplish this, one of the smaller locks would be discontinued as a boat transfer lock. The gates would be retained to serve as coffer dams during construction of the fishway, and for isolating the fishway for future maintenance or in case of a flood.

The interior of the lock would be redeveloped to install a Denil or steeppass type fishway. A fishway at a 10% gradient would fit easily within the lock (total estimated length of lock is 120 feet), to accomplish up to a 7-foot rise. This rise is anticipated to be sufficient to cover the range from mean low tide to normal operating level of the freshwater basin.

Installation elements include:

- A Denil or steeppass type of fishway constructed within the central part of the lock.
- A concrete baffle wall across the lock at the upstream end of the fishway, fitted with stop logs to adjust flow to the fishway.

- A concrete baffle downstream of the lower end of the fishway, fitted with a self-regulating tidegate, to automatically prevent high tide from exceeding the inlet end of the fishway, thus preventing saltwater influx to the freshwater basin.

3. **Installation of a fish bypass channel.**

This option comprises a bypass channel around the eastern end of dam, with a culvert under the access roadway. The existing lock structures would not be altered as a part of this modification. Elements of this concept include:

- A naturalized channel excavated in the earthen embankment located at the east end of the existing dam structure. The channel would transition from the normal operating pool of the freshwater basin to the vicinity of mean low water, or somewhat lower. The channel would be concave in cross section, and lined with stone placed to achieve a naturalized "pool-riffle" structure (similar in concept to a "rock ramp fishway"). This type of channel is anticipated to be passable under a wide range of flow conditions, and would be suitable for various fish species and individual sizes within species.

- An inlet structure fitted with stop logs at the inlet end of the channel, to govern flows to the channel.

- A box culvert constructed at the road crossing. The culvert would be installed with the invert submerged below the nominal channel gradient, and back-filled with natural substrate material.

- At the outlet end of the culvert, a self-regulating tide gate would be installed, to allow flows under all conditions except when the tide is higher than the freshwater basin pool elevation. The closure setting of the gate would be set based on the operating invert of the inlet structure, to prevent saltwater influx to the freshwater basin.

Conceptual Cost Estimate
Option 1: Operational Changes to the Lock System

Element	Estimated Cost	Remarks
Allowance for attraction lighting	$10,000	
Total Capital Cost	**$10,000**	
Protocol development	$30,000	Develop lock operation protocol, monitor for first year, and refine protocol
Setup Cost	**$40,000**	
Contingencies	$8,000	20% of estimated setup costs
Permitting	$0	None anticipated
Total Initial Cost	**$48,000**	
Annual Operation	**$38,000 to $40,000**	Monitor fish passage and operate lock during spring migration period of Atlantic rainbow smelt

Title	Date 01/08/04	Dwg.	Project	Proposal

OPTION 1

REUSE LOCK OPERATION TO ENABLE TRANSFER OF RAINBOW SMELT:

MONITOR FOR FISH & OPERATE LOCK -
SPRING MIGRATION:
MARCH / APRIL / MAY

SAY 90 DAYS
2 - 4 HOUR SHIFTS, 2 PEOPLE

90 x 8 x 2 = 1440 HRS.

PAY RATE + BENEFITS = $26
$20/hr. + 30%

1440 x 26 = $37,440 ANNUAL COST

SAY 38,000 - 40,000 / YEAR

SET UP PROGRAM

DEVELOP PROTOCOL
40 hrs. x 150 = $6,000

FIRST YEAR MONITORING
120 hrs. x 100 = 12,000

REVISE PROTOCOL + REPORT 6 000

$24,000 + EXPENSES

SAY 30,000

CAPITAL COSTS:
ATTRACTION LIGHTS - SAY $10,000

FORM 1052

Conceptual Cost Estimate
Option 2: Retrofit One of Smaller Locks to Provide a Fish Passage Structure

Element	Estimated Cost	Remarks
Internal structural modifications of lock	$70,000	Concrete baffles, piers, alterations to inlet openings, to prepare lock for fishway installation
Fishway structure	$77,000	Assumes Steeppass type fishway. Alternative Denil fishway could double this cost.
Self-regulating tidegate	$100,000	
Total Capital Cost	**$247,000**	
Engineering/survey	$63,000	
Setup Cost	**$310,000**	
Contingencies	$62,000	20% of estimated setup costs
Permitting	$25,000	
Total Initial Cost	**$397,000**	
Annual Operation	**$25,000**	Allowance for routine maintenance and repairs

Title	Date	Dwg.	Project	Proposal
	01/08/04			

OPTION 2
RETROFIT LOCK

INTERNAL STRUCTURAL MODIFICATIONS

CONCRETE BAFFLES TO
ISOLATE FISHWAY COMPARTMENT
2 @ 12,000 $24,000
MISC SUPPORT ITEMS, ETC 12,000
MODIFY INLET PORTS AND OTHER
MISC. MODIFICATIONS 30,000

$ 66,000
SAY $ 70,000

STEEPPASS FISHWAY
URI WEBSITE: 10000/FT.
UPDATE FROM 2001 TO 2003 (ENR INDEX)
$10000 \times \frac{6782}{6281} \approx 10800$ /ft.
SAY 11000/ft x 7 $ 77,000

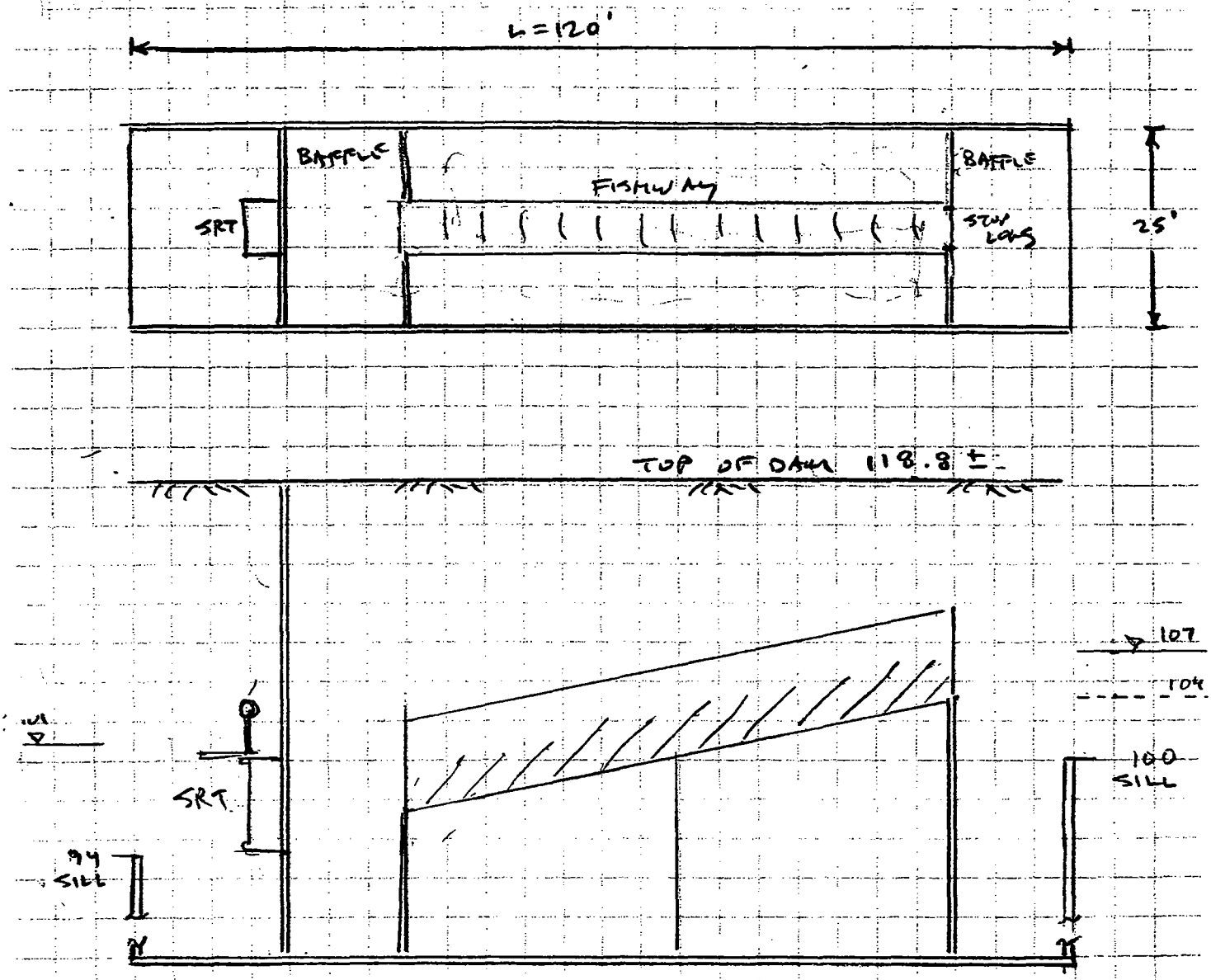
SELF REGULATING TIDEGATE

PER WATERMAN REP. -
6 x 6 ≈ $75,000 TO $80,000
ADD FOR INSTALLATION 20000

$ 100,000 $ 100,000
247,000
ADD FOR ENGINEERING @ 25% ± 63,000
+ SURVEY
310,000

FORM 1052

Title	Date	Dwg.	Project	Proposal



101 = "AVERAGE" LOW TIDE (MEAN LOW ?) 107 = "NORMAL" BASIN LEVEL (?)
104 = STORM PREP LEVEL (?)

SMALL LOCK CONFIGURATION ESTIMATED FROM
CE MAGUIRE ASSOC. REPORT 1962

FORM 1052

Conceptual Cost Estimate
Option 3: Installation of a Fish Bypass Channel

Element	Estimated Cost	Remarks
Channel excavation and lining	$200,000	Does not include disposal costs of contaminated soil material, if required.
Inlet control structure	$60,000	
Box culvert and headwalls	$60,000	
Self-regulating tidegate	$100,000	
Pavement repair and site restoration	$25,000	Includes riparian plantings along channel
Total Capital Cost	**$445,000**	
Engineering/survey/ geotechnical	$130,000	
Setup Cost	**$575,000**	
Contingencies	$115,000	20% of estimated setup costs
Permitting	$50,000	
Total Initial Cost	**$740,000**	
Annual Operation	**$25,000**	Allowance for routine maintenance and repairs

Title	Date 01/08/04	Dwg.	Project	Proposal

OPTION 3

BYPASS CHANNEL

CHANNEL EXCAV. & LINING
2 SECTIONS @ ~150 FT.
EXCAV. + STONE PLACEMENT $ 200,000

CULVERT
8x8 BOX 36 000
HEADWALLS 20 000
56 00
SAY 60,000 60,000

INLET CONTROL STRUCTURE AT
UPSTREAM END OF CHANNEL -
ASSUME EQUIV. IN SCOPE
TO CULVERT INSTALLATION 60,000

SELF REGULATING TIDE GATE
SIMILAR TO OPTION 2 100,000

SITE RESTORATION -
PAVEMENT - 5000
PLANTINGS - 20 000
25 000 25,000

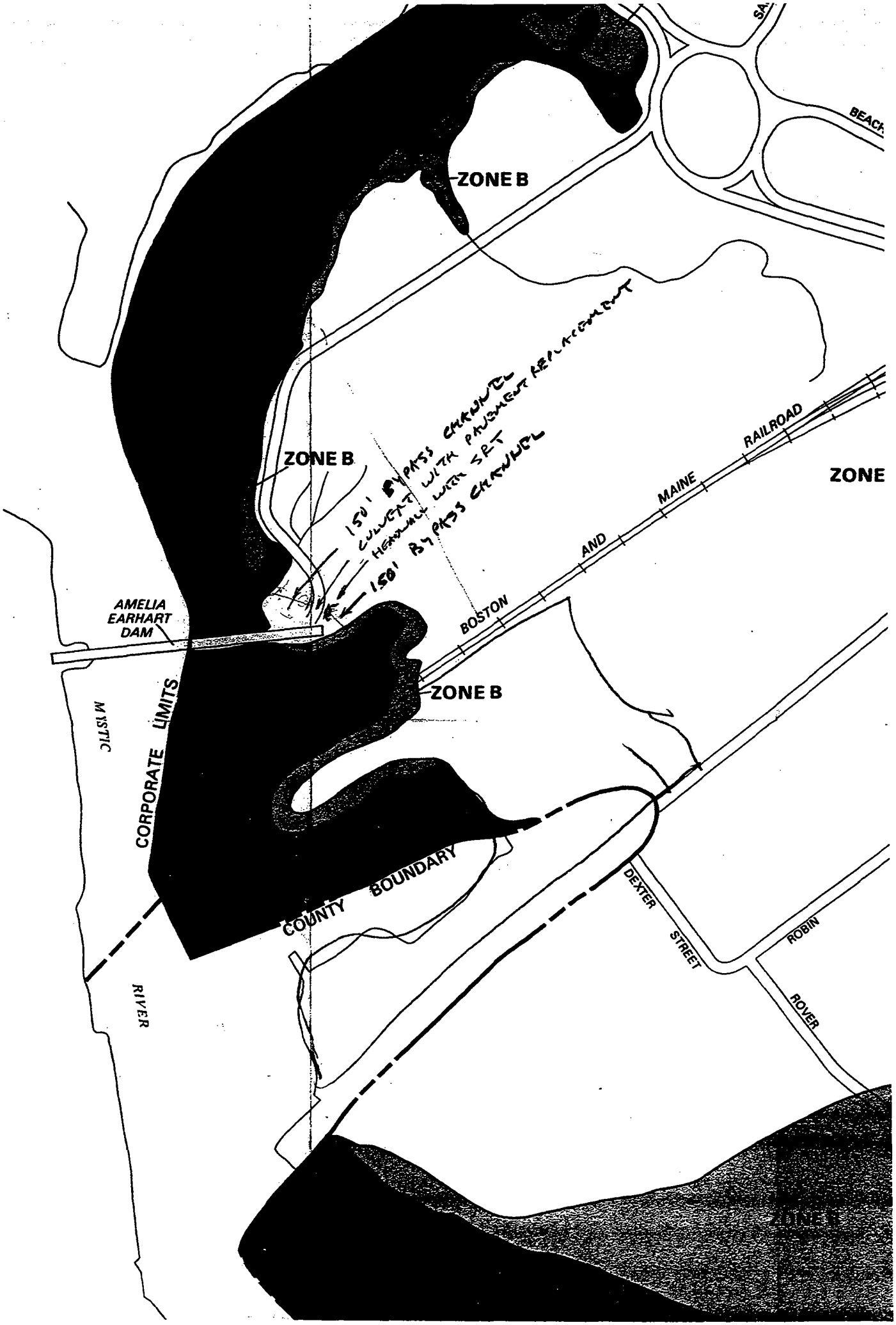
CAPITAL COSTS 445,000

ENGINEERING/SURVEY
25% = 112 000
GEOTECH = 15000
127,000
SAY 130,000 130,000

$ 575 000

+ CONTINGENCIES + PERMITTING

FORM 1052


ZONE B
ZONE B
ZONE B
ZONE
1501 BYPASS CHANNEL
CULVERT WITH PAVEMENT REPLACEMENT
HEADWALL WITH SPT
1501 BYPASS CHANNEL
AMELIA EARHART DAM
BOSTON AND MAINE RAILROAD
CORPORATE LIMITS
MYSTIC
COUNTY BOUNDARY
RIVER
DEXTER STREET
ROBIN
ROVER

Title	Date	Dwg.	Project	Proposal

COST DATA FROM:

MEANS SITEWORK 2000

URI WEBSITE:
www.edc.uri.edu/restoration/html/tech_sci/socio/cost.htm

ENGINEERING NEWS RECORD (ENR) COST INDEX
www.enr.com

X-rates.com (HISTORIC EXCHANGE RATES - CANADA: U.S.)

KATOPODIS, C. 1992. INTRODUCTION TO FISHWAY DESIGN. Department of Fisheries and Oceans, Winnipeg, Manitoba.

WATERMAN INDUSTRIES SRT:
MIKE BRILLON
TECHNOLOGY SALES ASSOC.
PLAINVILLE, MA
508 · 695 · 6070 EXT 16 brillontsai@aol.com

FORM 1052

APPENDIX ~~D~~ F DOCUMENTS

The following information is provided in Appendix ~~D~~ F:

1.) A *Data Needs* worksheet used to summarize the existing information about the river sediments and to indicate potential data gaps for both Phase I and Phase II tasks.

2.) Summary tables of available sediment data in the Malden River. This information is organized by and presented in the following manner – river segment, sediment depth, and physical and chemical parameters.

River Segments (going from upstream to downstream):

- *Upper River* refers to sediments located in the river segment from the upstream culverts to approximately 100 ft north of the Medford Street Bridge,
- *Upper Section* of the Study Area refers to sediments located in Area 1, which includes an area approximately 100 ft upstream of the Medford St. Bridge to the Revere Beach Parkway (Route 16) bridge; and
- *Lower River* refers to sediments located in the river downstream of the Route 16 Bridge.

Sediment Depth – sediments are divided between surface sediments (i.e., 0 – 2 ft sediment depth) and sub-surface sediments (i.e., > 2 ft sediment depth).

Parameters – data is provided about the following classes of chemicals

- General parameters - including physical and non-toxic chemical parameters (for surface sediments only;
- Semi-volatile organic compounds (SVOCs) including PAHs, dioxins, and PCBs;
- Volatile organic compounds (VOCs); and
- Metals.

3.) Two profiles of Malden River main channel sediment composition; taken from two larger reports (Haley and Aldrich, 2001; and NCA, 2003a)

Data Needs
TeleComCity Area

General Information

1. **Current and Proposed Uses – Navigation? Recreational Boating? Swimming? Fishing?** *Impacts dredging and capping options*

2. **Water Uses** *Impacts Dredging and Capping Options*

- **Location and description of any potable water intakes –**
- **Location and description of any industrial water intakes –**

Drinking and industrial water are provided by public water supply and there are no private wells in the vicinity of the site (TRC Study, page 3, Volume 1).

- **Location and Description of Discharge points (stormwater, industrial, sewer)**
- **Flood Control/storage (flood insurance and other studies)**

Amelia Earhart Dam?

3. **Nearby Land Use (within ½ mile)** *Primarily impacts ex-situ treatment/transport/disposal options*

- **Industrial**
- **Commercial**
- **Residential**
- **Schools/Daycare Centers**
- **Hospitals**

All the above info should be available through existing reports, aerial photos, or town records

Equipment Access and Staging Areas –TeleComCity Area

1. **Potential access points for barges and dredging equipment (include possible water route from Boston Harbor through the dam)**

2. **Potential Upland Areas for Sediment Drying and Stockpiling**

3. **Potential Upland Areas for Loading Sediment for Off-site Disposal**

4. Property Ownership/Access Issues

From Aerial photos, maps, site visit

Bathymetry/General River Information – TeleComCity Area

1. Depths (general description and cross sections, USGS&flood insurance)
Profile of the Telecom City was done by Nangle Consulting Associates in 2000 (Volume 3).

2. Width (general description and cross sections, USGS& flood insurance)
Little Creek: 50' narrows to 15' 300' downstream and opens to 50' at confluence with Malden River (Wetlands & Wildlife, Inc, page 5, Volume2).

3. Wave Height (estimate)
Flood control structures on the mystic river eliminated the tidal nature of the Malden river and inflow of brackish water (TRC study, page 3, Volume 1).

4. Seasonal Conditions (variations in water height, flooding, icing conditions)

5. Presence of Obstacles – *Geophysical Survey?*

Bridges

Large Debris

Sunken Ships

Large Stones

Footings for existing or abandonded structures

Utilities

Piers

6. Depositional Rate

7. Depth of Mixing Layer

8. Water Temperature Profile

9. Dam Operation

Potential Continuing Sources of Contamination – TeleComCity Area

1. List Know Release Sites Along the River (contaminants, soil?, groundwater? Known release to River? NAPL?)

2 spills reported by Wehran Engineering, page14, Volume 1:

General Electric, 1987, <1 quart of Transformer oil

Massachusetts Electric Co., 1984, 10 gallons of Transformer oil.

Numerous spills in mystic River reported.

2. Visible Seeps into River

3. Groundwater Data Along River Banks

On DPW and Wellington Realty property, soil permeabilities ranged from $7.12X10^{-4}$ cm/sec and $2.6x10^{-3}$ cm/sec. Darcien flow velocities were 0.10 feet/day toward the Malden River and 0.28 feet/day toward the Little Creek (TRC study, page 16, Volume 1).

Compounds found on the Wellington property are characteristically coal tars (hydrocarbons); the Lombard property contains solvents; pockets of fuel and waste oil; other areas along the river are known to be contaminated (TRC study, pages20-25, Volume1).

4. Outfalls

9 stormwater and combined sewer overflow discharges (Wehran Engineering study, table 5, Volume 1)

3 NPDES permits issued on the Malden as of 1986 (Wehran Engineering study, table 9, Volume 1)

5. Tributaries

Little Creek (the results of one sediment sample can be found in the TRC study, page 23, Volume 1)

Another small stream appears to originate at a culvert west of the Boston &Maine Railroad, it starts as 5' wide and opens to 50' wide. (Wetlands & Wildlife Inc, page 6, Volume2)

GENERAL PARAMETERS – Upper River

Surface Sediments (0-2 feet)

Parameter	Sample Ids	# Samples	Range	Average	Hotspots
Descriptions					
Particle Size					
Bulk Density					
Bearing Strength					
Liquid Limits					
Plastic Limits					
Total Organic Carbon	USGS9	1		2.28%	
Chemical Oxygen Demand					
Biological Oxygen Demand					
Moisture Content					
PH					
Redox Potential					
Nutrients C N P					
Microbial Plate Count					

GENERAL PARAMETERS – Upper River

Subsurface Sediments (2 feet and deeper)

Parameter	Sample Ids	# Samples	Range	Average	Hotspots
Descriptions					
Particle Size					
Bulk Density					
Bearing Strength					
Liquid Limits					
Plastic Limits					
Total Organic Carbon					
Biological Oxygen Demand					
Chemical Oxygen Demand					
Moisture Content					
PH					
Redox Potential					
Nutrients C N P					
Microbial Plate Count					

CHEMICAL PARAMETERS
Upper Section

Surface Sediments (0-2 foot) Semivolatile Organics, Dioxins, And PCBs

In mg/kg – parts per million

Parameter	Level of Interest	Sample Ids	# Samples	Range	Average	Hotspots?
TPAHs						
CPAH						
LPAH	370					
HPAH	960					
LNAPL	Any (sheen)					
DNAPL Observed or potential	Any observed or >1000 ppm COI					
Naphthalene	99	USGS9 HASED-4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21	1 40	0-0 ND-170000 ug/Kg	0 22140 ug/Kg	
Acenaphthylene	66	USGS9 HASED-4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21	1 57	0-0 ND-13000 ug/Kg	0 1927 ug/Kg	
Acenaphthene	16	USGS9 HASED-4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21	1 58	0-0 ND-82000 ug/Kg	0 6519 ug/Kg	
Fluorene	23	USGS9 HASED-4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21	1 58	0-0 ND-53000 ug/Kg	0 5410 ug/Kg	
Phenanthrene	100	USGS9	1		1050ppb	
Anthracene	220	USGS9 HASED-	1		1050ppb	

		4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21	58	ND-58000 ug/Kg	7123 ug/Kg	
2-Methylnaphthalene	38	HASED-4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21	58	ND-110000 ug/Kg	8866 ug/Kg	
Fluoranthene	160	USGS9 HASED-4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21	1 58	ND-83000 ug/Kg	21509ppb 19688 ug/Kg	
Pyrene	1,000	USGS9	1		19608ppb	
Benz(a)anthracene	110	USGS9	1		9300ppb	
Chrysene	110	USGS9 HASED-4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21	1 58	ND-36000 ug/Kg	9287ppb 8595 ug/Kg	
Tbenzofluoranthenes	230					
Benzo(a)pyrene	99	USGS9 HASED-4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21	1 58	ND-48000 ug/Kg	11130ppb 9463 ug/Kg	
Indeno(1,2,3-c,d)pyrene	34	USGS9 HASED-4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21	1 58	ND-15000 ug/Kg	0 1926 ug/Kg	
Dibenzo(g,h,I)perylene	12					
Benzo(g,h,I)perylene	31	USGS9 HASED-4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21	1 57	ND-13000 ug/Kg	0 1434.7 ug/Kg	
1,2-Dichlorobe	2.3	SED-1,2,3,3A,4,4	9	ND		

nzene		D,5,5D,6				
1,4-Dichlorobenzene	3.1	SED-1,2,3,3A,4,4D,5,5D,6	9	ND-16 ug/Kg	1.8 ug/Kg	
1,2,4-Trichlorobenzene	.81					
Hexachlorobenzene	.38					
Dimethyl phthalate	53					
Diethyl phthalate	61					
Di-n-butyl phthalate	220					
Butyl benzyl phthalate	4.9					
Bis(2-ethylhexyl) phthalate	47	HASED-4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21	58	ND-170000 ug/Kg	12069 ug/Kg	
Di-n-octyl phthalate	58					
Dibenzofuran	15					
Hexchlorobutadiene	3.90					
N-Nitrosodiphenylamine	11					
Phenol	420					
2-Methylphenol	63					
4-Methylphenol	670					
2,4-Dimethyl Phenol	29					
PentaChlo	360					

rophenol						
Benzyl Alcohol	57					
Benzoic Acid	650					
Total PCBs	2					
Pesticides	0.5					
Total Dioxins	0.5					
DDD		USGS9	1		0ppb	
Methoxychlor		USGS9	1		0ppb	
Benzo(b) fluoranth		USGS9 HASED-4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21	1 57	ND-39000 ug/Kg	9343 ppb 10906 ug/Kg	
Dibenz(a,h) anthracene		USGS9	1		0 ppb	
Benzo(k) fluoranth		USGS9 HASED-4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21	1 59	ND-12000 ug/Kg	9300 ppb 3061 ug/Kg	
Benzo (a) anthracene		HASED-4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21	58	ND-46000 ug/Kg	9115 ug/Kg	
Isophorone		HASED-4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21	58	ND-6200 ug/Kg	963 ug/Kg	

CHEMICAL PARAMETERS
Upper Section

Surface Sediments (0-2 foot) Volatile Organic Compounds
In mg/kg – parts per million

Parameter	Level of Interest	Sample Ids	# Samples	Range	Average	Hotspots?
TVOC	5					
TCVOC	1					
Screen PID						
Trichloroethene						
Tetrachloroethene						
1,1,1 Trichloroethane						
Vinyl Chloride						
1,1 Dichloroethane		SED-1,2,3,3A,4,4D,5,5D,6	9	ND		
Cis 1,2 dichloroethene	Cis and trans combined	SED-1,2,3,3A,4,4D,5,5D,6	9	ND		
Trans 1,2 dichloroethene						
1,1 Dichloroethene		SED-1,2,3,3A,4,4D,5,5D,6	9	ND		
1,2 Dichloroethane		SED-1,2,3,3A,4,4D,5,5D,6	9	ND		
Benzene		SED-1,2,3,3A,4,4D,5,5D,6 HASED-4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21	9 40	ND ND-23000 ug/Kg	948 ug/Kg	
Ethylbenze		SED-	9	ND-13	1.4 ug/Kg	

ne		1,2,3,3A,4,4D,5,5D,6		ug/Kg		
Toluene						
Total Xylenes						
Bromomethane		SED-1,2,3,3A,4,4D,5,5D,6	9	ND		
Carbon Tetrachloride		SED-1,2,3,3A,4,4D,5,5D,6	9	ND		
Bromoform		SED-1,2,3,3A,4,4D,5,5D,6	9	ND		
Chloroethane		SED-1,2,3,3A,4,4D,5,5D,6	9	ND		
Chlorobenzene		SED-1,2,3,3A,4,4D,5,5D,6	9	ND-15ug/Kg	1.7ug/Kg	
Bromodichloromethane		SED-1,2,3,3A,4,4D,5,5D,6	9	ND		
1,2,4-Trimethylbenzene		HASED-4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21	40	ND-3600 ug/Kg	310.8 ug/Kg	

SED1-6 is from TRC study, 1997, Volume 3.

The following chemicals were all no detects (ND) for the TRC samples: 2-Chloroethylvinyl ether, Chloroform, Chloromethane, Dibromochloromethane, 1,3-Dichlorobenzene, 1,2-Dichloropropane, cis-1,3-Dichloropropene, trans-1,3-dichloropropene, Methylene chloride.

HASED- samples are from the Haley & Aldrich, Inc. study located in Volume 3. The HASED-samples are sediment samples, so some of the same numbered have multiple samples (different depths).

CHEMICAL PARAMETERS

Upper Section

Surface Sediments (0-2 foot) Metals

In mg/kg – parts per million

Parameter	Level of Interest	Sample Ids	# Samples	Range	Average	Hotspots?
Arsenic	10	USGS9	1		5 ppm	
Cadmium	1	USGS9	1		1 ppm	
Chromium	100					
Lead	200	USGS9	1		205 ppm	
Nickel	100	USGS9	1		16 ppm	
Mercury (total)	1					
Mercury (organic)	1					
Silver	1	USGS9	1		0.4 ppm	
Barium	20	USGS9	1		48 ppm	
Copper	100	USGS9	1		50.2 ppm	
Zinc	100	USGS9	1		192 ppm	
Selenium	20					
Be		USGS9	1		20.5 ppm	
Na		USGS9	1		0.04%	
Mg		USGS9	1		0.21%	
Al		USGS9	1		0.43%	
P		USGS9	1		0.04%	
K		USGS9	1		0.09%	
Ca		USGS9	1		0.18%	
Sc		USGS9	1		1.2ppm	
Ti		USGS9	1		0.03%	
V		USGS9	1		24ppm	
Mn		USGS9	1		148 ppm	
Fe		USGS9	1		1.36%	
Co		USGS9	1		5 ppm	
Sr		USGS9	1		12.4 ppm	
Y		USGS9	1		4.4 ppm	
Zr		USGS9	1		3 ppm	
Mo		USGS9	1		1 ppm	
Sn		USGS9	1		<10	
Sb		USGS9	1		<5	
La		USGS9	1		8.6 ppm	

W		USGS9	1		<10 ppm	
Bi		USGS9	1		<5 ppm	
Li		USGS9	1		8 ppm	

CHEMICAL PARAMETERS
Upper Section

Subsurface Sediments (>2 foot) Semivolatile Organics, Dioxins, And PCBs

In mg/kg – parts per million

Parameter	Level of Interest	Sample Ids	# Samples	Range	Average	Hotspots?
TPAHs						
CPAH						
LPAH	370					
HPAH	960					
LNAPL	Any (sheen)					
DNAPL Observed or potential	Any observed or >1000 ppm COI					
Naphthalene	99	HASED-4,5,6,7,8,9,10,12,13,14,15,17,19,20	14	ND-1100000 ug/Kg	212262 ug/Kg	
Acenaphthylene	66	HASED-4,5,6,7,8,9,10,12,13,14,15,17,19,20	18	ND-33000 ug/Kg	2744 ug/Kg	
Acenaphthene	16	HASED-4,5,6,7,8,9,10,12,13,14,15,17,19,20	18	ND-630000 ug/Kg	75355 ug/Kg	
Fluorene	23	HASED-4,5,6,7,8,9,10,12,13,14,15,17,19,20	18	ND-300000 ug/Kg	39617 ug/Kg	HASED-4, HASED-9
Phenanthrene	100					
Anthracene	220	HASED-4,5,6,7,8,9,10,12,13,	17	ND-380000 ug/Kg	46858 ug/Kg	HASED-4

		14,15,17,19,20				
2-Methylnaphthalene	38	HASED-4,5,6,7,8,9,10,12,13,14,15,17,19,20	18	ND-700000 ug/Kg	129111 ug/Kg	
Fluoranthene	160	HASED-4,5,6,7,8,9,10,12,13,14,15,17,19,20	17	ND-380000 ug/Kg	54622 ug/Kg	
Pyrene	1,000					
Benz(a)anthracene	110					
Chrysene	110	HASED-4,5,6,7,8,9,10,12,13,14,15,17,19,20	18	ND-150000 ug/Kg	17789 ug/Kg	
Tbenzofluoranthenes	230					
Benzo(a)pyrene	99	HASED-4,5,6,7,8,9,10,12,13,14,15,17,19,20	18	ND-180000 ug/Kg	17111 ug/Kg	
Indeno(1,2,3-c,d)pyrene	34	HASED-4,5,6,7,8,9,10,12,13,14,15,17,19,20	18	ND-80000 ug/Kg	5617	HASED-4
Dibenzo(g,h,I)perylene	12					
Benzo(g,h,I)perylene	31	HASED-4,5,6,7,8,9,10,12,13,14,15,17,19,20	18	ND-99000 ug/Kg	6289 ug/Kg	HASED-4
1,2-Dichlorobenzene	2.3					
1,4-	3.1					

Dichlorobenzene						
1,2,4-Trichlorobenzene	.81					
Hexachlorobenzene	.38					
Dimethyl phthalate	53					
Diethyl phthalate	61					
Di-n-butyl phthalate	220					
Butyl benzyl phthalate	4.9					
Bis(2-ethylhexyl) phthalate	47	HASED-4,5,6,7,8,9,10,12,13,14,15,17,19,20	18	ND-1200000 ug/Kg	104268 ug/Kg	HASED-4
Di-n-octyl phthalate	58					
Dibenzofuran	15					
Hexchlorobutadiene	3.90					
N-Nitrosodiphenylamine	11					
Phenol	420					
2-Methylphenol	63					
4-Methylphenol	670					
2,4-Dimethyl Phenol	29					
PentaChlorophenol	360					
Benzyl	57					

Alcohol						
Benzoic Acid	650					
Total PCBs	2					
Pesticides	0.5					
Total Dioxins	0.5					
Benzo (a) anthracene		HASED-4,5,6,7,8,9,10,12,13,14,15,17,19,20	18	ND-180000 ug/Kg	20527 ug/Kg	
Benzo (b) fluoranthene		HASED-4,5,6,7,8,9,10,12,13,14,15,17,19,20	18	ND-140000 ug/Kg	15311 ug/Kg	HASED-4
Benzo(k) fluoranthene		HASED-4,5,6,7,8,9,10,12,13,14,15,17,19,20	18	ND-7000 ug/Kg	961 ug/Kg	
Isophorone		HASED-4,5,6,7,8,9,10,12,13,14,15,17,19,20	18	ND-73000 ug/Kg	4805 ug/Kg	HASED-4

CHEMICAL PARAMETERS
Upper Section

Subsurface Sediments (>2 foot) Volatile Organic Compounds

In mg/kg – parts per million

Parameter	Level of Interest	Sample Ids	# Samples	Range	Average	Hotspots?
TVOC	5					
TCVOC	1					
Screen PID						
Trichloroethene						
Tetrachloroethene						
1,1,1 Trichloroethane						
Vinyl Chloride						
1,1 Dichloroethane						
Cis 1,2 dichloroethene						
Trans 1,2 dichloroethene						
1,1 Dichloroethene						
1,2 Dichloroethane						
Benzene		HASED-4,5,6,7,8,9,10,12,13,14,15,17,19,20	15	ND-120000 ug/Kg	12632 ug/Kg	
Ethylbenzene						

Toluene						
Total Xylenes						
1,2,4-Trimethylbenzene		HASED-4,5,6,7,8,9,10,12,13,14,15,17,19,20	16	ND-67000 ug/Kg	4256 ug/Kg	

CHEMICAL PARAMETERS
Upper Section

Subsurface Sediments (>2 foot) Metals

In mg/kg – parts per million

Parameter	Level of Interest	Sample Ids	# Samples	Range	Average	Hotspots?
Arsenic	10					
Cadmium	1					
Chromium	100					
Lead	200					
Nickel	100					
Mercury (total)	1					
Mercury (organic)	1					
Silver	1					
Barium	20					
Copper	100					
Zinc	100					
Selenium	20					
Be						
Na						
Mg						
Al						
P						
K						
Ca						
Sc						
Ti						
V						
Mn						
Fe						

Co						
Sr						
Y						
Zr						
Mo						
Sn						
Sb						
La						
W						
Bi						
Li						

GENERAL PARAMETERS – Lower River

Surface Sediments (0-2 feet)

Parameter	Sample Ids	# Samples	Range	Average	Hotspots
Descriptions					
Particle Size					
Bulk Density					
Bearing Strength					
Liquid Limits					
Plastic Limits					
Total Organic Carbon	USGS36,41, 46,47	4	4.17-4.98%	4.575%	
Chemical Oxygen Demand					
Biological Oxygen Demand					
Moisture Content					
PH					
Redox Potential					
Nutrients C N P					
Microbial Plate Count					

GENERAL PARAMETERS – Lower River

Subsurface Sediments (2 feet and deeper)

Parameter	Sample Ids	# Samples	Range	Average	Hotspots
Descriptions					
Particle Size					
Bulk Density					
Bearing Strength					
Liquid Limits					
Plastic Limits					
Total Organic Carbon					
Biological Oxygen Demand					
Chemical Oxygen Demand					
Moisture Content					
PH					
Redox Potential					
Nutrients C N P					
Microbial Plate Count					

CHEMICAL PARAMETERS
Lower River

Surface Sediments (0-2 foot) Semivolatile Organics, Dioxins, And PCBs

In mg/kg – parts per million

Parameter	Level of Interest	Sample Ids	# Samples	Range	Average	Hotspots?
TPAHs						
CPAH						
LPAH	370					
HPAH	960					
LNAPL	Any (sheen)					
DNAPL Observed or potential	Any observed or >1000 ppm COI					
Naphthalene	99	USGS36,41, 46,47	4	0-2672ppb	668ppb	
Acenaphthylene	66	USGS36,41, 46,47	4	0-0ppb	0ppb	
Acenaphthene	16	USGS36,41, 46,47	4	0-0ppb	0ppb	
Fluorene	23	USGS36,41, 46,47	4	0-0ppb	0ppb	
Phenanthrene	100	USGS36,41, 46,47	4	0-3890ppb	1094.25 ppb	
Anthracene	220	USGS36,41, 46,47	4	0-3900ppb	1100ppb	
2-Methylnaphthalene	38					
Fluoranthene	160	USGS36,41, 46,47	4	0-6882ppb	2501ppb	
Pyrene	1,000	USGS36,41, 46,47	4	0-13334ppb	6292.25 ppb	
Benz(a)anthracene	110	USGS36,41, 46,47	4	0-10207ppb	5173.5ppb	
Chrysene	110	USGS36,41, 46,47	4	0-10180ppb	5141.25 ppb	
Tbenzofluoranthenes	230					

Benzo(a)pyrene	99	USGS36,41, 46,47	4	0-21064ppb	9301ppb	
Indeno(1,2,3-c,d)pyrene	34	USGS36,41, 46,47	4	0-6636ppb	2301.5ppb	
Dibenzo(g,h,l)perylene	12					
Benzo(g,h,l)perylene	31	USGS36,41, 46,47	4	0-5852ppb	2678.75 ppb	
1,2-Dichlorobenzene	2.3					
1,4-Dichlorobenzene	3.1					
1,2,4-Trichlorobenzene	.81					
Hexachlorobenzene	.38					
Dimethyl phthalate	53					
Diethyl phthalate	61					
Di-n-butyl phthalate	220					
Butyl benzyl phthalate	4.9					
Bis(2-ethylhexyl) phthalate	47					
Di-n-octyl phthalate	58					
Dibenzofuran	15					
Hexchlorobutadiene	3.90					
N-Nitrosodiphenylamine	11					
Phenol	420					

2-Methylphenol	63					
4-Methylphenol	670					
2,4-Dimethyl Phenol	29					
PentaChlorophenol	360					
Benzyl Alcohol	57					
Benzoic Acid	650					
Total PCBs	2					
Pesticides	0.5					
Total Dioxins	0.5					
DDD		USGS36,41, 46,47	4	0-0ppb	0ppb	
Methoxychlor		USGS36,41, 46,47	4	0-0ppb	0ppb	
Benzo(b)fluoranth		USGS36,41, 46,47	4	0-10934ppb	6157.5ppb	
Benzo(k)fluoranth		USGS36,41, 46,47	4	0-10900ppb	6200ppb	
Dibenz(a,h)anthracene		USGS36,41, 46,47	4	0-0ppb	0ppb	

CHEMICAL PARAMETERS
Lower River

Surface Sediments (0-2 foot) Volatile Organic Compounds

In mg/kg – parts per million

Parameter	Level of Interest	Sample Ids	# Samples	Range	Average	Hotspots?
TVOC	5					
TCVOC	1					
Screen PID						
Trichloroethene						
Tetrachloroethene						
1,1,1 Trichloroethane						
Vinyl Chloride						
1,1 Dichloroethane						
Cis 1,2 dichloroethene						
Trans 1,2 dichloroethene						
1,1 Dichloroethene						
1,2 Dichloroethane						
Benzene						
Ethylbenzene						
Toluene						
Total Xylenes						

CHEMICAL PARAMETERS
Lower River

Surface Sediments (0-2 foot) Metals

In mg/kg – parts per million

Parameter	Level of Interest	Sample Ids	# Samples	Range	Average	Hotspots?
Arsenic	10	USGS36;41; 46;47	4	14-28ppm	19.5ppm	
Cadmium	1	USGS36;41; 46;47	4	2-4ppm	3ppm	
Chromium	100					
Lead	200	USGS36;41; 46;47	4	169-319ppm	260.75ppm	
Nickel	100	USGS36;41; 46;47	4	28-43ppm	36.25ppm	
Mercury (total)	1					
Mercury (organic)	1					
Silver	1	USGS36;41; 46;47	4	0.7-1.5ppm	1.02ppm	
Barium	20	USGS36;41; 46;47	4	58-96ppm	81.75ppm	
Copper	100	USGS36;41; 46;47	4	112-176ppm	149.75ppm	
Zinc	100	USGS36;41; 46;47	4	498-815ppm	692.5ppm	
Selenium	20					
Be		USGS36;41; 46;47	4	.5-.9ppm	0.7ppm	
Na		USGS36;41; 46;47	4	.09-.16%	0.1175%	
Mg		USGS36;41; 46;47	4	.43-.54%	0.4925%	
Al		USGS36;41; 46;47	4	1.07-1.75%	1.3275%	
P		USGS36;41; 46;47	4	.1-.23%	0.145%	
K		USGS36;41; 46;47	4	.2-.27%	0.24%	
Ca		USGS36;41; 46;47	4	.35-.44%	0.3825%	
Sc		USGS36;41; 46;47	4	2-2.8ppm	2.4ppm	

Ti		USGS36;41; 46;47	4	.05-.05%	0.05%	
V		USGS36;41; 46;47	4	49-75ppm	64ppm	
Mn		USGS36;41; 46;47	4	235-302ppm	274.25ppm	
Fe		USGS36;41; 46;47	4	2.71-3.85%	3.355%	
Co		USGS36;41; 46;47	4	12-15ppm	13.5ppm	
Sr		USGS36;41; 46;47	4	28.3-40.6ppm	34.25ppm	
Y		USGS36;41; 46;47	4	7.8-10.6ppm	9.275ppm	
Zr		USGS36;41; 46;47	4	5.2-6.9%	6.125ppm	
Mo		USGS36;41; 46;47	4	2-3ppm	2.25ppm	
Sn		USGS36;41; 46;47	4	12-37ppm	23.5ppm	
Sb		USGS36;41; 46;47	4	<5ppm	<5ppm	
La		USGS36;41; 46;47	4	12.1-14.7ppm	13.425ppm	
W		USGS36;41; 46;47	4	<10ppm	<10ppm	
Bi		USGS36;41; 46;47	4	<5ppm	<5ppm	
Li		USGS36;41; 46;47	4	23-32ppm	26.5ppm	

CHEMICAL PARAMETERS
Lower River

Subsurface Sediments (>2 foot) Semivolatile Organics, Dioxins, And PCBs

In mg/kg – parts per million

Parameter	Level of Interest	Sample Ids	# Samples	Range	Average	Hotspots?
TPAHs						
CPAH						
LPAH	370					
HPAH	960					
LNAPL	Any (sheen)					
DNAPL Observed or potential	Any observed or >1000 ppm COI					
Naphthalene	99					
Acenaphthylene	66					
Acenaphthene	16					
Fluorene	23					
Phenanthrene	100					
Anthracene	220					
2-Methylnaphthalene	38					
Fluoranthene	160					
Pyrene	1,000					
Benz(a)anthracene	110					
Chrysene	110					
Tbenzofluoranthenes	230					
Benzo(a)pyrene	99					

Indeno(1,2,3-c,d)pyrene	34					
Dibenzo(g,h,l)perylene	12					
Benzo(g,h,l)perylene	31					
1,2-Dichlorobenzene	2.3					
1,4-Dichlorobenzene	3.1					
1,2,4-Trichlorobenzene	.81					
Hexachlorobenzene	.38					
Dimethyl phthalate	53					
Diethyl phthalate	61					
Di-n-butyl phthalate	220					
Butyl benzyl phthalate	4.9					
Bis(2-ethylhexyl) phthalate	47					
Di-n-octyl phthalate	58					
Dibenzofuran	15					
Hexchlorobutadiene	3.90					
N-Nitrosodiphenylamine	11					
Phenol	420					
2-Methylphe	63					

CHEMICAL PARAMETERS
Lower River

Subsurface Sediments (>2 foot) Volatile Organic Compounds

In mg/kg – parts per million

Parameter	Level of Interest	Sample Ids	# Samples	Range	Average	Hotspots?
TVOC	5					
TCVOC	1					
Screen PID						
Trichloroethene						
Tetrachloroethene						
1,1,1 Trichloroethane						
Vinyl Chloride						
1,1 Dichloroethane						
Cis 1,2 dichloroethene						
Trans 1,2 dichloroethene						
1,1 Dichloroethene						
1,2 Dichloroethane						
Benzene						
Ethylbenzene						
Toluene						
Total Xylenes						

CHEMICAL PARAMETERS
Lower River

Subsurface Sediments (>2 foot) Metals

In mg/kg – parts per million

Parameter	Level of Interest	Sample Ids	# Samples	Range	Average	Hotspots?
Arsenic	10					
Cadmium	1					
Chromium	100					
Lead	200					
Nickel	100					
Mercury (total)	1					
Mercury (organic)	1					
Silver	1					
Barium	20					
Copper	100					
Zinc	100					
Selenium	20					
Be						
Na						
Mg						
Al						
P						
K						
Ca						
Sc						
Ti						
V						
Mn						
Fe						
Co						
Sr						
Y						
Zr						
Mo						
Sn						
Sb						
La						