Spring 2015
Final Report:
Risk Assessment of the Malden River: Planning
Acknowledgements

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# Table of Contents

Abstract 6  
Executive Summary 7  
Research Partners 8  
Introduction 10  
Human Health Risk Assessment 10  
Methods 12  
  a) Study Design 12  
  b) Literature Review, Documentation Collection 12  
  c) Interview Design 12  
  d) Survey Design 13  
  e) Data Collection and Analysis 13  
    i. Interviews 13  
    ii. Surveys 14  
Results 14  
  a) Where do these environmental hazards come from? 14  
  b) What are the environmental hazards of concern? 15  
  c) Who/what/where is at risk? 16  
    i. Use types 16  
    ii. Age of Users 16  
  iii. Frequency and Duration of Use 16  
  iv. Exposure to Water and Sediments 17  
  v. Location of use and contact 20  
  d) Perceptions 21  
Discussion 22  
  a) Age, Frequency, Duration of Users 22  
  b) Contact with Water and Sediments 22  
  c) c) Perceptions 23  
Future Work/Conclusions 23  
References 26  
Appendices 28
Figures

Figure 1: Malden River subwatershed drainage basin
Figure 2: Risk Assessment Process
Figure 3: Points of interest on the Malden River
Figure 4: Impervious surfaces of area surrounding the Malden River
Figure 5: Average frequency and duration of each activity type compiled from interviews (a and b) and surveys (c and d). Error bars show minimum and maximum values reported.
Figure 6: Observed and reported uses
Figure 7: Water and sediment contact across use
Figure 8: E. coli contamination and points of water contact
Figure 9: Water and sediment contact across use

Appendices

Appendix A: Interview Protocol
Appendix B: Survey
Appendix C: Interview Subjects
Appendix D: Interview Data Summary
Appendix E: Survey Data Summary
Appendix F: Memorandum of Understanding
Appendix G: IRB Notice of Action
Abstract

Industrial pollution, stormwater runoff and sanitary sewer overflows have led to significant degradation of water and sediment quality in the Malden River. At the same time, the river is frequented by various user groups who are concerned about the river’s health. The Mystic River Watershed Association (MyRWA) intends to conduct a human health risk assessment, but requested more in depth research on who uses the river and who is potentially exposed to the greatest risk. According to the Environmental Protection Agency (EPA), the process before a comprehensive risk assessment involves determining the types of environmental hazards, their origins, how exposure occurs based on these hazards and who/what/where has an exposure risk. Through personal interviews and a survey, disseminated by MyRWA and Friends of the Malden River (FOMR), we found that crew teams are the largest user group and come in contact with the water and sediment most frequently. In addition to crew, other activities such as water sampling and water chestnut removal lead to users contact with the water and sediment. Other than the winter months, the Malden River is widely used and people have voiced increasing their use with better access and trash removal. The results from this study highlight the need for a more extensive health risk assessment of the Malden River.
Executive Summary

The current state of the Malden River, a 2.3-mile tributary of the Mystic River, is heavily degraded due to a history of industry coupled with the effects of urbanization and development. The Mystic River Watershed Association (MyRWA), seeking to do a formal risk assessment through an EPA grant, requested that the Team MyRWA Field Projects group perform an initial analysis of recreational uses of the Malden River to support a future formal risk assessment. The project involved collecting data on individual users, typical recreational uses and exposure pathways of the Malden River. Research was structured around four questions found in the planning phase of EPA’s guidance on human health risk assessments, which ask about the types of environmental hazards, their origins, how exposure occurs based on these hazards and who/what/where has an exposure risk. Because the information was deemed as being important to MyRWA, perceptions of the river were also included. Methodology included a literature review, personal interviews with twelve individuals participating in various activities on the Malden River and a survey disseminated online by MyRWA that received thirty-five respondents. Participants were asked about their individual use habits as well as the observed use of other groups on the Malden River, concerning frequency and duration of use as well as contact with water or sediment. In addition, the extreme users and user groups were noted during the data gathering process.

Contaminants included E. coli. bacteria in the water and semi-volatile organic compounds, trace metals and high concentrations of beryllium, lead and zinc in the sediments. Prolonged and acute exposure to these contaminants have particular health effects on humans, ranging from nausea and skin irritation to more fatal consequences. Results on user groups found that the Malden River is host to 13 different types of recreational activities, categorized as activities that promote direct and indirect exposure to contaminants in the water and sediment of river. Seven of these activities are classified as direct exposure. Of all activities documented, crew teams on the Malden are the most frequent and consistent users. They are also the largest group, with some teams having as many as 100 rowers. In age range, the youngest known users are an 11 old angler and a ten year old who participated in a rowing camp, and the oldest user is a 70-year old rower in the Gentle Giant Rowing Club. Direct exposure to water and sediment occurs through splashing of the water surface into the faces of users. In addition, crew teams noted that three to five rowers falling in every year. Other events included less frequent occasions when crew members jumped into the water, rowers and coaches repositioned docks, coaches dropped anchors and rowers and coaches picked up trash along the river. Rowing has been reported to result in sporadic ingestion of water, although amounts greater than 10 ml have not been documented. No one from the survey or the interview process reported instances of swimming or eating fish catch.

Many individuals believe the Malden River is heavily polluted, with trash, water quality and sediment quality being an issue for users. Most respondents are concerned about the state of the river. However, the state of the river does not impede active users from continuing to use the river. Many still view the Malden River as a beneficial resource for the area, reported as serene and peaceful.

Based on our findings, the Malden River supports a variety of uses. We feel the main user groups are represented by our findings, but there are likely many individuals and uses that should be further investigated for a more comprehensive understanding of uses of the Malden River.
Research Partners

Tufts UEP/WSSS Field Projects Team

The present report is the result of work carried out by a team of graduate students at Tufts University during the Spring Semester of 2015 as requirement for the Field Projects course at the Department of Urban and Environmental Policy and Planning and the field practicum of the Water System Science and Society (WSSS) Program at the Tufts Institute for the Environment. The objective of this partnership is to integrate theory and practice by providing students with the opportunity to work on real-world challenges in their areas of interest, while offering community organizations and public agencies expert analysis and advice that enhances insight into priority issues and advances strategic objectives.

The research team, composed of students from the Urban and Environmental Policy and Planning Department, the Civil and Environmental Engineering Department, and the Fletcher School, worked for the Mystic River Watershed Association (MyRWA) through a consultant-client relationship. MyRWA is an organization based in Arlington that uses science-based advocacy to improve water and environmental conditions within the Mystic River watershed. Having a history of working with Tufts University, MyRWA proposed the topics of risk assessment and property values trends with urban river restoration as research topics that would greatly benefit the organization’s mission statement. In the near future, MyRWA intends to apply for an EPA grant to fund a full human health risk assessment of the Malden River, thus the present study is designed to inform that process.

The Mystic River Watershed Association (MyRWA)

The client, MyRWA, is an Arlington based organization that uses science based advocacy to improve water and environmental conditions within the Mystic River watershed. Having a history of working with Tufts University, MyRWA proposed the topics of risk assessment and property values trends with urban river restoration as research that would greatly benefit the organization’s mission statement. In the near future MyRWA intends to apply for an EPA grant to fund a full human health risk assessment of the Malden River. This study is designed to initiate that process.
Introduction

The Malden River watershed, a sub-basin of the Mystic River, is approximately 11 square miles in area and located in the urban areas of Wakefield, Stoneham, Melrose, Malden, Medford and Everett, Massachusetts (see Figure 1). This urban river originates from the outflow of Spot Pond in the Fells Reservation and passes beneath the cities of Melrose and Malden in channelized conveyances through much of the upper watershed. The Malden River daylights from two sets of stormwater culverts south of Malden Center and flows for approximately 2.3 miles as open surface water through the densely populated cities of Malden, Everett and Medford prior to its confluence with the Mystic River, just upstream of the Amelia Earhart Dam (see Figure 1).

Impacts of past industries and current urbanization have resulted in the degradation of the Malden River. Knowledge of the river’s history and visible pollution in and along the river have led to public concern for the safety of boaters and other users. However, at the same time, there is much interest in increasing access to the river. Many believe that in order to be able to increase access for use, the river needs to be restored to ensure public health safety. While there is concern, documented information supporting the idea that the river’s current state poses a risk is scarce. As a result, MyRWA is motivated to seek funding from the Environmental Protection Agency (EPA) for a formal risk assessment of the Malden River. The organization hopes to determine what human health risks the water and sediment quality pose if any. With their findings, they would like to either redirect public perceptions or incite the surrounding cities to take action in supporting a river restoration project.

Human Health Risk Assessment

According to the EPA, a human health risk assessment is used to characterize the human health risks associated with direct and indirect exposure to contaminated environmental media. This contaminated media has the potential to pose a risk to the health of a community that may come in contact with it through recreational activities and therefore needs to be evaluated. The assessment is then used for risk management to inform the public and guide policy decisions. When a comprehensive human health risk assessment is conducted, there are five phases: planning, hazard identification, dose-respondent assessment, exposure assessment and risk characterization. (U.S. EPA, 2012)
The steps of a human health risk assessment involve:

- **Planning**: research into the background information framing the process of a human health risk assessment
- **Hazard identification**: assess the potential of a pollutant to cause harm to humans
- **Dose-response assessment**: examine the relationship between health problems and exposure.
- **Exposure assessment**: assess the extent to which people are exposed to a pollutant during a specific time period and how many people are exposed
- **Risk characterization**: identify if there is an extra risk of health problems in the exposed population

(U.S. EPA, 2012)

To understand how a health risk assessment is conducted in a degraded river system, we reviewed the Syracuse Research Corporation (SRC) health risk assessment for the Upper Columbia River (2009). In the report, they found that the major pathways in water for contaminants are ingestion of river water and contact with contaminated sediments. They then conducted a toxicity assessment process in two parts. The first part characterized and quantified non-cancer effects through the assessment of the no-observed-adverse-effect-level (NOAEL) and the lowest-observed-adverse-effect-level (LOAEL). The second part of the process was to identify the contaminants with cancerous effects and their carcinogenic potency (SRC, 2009). To determine the risks associated with the levels of contaminants, they used the EPA’s Integrated Risk Information System (IRIS), an electronic database containing human health assessments for a number of chemicals.

With funding from the EPA, MyRWA will conduct a similar risk assessment in the future. The purpose of this report is to carry out the planning phase of the human health risk assessment process to document the use of the Malden River, similar to the work done by Industrial Economics on the Upper Columbia River (Industrial Economics, Incorporated, 2013). The planning phase lays the foundation and is instrumental in identifying need for further assessment. In this step, we characterize the environmental hazards and the people who are exposed to them.

To begin to understand the impact of a pollutant on the environment, it is important to know where it originates. According to the EPA, point source pollution comes from discernible conveyances and nonpoint source pollution results from runoff and other diffuse sources (U.S. EPA, 2015b). Determining whether the environmental hazard is from a point source or nonpoint source helps confirm the identity of the pollutants and the pathways they take on in the environment. Once we know the pollutants, we can assess how people come into contact with them, such as whether there is direct or indirect exposure, if people eat fish from a polluted waterbody or if people touch contaminated soil.

Another key component to the planning phase is understanding aspects of individuals who may be at risk, including information such as age and information about the general population who is at risk (U.S. EPA, 2012). Because fetuses and children are still developing, The EPA Child-Specific Exposure Factors Handbook states, “Because of physiological and behavioral differences, exposures among children are expected to be different from exposures among adults” (U.S. EPA 2008). Children frequently touch the ground and bring their hands to their mouths, potentially putting them in contact more frequently than adults. In a study on children’s exposure to mercury-contaminated soils, Guney et. al. (2012) found that exposure to highly contaminated soils could pose a serious risk to children under normal exposure. Therefore, this type of demographic information is important to collect during this planning process. Additionally, to understand how a specific resource may pose a risk to individuals and populations, it is important to understand how people come in contact with the resource, how often and for how long. The most extreme user/s or the user/s that come into contact with the environmental hazard for the longest duration and frequency have the most risk.

Several past studies have examined the ecological degradation and potential for restoration associated with the Malden River; however, there are few studies that characterize the human health risks for the degraded urban river. In 2001, the consulting company Haley and Aldrich conducted a human health risk assessment.
for the upper Malden River north of the Medford Street Bridge. The report "Malden River Ecosystem Restoration Detailed Project Report & Environmental Assessment" by the United States Army Corps of Engineers (USACE) cites that in 2001, the consulting company Haley and Aldrich conducted a human health risk assessment for the upper Malden River north of the Medford Street Bridge (2008, see Figure 3). In the Haley and Aldrich study (2008), they found No Significant Risk for recreational contact with surface water, but they could not demonstrate this condition for ingestion of fish caught in the Malden River. The USACE concluded in their environmental analysis that “Without significant improvement in the water quality and reduction in the concentrations of toxic chemicals in the sediments, potential human health risk concerns will persist regarding exposure to Malden River fish or sediments” (USACE, 2008). As it stands currently, there are no major restoration plans taking place on the river. Because water and sediment quality is not improving, further investigation on human health risk associated with the Malden River is warranted.

Methods

a) Study Design

The main goal of this project is to assist MyRWA in their initiation of a human health risk assessment of the Malden River by carrying out the planning phase of this type of an assessment (U.S. EPA, 2012). We aim to do this by investigating the history of the Malden River and contaminants of concern within the river, and we will also collect data on individual users, typical recreational uses and exposure pathways. We have structured our research around four questions posed by the EPA in their planning phase of a human health risk assessment (U.S. EPA, 2012):

1. Where do these environmental hazards come from?
2. What is the environmental hazard of concern?
3. Who/what/where is at risk?
4. How does exposure occur?

In addition to evaluating information for a future risk assessment, we also collected information regarding individuals’ perceptions of the Malden River. Because the risks posed to recreational users due to the state of the river are not well documented, we attempted to capture the difference between perceived risks and actual risks.

5. How do individuals perceive the state of the Malden River?

b) Literature Review, Documentation Collection

We consulted the academic literature and collected documentation and data on the Malden River to answer our first two research questions. The main two sources of information used to investigate these two questions were the USACE report and water quality data provided by MyRWA.

c) Interview Design

To investigate research questions three and four regarding recreational use of the Malden River and exposure to contaminants, we used interviews as our main method of data collection. While other studies use interception surveys and observations (Industrial Economics,
Incorporated, 2013; Syracuse Research Corporation, 2009; Barr, 1999; Breton et al., 1996; Morgan et al., 1993), we thought interviews would be more effective because of the timing of our study during the winter. We designed a 30-60 minute long interview protocol that aimed to understand the interviewee's demographics, frequency and duration of each recreational activity they participate in on the river, their contact with water and sediments, their observed activity on the river and their perceptions of the river's current state (see Appendix A). Although questions regarding the users' perceptions are not usually included in a risk assessment, because MyRWA is trying to better understand peoples' perceptions versus the actual conditions of the river, we found these questions important to include.

Our interview protocol was built based on our general understanding of the types of recreational activities common on the Malden River as well as information from the literature about human health risk assessments. Because contaminants pose different risks to people of different ages and genders, our first section of questions collects this important demographic information (see Appendix A).

We designed the second section of the interview to gather information about the interviewee's personal use of the river (see Appendix A). The questions regarding the interviewee's contact with the water and sediments aim to understand possible pathways for contaminants. Based on previous studies of the Malden River, and information in the literature, we believe that the contaminants found in the water and sediments of the Malden River may pose a risk if ingested or if they come in contact with the skin and eyes. We developed questions to understand the extent, duration and frequency of these types of interactions for each user. Additionally, based on information from the MIT research team, we included a question about the specific quantity of water users ingested while visiting the river (“Did you ingest <5 ml, 5-10 ml or >10 ml of water?”, see Appendix A). While we are concerned about the accuracy of information people will be able to provide to such a specific degree about an occurrence that happened six or more months ago, we still included the question for the MIT study and made a point to record how confident the interviewee seemed about their answer.

The third section of the interview protocol asks most of the same questions as the second section but also includes observed uses (see Appendix A). For people such as crew team coaches, this will include both use by their team as well as other people observed on the river during their personal use. This section not only helped us to understand the uses of people we did not directly interview, but also helped us to identify new potential interviewees, or gaps in our data to consider during analysis.

The final section of the protocol asks questions regarding the interviewee's perception of the river (see Appendix A). These questions are asked to understand what people think of the river's condition in relation to their use of river. There were also questions about support for river restoration, either because the river is perceived as contaminated and unsafe or because people would like to someday use the river for more.

d) Survey Design

After designing the interview protocol, MyRWA decided it would be valuable to distribute many of the interview questions as a survey to reach people who use the river that we may have missed in our recruitment process and also to gather the perceptions and opinions of the river from people who do not use it. We designed the survey for MyRWA mainly based on our interview protocol, and the questions were created to gather similar information (see Appendix B). We developed the multiple choice answers for each survey question based on the answers heard during our interviews. The survey itself was written in Google Forms, and once designed was tested by all group members, employees at MyRWA and professors and teaching assistants in the Tufts UEP Department. After testing, we revised the survey, re-tested for finalization and delivered the link and Google Doc to MyRWA.

e) Data Collection and Analysis

i. Interviews

We began our interview process by speaking with individuals from the main organizations affiliated with the Malden River, including MyRWA, Friends of the Malden River, Tri-City Action Program, Malden Redevelopment Authority, Malden Parks Department and the Massachusetts Department of Conservation and Recreation. We asked them to identify individuals who they know use the river. We began by interviewing the individuals these organizations identified and asked them to identify other individuals who use the river. We continued this approach until we felt we had a comprehensive list of people who
either use the river or represent other individuals or groups of people who use the river (Appendix C). In total, we interviewed 12 individuals who participate in a variety of activities on the Malden River from March to April 2015 (Table 1). Specifically, we interviewed seven individuals affiliated with crew teams who represent three of the six total teams that row on the Malden River.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Number of Interviewees</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crew Teams</td>
<td></td>
</tr>
<tr>
<td>Tufts Team Members</td>
<td>1</td>
</tr>
<tr>
<td>Tufts Coaches</td>
<td>2</td>
</tr>
<tr>
<td>Gentle Giant Club Members</td>
<td>2</td>
</tr>
<tr>
<td>Malden High Coaches</td>
<td>2</td>
</tr>
<tr>
<td>Charter School Coach</td>
<td>1</td>
</tr>
<tr>
<td>Total Row</td>
<td>7</td>
</tr>
<tr>
<td>Individual Users</td>
<td></td>
</tr>
<tr>
<td>Anglers</td>
<td>1</td>
</tr>
<tr>
<td>Walkers</td>
<td>2</td>
</tr>
<tr>
<td>Bikers</td>
<td>1</td>
</tr>
<tr>
<td>Canoe/Kayakers</td>
<td>1</td>
</tr>
<tr>
<td>Rower</td>
<td>1</td>
</tr>
<tr>
<td>Water sampling</td>
<td>1</td>
</tr>
<tr>
<td>Trash clean up</td>
<td>4</td>
</tr>
<tr>
<td>Invasive Species Removal</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 1: Recreational activities interviewees participate in on the Malden River, and quantity of interviewees who participate in each.

Interviews were conducted in a location chosen by the interviewee. Interviews lasted thirty minutes to an hour depending on the amount of time the interviewee had available and the amount of information they had to share. While all questions on the interview protocol were asked and included, depending on the nature of the interview and the information the interviewee had to share, some interviews deviated slightly from the interview protocol.

Information from the first three sections of the interviews were compiled into a spreadsheet. From the information provided, we calculated the range, frequency and noted any extremes in frequency and duration of use. Contact with water and sediment were categorized and described based on use type.

Information provided by interviewees during the fourth section of perception questions and any other information provided during the interview were organized by common themes. Topics that were repeated among different interviewees or within an interview are emphasized and discussed in this report. Similarly, topics, anecdotes and comments we found particularly interesting or that may be of interest to MyRWA are also discussed. We did not conduct statistical analyses, or use methods to quantify this qualitative information.

ii. Surveys

MyRWA distributed the survey to their email lists, the Friends of the Malden River, local newspapers, and intends to distribute it to the cities of Malden, Medford and Everett, pending the Mayors’ approval. The survey is still ongoing, and likely will be for some time into the future. Two weeks after the survey was distributed, MyRWA shared with us the responses they had collected thus far.

After each respondent completed the survey, the answers are automatically compiled into a Google spreadsheet. We received 36 responses from MyRWA. Of the 36 responses, one response was eliminated because it failed basic logic tests during our survey cleaning process. Of the 35 total responses, 26 individuals responded that they use the Malden River for recreational uses. Information from the binary, numeric and multiple choice answers of the first three sections of these twenty-six responses was compiled in the same way as answers from sections one, two and three from the interviews, as described above. Answers to open ended perceptions questions from all thirty-five responses were analyzed the same way as information resulting from section 4 of the interviews, as described above.

Results

a) Where do these environmental hazards come from?

Point (i.e industrial and municipal discharges) and nonpoint (i.e stormwater runoff) sources of nutrients and contaminants have led to significant water and sediment quality issues in the Malden River. The river remained undeveloped until around 1845 with the construction of the Boston and Maine Railroad. In the late 19th and early 20th centuries, industrial activity overwhelmed the Malden River. The industries that settled along the river became instrumental in supporting the war effort including the manufacturing of rubber boots and bullets. Along the
river, there were coal gasification plants, tar distillation plants, tanneries, chemical manufacturers, metal refineries and textile manufacturers. With no effluent guidelines, these industries discharged hazardous waste directly into the river through groundwater leachate or stormwater conveyance (USACE, 2008). During the industrial era, the river was dredged, straightened and filled to facilitate transport and commerce from the port of Boston (City of Malden, n.d.). The material cast to the banks from dredging destroyed much of the wetland habitat along the river. With the construction of the Amelia Earhart Dam in 1966, the Malden River lost tidal circulation, disturbing the river’s mixing and self-cleansing properties. This also led to the accumulation of contaminated sediments. In 1996, the Mystic Valley Development Commission initiated the planning for River’s Edge, a thirty-acre mixed-use project abutting the riverfront (Figure 3). The project entailed significant restoration efforts that involved removing over twelve-hundred tons of metal and other debris, 176 tons of rubber and 191 tons of tires of the river. In addition to a 10-acre public park, phragmites and other invasive species were removed and clean soil was used as a capping material (Preotle, n.d.). As a result, River’s Edge was chosen by the EPA to be a part of the Brownfields Demonstration Pilot Project (USACE, 2008). River’s Edge exemplifies the potential restoration efforts have; however, it is one piece of a much larger puzzle in managing the health of the river.

The most pressing issue currently stressing the Malden River is pollution from stormwater runoff and sanitary sewer overflows. The surrounding areas of the river are highly urbanized, with extensive impervious surface cover (Figure 4). Precipitation from rain and snow melt accumulates trash and pollutants within the Malden watershed, flows over impervious surfaces and discharges into the river. During intense rainfall events, leaky sanitary sewers and illegal connections between sanitary sewers and storm drains can lead to the discharge of raw sewage into the river. The combined impact of continuing discharge of household waste and urban runoff is the failure to meet water quality standards.

b) What are the environmental hazards of concern?

Despite increased public attention to water quality in recent years, the Malden River is on the Massachusetts 303(b) of the Federal Clean Water Act list of Impaired Waterbodies and must comply with the Total Maximum Daily Load (TMDL) for nutrients, pesticides, priority organics, organic enrichment/low DO, pathogens, oil and grease, taste, odor and color, suspended solids and “objectionable deposits” (Card, 2014). A TMDL is the maximum amount of pollutant that can discharge into a waterbody and still meet water quality standards (U.S. EPA, 2015a). It not only requires the evaluation of pollution sources, but it also links pollutants sources and their impacts on water quality.

We compiled contaminants of concern from the USACE Report (2008), Water Quality Monitoring data provided my MyRWA (2015) and other past reports on the Malden River’s water quality. Urban runoff from Malden, Everett and Medford contains high concentrations of bacteria, nutrients, oil and grease (Breault et al., 2005). The key indicator of sewage contamination in a river is the bacteria Escherichia coli (E. coli). Illnesses such as mild gastroenteritis to cholera and dysentery can result from contact with the bacteria and other pathogens in the sewage (MyRWA, n.d.). In addition to pollutants in the water column of the Malden River, humans may come
into contact with sediment contamination through recreational activities. The major contaminants in the sediment include semi-volatile organic compounds, polycyclic aromatic hydrocarbons and trace metals such as arsenic, cadmium, chromium, copper, lead, mercury, nickel and zinc (USACE, 2008). Although multiple pollutants are at or just below soil contamination standards, beryllium, lead and zinc surpass normal levels. Lead and zinc exceed safe concentration standards, according to the Massachusetts Department of Environmental Protection guidelines within the Massachusetts Contingency Plan, by six and two times, respectively, while beryllium is 11 times the standard level (Breault, et al., 2005). Prolonged ingestion of zinc can lead to chills, nausea and vomiting with extreme exposure leading to nerve damage, pancreatic damage and anemia (Department of Public Health n.d.). Health risks from extended lead exposure can result in elevated blood level, renal failure, damage to the reproductive system and in more extreme cases can cause coma and death (U.S. EPA, 2013). Acute exposure to beryllium can lead to skin and lung problems, including shortness of breath, rashes, pneumonia and difficulty breathing, although the concentration needed for these events is uncommon even through soil exposure (ATSDR, 2008).

c) **Who/what/where is at risk?**

<table>
<thead>
<tr>
<th>Recreational Activities on the Malden River</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Direct Contact</strong></td>
</tr>
<tr>
<td>Rowing</td>
</tr>
<tr>
<td>Fishing</td>
</tr>
<tr>
<td>Canoeing</td>
</tr>
<tr>
<td>Kayaking</td>
</tr>
<tr>
<td>Water Chestnut Removal</td>
</tr>
<tr>
<td>Water Sampling</td>
</tr>
<tr>
<td>Motorboating</td>
</tr>
<tr>
<td><strong>Indirect Contact</strong></td>
</tr>
<tr>
<td>Walking</td>
</tr>
<tr>
<td>Running</td>
</tr>
<tr>
<td>Biking</td>
</tr>
<tr>
<td>Picnicking</td>
</tr>
<tr>
<td>Bird Watching</td>
</tr>
<tr>
<td>Site Seeing</td>
</tr>
</tbody>
</table>

*Table 2: Activities reported and observed on the Malden River*

i. **Use types**

The Malden River supports a variety of recreational activities throughout the year. Based on our interview and survey data, we found that people participate in 13 different activities on and near the Malden River (see Table 2). These activities can be categorized as activities that allow direct and indirect exposure to contaminants in the water and sediment of the river (see Table 2).

ii. **Age of Users**

The age of individuals who visit the Malden ranges from small children (under 7 years old) to older adults (see Appendices D and E). The youngest children who participate in a direct contact activity are a 10-year old who participates in the Malden Middle School rowing summer camp and an 11-year old child who fishes (see Appendix C). The oldest person who participates in a direct contact activity is a 70-year old rower in the Gentle Giant rowing club.

iii. **Frequency and Duration of Use**

Crew teams are the largest user group, with the largest teams having 100 rowers (Tufts and Gentle Giant, see Appendix D). Based on both interview and survey data, rowers are also on average the most frequent users of the river (see Appendices D and E). The maximum frequency reported was an individual from the Tufts crew team who rows on the Malden River 120 times per year. The Tufts crew team practices five days a week with races on Saturdays during both the fall and spring. High school teams practice five days a week during the spring only. The Gentle Giant Rowing Club rows three days a week in the spring, summer and fall. Their boathouse is located on the Mystic River, but they usually row on the Malden every practice except those following a large rain event. Because the survey data on frequency was collected cat-
egorically (see Appendices B and E), we do not know the most frequent user from survey data, but individuals who participate in rowing, motorboating, walking, running and other undeclared activities reported visiting the river more than 30 times a year (Appendix E).

The maximum amount of time any individual reported visiting the river in one visit is a kayaker who has visited the river for 230 minutes (see Figure 5, Appendix E). The Malden High School crew team uses the river for the second longest duration of 180 minutes. Aside from these two extremes, duration of use is well mixed across the other activities.

The 11-year old who fishes has only visited the river a few times, but each time was at the river for about 3 hours (see Appendix D). The 10-year old rower participated in a 7 day summer camp where they spent 180-300 minutes on the river each day (see Appendix D). The oldest user rows often, reporting rowing 3 days a week for 90 minutes each visit from April to October. He has been rowing with the Gentle Giant Rowing Club for 12 years.

iv. Exposure to Water and Sediments

Crew Teams

All crew teams reported having a protocol for instances where rowers fall in, which includes getting out of the water as quickly as possible (within a few minutes) and showering or hosing off. As part of their protocol, the Tufts team practices getting in and out of the water at Mystic Lakes to ensure rowers can quickly react to a fall into the water and get back into their boat if not close to the shore.

Splashing

Every time crew teams visit the river to row they come in to contact with water through splashing, docking, getting in and out of the boats and putting the boats in and out of the water. The water mainly gets on their skin but also splashes in their noses, eyes, ears and mouths. All rowers confirmed that the extent of splash-
ing varies with skill level and river conditions. Beginner rowers splash more than experienced rowers, and more splashing occurs on days when the water is rough. Six rowers out of the eighteen interviewed and surveyed reported ingesting a small amount of water from this splashing, likely less than 5 ml each practice. In the survey, two rowers reported ingesting 5-10 ml each trip while rowing. While interviewees were asked to report an estimated quantity, they did not seem confident, mentioning that they “probably” ingest some water, and if so it is “probably not very much”, or they “can’t really say how much”. While no interviewees mentioned sediment contact while rowing, one survey respondent explained that “After it rains, thick solid tar like materials float to the surface, which land on me when I am rowing”.

All crew coaches reported coming in to contact with water during practices. Some splashing from their launches occasionally occurs and they touch the water docking and taking the launches out of the water. One coach explained that if the water is rough enough to create excessive splashing on the launch, then conditions are not fit for rowing.

Falling In

Rowers and crew coaches come into more extensive contact with water and possibly sediments when they accidentally fall into the water. Two individuals from the Tufts crew team reported that 2-3 people fall in each year, mostly by flipping boats. This occurs more often during the fall because they use smaller boats (doubles and fours) and have more beginner rowers than in the spring. Two individuals from the Malden High School crew team reported that 5 people fall in each year, mainly by falling in off their dock. The coach of the Mystic Valley Regional Charter School reported falling in off the dock. When people fall off the Malden High School dock, they come in contact with the sediment at the bottom of the river because the river is shallow here. In one instance, a rower fell in and was completely covered in sediment. This rower was instructed to shower off and was suspended from rowing for one to two practices. One rower described in the survey falling in along the river bank and having to walk through the sediment to get out of the water.

Jumping In

Although rowers do not necessarily intentionally swim in the river, two teams reported instances where rowers intentionally jump in the river. At the end of the year, the Malden High School seniors have jumped into the river (about eight students) and the Tufts crew team has reported doing the same (about 15 students). The crew teams who use the Malden River host races that bring up to 11 visiting teams to the Malden River on the weekends. Although we did not interview any of these rowers, the Malden High School team reported that there is a tradition in crew that the winning team of each race jumps into the water. Visiting teams occasionally carry on this tradition on the Malden River even when discouraged by the local teams.

Non rowing tasks

Rowers and coaches are responsible for tasks including maintaining docks, picking up trash and dropping anchors that involve contact with water, sediment or both. The Tufts crew team is responsible for putting in their docks, which entails holding their hands in the water. The coaches are responsible for taking them out. The Malden High School crew coaches install and remove the dock each year, and they have ten people (coaches and rowers) reposition the dock once after the ice melts. Repositioning the dock entails standing in the water and sediment. When the Malden High School coaches remove the dock, they noted that the dock comes up with sediment that touches their skin.

Both the Malden High School and the Tufts coaches participate in trash clean up on and along the river. The Malden High School team does this before one of their largest races, from boats and from the banks. Teams have emphasized the plethora of needles and animal waste during trash clean up. While they wear gloves, they do come into contact with the water and sediments. Additionally, the Tufts crew coaches clean up trash during the winter along the banks.
Anglers

The one person we interviewed who fishes on the river stated that she comes into contact with the water but not the sediment. This person has fished with her son, the 11-year old child, who is one of the youngest users of the Malden River. They did not eat the fish, but had intermittent contact with the water and the fish throughout the entirety of their visit. Other interviewees who observed fishing noted that anglers carried buckets, which they assumed was for harvesting fish for eating. No survey respondents reported fishing on the Malden River.

Boaters

Five of the six canoers and kayakers surveyed reported that they come into contact with the water by splashing from their paddles, and the one kayaker interviewed described the same. Motorboaters said they do not touch the water.

Water Sampling

One teacher from Malden High School described bringing her students to the Malden River to conduct water sampling and water quality testing. During water sampling, the students’ hands are in contact with the water and occasionally, the water quality instruments hit the bottom of the river and bring up sediments that the students touch with their hands. Additionally, the teacher allows students to fish during water sampling.

Water Chestnut Removal

One individual described participating in water chestnut removal. This entails pulling plants out of the river and touching water with their hands. Occasionally the seeds of the water chestnut bring sediment to the surface that the individual comes in contact with, but not very often.

Swimming

No individuals reported purposely swimming in the Malden River, or visiting the Malden River in order to swim.

Other

On the survey, one kayaker explained that they dip their hands in the water to pick up trash, and another individual noted that they come in contact with sediments “during clean up” for about two hours. Likely the person with the most extreme contact with the river reported in the survey, “My hands are in the sediment and water for over two hours as I collect objects and specimens from the riverbed”.

Illness related to contact

One survey respondent noted that a few rowers got sick after one incident where there was excessive splashing; however, we do not know the details of this sickness. One Tufts rower mentioned her teammates described feeling ill after falling in to the Malden River. She noted that she is not sure if they were actually ill, or were “being dramatic” about falling in. Both a Tufts coach and a Tufts rower explained that students often get blisters on their hands from rowing and the blisters get infected sometimes resulting in a staph infection. Two people from Tufts also mentioned multiple cases of conjunctivitis, but it is unclear if this occurred during the rowing season.

Indirect Contact Activities

There are many people who have been observed by interviewees enjoying the banks of the Malden River, eating lunch at picnic tables, walking at the River’s Edge Park and biking along the bike path. Based on interviews with people who take part in these activities and people who live or work in the area, there is no access directly to
the river water from locations where people participate in these activities. Interviewees and survey respondents have stated that they do not come in contact with water or sediments during these activities. Many mentioned that there is no access to the river at all from these locations as they are blocked off with bushes, trees and fences and, therefore, accidental contact is not likely. Other people familiar with the area have confirmed this statement.

v. Location of use and contact

Figure 6 depicts points where different recreational activities have been reported or observed based on interviews. These locations are estimated either by interviewee’s descriptions or by having interviewee’s draw locations on a map.

Many people have observed fishing from boats and the banks south of the Route 16 bridge, but that these people do not often travel north of the bridge. Two people described what they thought to be a population of homeless people living or spending long periods of time on the riverbanks south of the Route 16 bridge. There is more observed and reported use in general in the upper part of the river. Both the Tufts dock and the Malden High School dock are main access points for teams and individuals, and are areas of high activity. One individual reported seeing a paddle boarder on the river a couple times, but the exact location is not known.

Figure 7 shows areas where interviewees reported coming in contact with water or sediments in the river. Water chestnut removal occurs along both edges of the river north and south of the Route 16 bridge, the area surrounding where this point is located on the map. Just north of Route 16 is where crew coaches drop anchors for races. The points at the Tufts dock mainly represent regular contact including docking, putting in and taking out boats and docks, etc. The Malden River boathouse is a location where many types of contact occur for a variety of activities. Many people fall off the dock here in addition to the regular contact as described at the Tufts dock. The area surrounding the dock is where the Malden High school team cleans up trash, along both sides of the river banks. One Tufts crew team rower fell in just south of the Medford Street bridge; other locations where rowers have fallen in are unknown.
The area behind the Super 88, north of the Medford Street bridge, is described to have good fishing because there are extremely large carp at this location. One interviewee described fishing here and observing others fishing here. Additionally, one interviewee described fishing from the Medford Street bridge, and multiple other interviewees described observing people fishing here.

Lastly, there is continuous contact by rowers, canoers and kayakers along the entire length of the river (from the Medford St bridge south) through splashing. This is not indicated on the map.

Figure 8 shows that E. coli concentrations are above the EPA standards for boating (1260 cfu/100mL) and swimming (235 cfu/100mL) in the upper section of the river where extensive boating and fishing occurs and where there are the most instances with water contact.

d) Perceptions

Across both the interviews and the survey, all participants perceive the Malden River as having heavy pollution and serious degradation of water quality. When surveyed regarding concern for the water quality, on a scale of 1-5 (1 representing no concern and 5 representing great concern), the average score was 4.2. Visually, the majority of participants noted a proliferation of garbage, common trash and even needles, as well as the presence of human waste and odors from outflow areas (see Figure 9). The amount of trash on the river was consistently mentioned as a problem, even an embarrassment for crew teams hosting races. Other issues commonly noted were the further degrading of the water quality after a rain event and the clustering of invasive species in certain parts of the river segment that impeded recreational activities like rowing. All interviewees wish the Malden River were cleaner.

When asked what other factors prevented users from accessing the Malden River more, 60% of interviewees stated that low accessibility was a major issue. In addition, many believed that people in the surrounding towns simply did not know that the river existed or how to get there (20%), and that those that were informed about the Malden River were encouraged to not use it (20%). Others noted that a lack of infrastructure prevented more recreational activity (30%).

The health of the Malden River is problematic for the respondents because many view the river setting as an asset. Despite its degraded health, many interviewees who utilize the river do so because of its serene and peaceful nature as well as the proximity to wildlife. Almost all of the interviewees stated that they would use the river more often or for other uses if it were cleaner (90%). The most common suggestions by survey respondents for how to improve the conditions of the Malden River were to clean the trash from the water, increase infrastructure for boat access and recreation and to remove invasive species.
Many of the respondents are optimistic about the current conditions and future of the Malden River. Interviewees that had actively used the Malden River since 2000 noted that the quality of the water has improved significantly. Visual discharge into the river has reduced significantly, and a larger population of wildlife interacting with the river has been perceived in recent years. Current development projects on the Malden River are viewed positively; much of the interviewed population (approximately 50%) believe that the presence of development will encourage more of an impetus for river restoration projects as more people interact with the Malden River.

Discussion

a) Age, Frequency, Duration of Users

Young people do not seem to be active in direct contact activities on the Malden River. The few young individuals discussed previously do not visit the river often. The direct contact activities such as rowing may be difficult for young children to participate in and therefore there is likely some limit to the age of children on this river. On the contrary, the interviewee who fishes explained that her son (the 11-year old angler), grew bored of the Malden River as he got older and prefers to fish where there is a greater variety of fish to catch as opposed to mainly carp. Also, as he got older he grew less tolerable for the amount of trash along the Malden River and prefers fishing in cleaner places. It is possible that there are younger individuals participating in direct contact activities on the Malden River who we may have missed, but based on the types of activities prevalent, we think in general, Malden River users are teenagers to adults.

The crew teams are the most frequent user. It is likely that we did not encompass the maximum frequency of use in this study, but based on the information we gathered, we feel we can accurately predict who that might be. In addition, the frequency of rowing on the river is somewhat limited due to the crew teams’ schedules. The high school teams practice most regularly, five to six days per week but are limited by their school schedules, rowing only in the spring and fall. We calculate the maximum possible frequency for a school rowing team as six days per week during September through November and March through May, or about 144 visits in a year. The Gentle Giant rowing club rows through the summer unlike the school teams, but is limited by the number of days a week they row, which is only three. The maximum frequency a Gentle Giant club member may row is March through November, three days a week (assuming during every outing they visit the Malden River, not just the Mystic River), or about 108 visits in a year.

The only thing restricting duration of use for individual activities such as kayaking is hours of daylight. However, because the Malden River is so short, only 2.3 miles long, there is likely a limit on the number of hours one may choose to participate in any given activity in such a small area. The longest duration user, a kayaker, who kayaks for 230 minutes may be the upper limit on recreational activity duration.

b) Contact with Water and Sediments

The crew teams have the most frequent and extensive contact with water and sediments, and are the only user group who discussed ingesting water. This varies however based on experience; beginner rowers splash more and are more likely to flip a boat, and position...
either as a rower or a coach presents different methods of exposure as discussed previously. All individuals who participate in rowing however, have reported having some contact with water.

Contaminants in water may pose a risk to all direct contact activities such as rowing and fishing. Activities that occur in the upper section of the river where bacteria levels are higher, may be more at risk. Both crew teams’ docks provide access for the public to the river and are located in this area of high bacteria concentration, and therefore should also be further investigated.

We do not know concentrations of contamination in sediment and soil, therefore, for future analysis of the risks associated with discussed instances of sediment contact, the contaminant concentrations should be compared with exposure-based guidelines. If people swim near contaminated sediment, the sediment is quickly washed from their skin if it touches the skin at all. People who fall in and come in direct contact with sediment or people who are exposed to contaminated soil on the banks experience longer contact and therefore the contaminants are more likely to enter the body. Each sediment contact instance described in this document should be investigated individually because exposure from contaminants may differ even within one user group.

There are likely people who come in contact with water and sediments that we may have missed. Specifically, we only interviewed one individual who fishes but many individuals reported seeing anglers in multiple areas on the river (Figure 7). In addition, two interviewees mentioned observing anglers with buckets who may be consuming the fish. Anglers are a user group who may be at risk and should be further investigated.

Another possibly vulnerable population may be the people living along the banks at the mouth of the Malden River (Figure 7). It should be confirmed if, in fact, these individuals do live here, and if so, how much time they spend there and their duration and frequency of contact with water and sediments. If it is found that these individuals live on the river, they may be the highest frequency and duration user, above crew teams and boaters. Future work should investigate these specified user groups and other individuals and groups this study missed (Table 3).

Although individuals have reported illnesses that they perceive were linked to contact with the Malden River, there is not enough evidence to support a causal link between contact and illnesses such as conjunctivitis or staph infection, because, in some instances, individuals could not confidently report that the illnesses occurred during the rowing season.

c) Perceptions

Based on our findings, people widely consider the river contaminated but not necessarily unfit for use. People discuss feeling concerned about contact with water and sediments, but this does not seem to hinder their use significantly. Many people mentioned trash as a reason for concern on the river. Trash does not likely pose as significant a risk as contaminated sediment or bacteria concentrations in river water, but because it is so visible, it seems to be driving people’s perceptions.

Many people do not visit the river because they are not aware it is there or do not know how to access the river. This is not necessarily related to the state of the river concerning risks. However, many people hear that the river is contaminated and therefore choose to visit the Mystic River or the Charles River instead. Apart from crew teams, people do not generally seem to travel to the Malden River to participate in recreational activities. The majority of individual users live and work nearby.

It should be noted that because individuals care about improving the state of the river, their efforts to do so lead to exposure beyond what is typical of recreational use. For example, crew teams and individuals participate in cleanup activities, collecting trash in and along the river which causes additional exposure to water and sediments that does not occur during rowing or boating.

Future Work/Conclusions

Based on our findings, the Malden River supports a variety of uses. Crew teams are the most active user on the river. Rowers do come in contact with water often, and rowers and boaters occasionally ingest small amounts of water and come in contact with sediments from time to time. We feel the main user groups are represented by our findings, but there are likely many individuals and uses that should be further investigated for a more comprehensive understanding of uses of the Malden River. Some individuals we were not able to interview were a police officer who patrols the river by
boat, a professional muralist who leads a group of high schoolers in studying and painting murals of the river, and people who participate in volunteer water sampling and river clean up efforts. Groups we could not reach or well represent in our findings are anglers, the perceived homeless population observed at the south end of the river, non english speaking populations, the Medford and Everett/Somerville High School Crew teams, and individual rowers from the crew teams we interviewed. We suggest using MyRWA's survey and conducting intercept surveys on the river during the summer on weekends and during crew races and festivals on the river.

Most people view the river as degraded, but this does not impede the main users from visiting the river. Crew teams and others recognize the need to shower and wash their hands after contact with the river. Despite the perceived health of the river, individuals see the river as a positive resource, have noticed an increase in wildlife in the past years and are optimistic about the development occurring along the river. For more information regarding the optimism of this resource now and into the future as restoration is considered, please consider reading “Potential Economic Impacts of Restoring the Malden River” written by the same authors as this report.
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References


Appendix A: Interview Protocol

Risk characterization and economic trends of the Malden River

*Italicized text indicate notes for interviewer.

**Interview 1: Risk Characterization**

Before I start, let me show you exactly what area the study is focusing on. It’s the area outlined in red on this map. During the survey, I’ll refer to this entire area as the “Malden River” or “the river”.

**Section 1: User demographics**

1. What year were you born?
2. Gender: Male or Female (*Interviewer Records*)
3. What is the zip code of your primary residence?
4. *(If the interview is occurring in a professional setting)* What is your occupation and how does it relate to the Malden River?

**Section 2: Individual Use Questions**

5. How do you use the Malden River?
6. What activities do you participate in on the Malden River?
   i. How often do you participate in this activity on the river? (*Interviewer Note: Get a timeframe for frequency for each activity*)
   ii. How long do you typically spend on the Malden River when you are participating in this activity?
7. Did you come in contact with the water? If so, can you elaborate on this experience?
   i. Where exactly along the river?
   ii. How regularly do you come into contact with the water?
   iii. How long are you in contact with the water?
8. *(If yes to question 6)* Because you said you came in contact with the water, I am going to ask a few detailed follow-up questions.
   i. Did you fall in?
   ii. Did the water get in your mouth?
      i. If so, did you swallow it?
      ii. If so, approximately how much water do you ingest per outing, 1-5mL, 5-10mL or greater than 10mL? *If interviewee can not accurately estimate in milliliters, ask a mouthful, multiple mouthfuls.*
9. Have you ever had a staph infection, pink eye or other illness during the season when you were using the river?
   i. If so, how many times?
   ii. How long did it last?

Specific to crew teams and crew coaches:

10. How many students are on the team?
11. Age range of the students?
12. What is the range of boat sizes your team uses?

Below questions should be asked regarding the team’s use of the river as well as regarding other people seen while on the river, or other known people.

Section 3: Observed visitor use questions

13. As someone who regularly uses the Malden River, can you describe some of the activities you have seen other individuals participating in on the Malden River?
   i. How regularly do you see people participating in these activities?
   ii. Do any of these people appear to be minors between the ages of 7 and 17? Minors under the age of 7?

14. If you are familiar with their use, can you answer some questions about how they might come into contact with the river?
   i. Where along the river have you seen them?
   ii. How regularly do they come into contact with the river?
   iii. How long are they in contact with the water?

15. For the visitors that you know come into contact with the river, can you answer some detailed follow-up questions?
   i. Did they fall in?
   ii. Do they get water in their mouth?
      i. If so, do they swallow it?
      ii. If so, approximately how much water do they ingest per outing. 1-5mL, 5-10mL or greater than 10mL? (Use a prop like a 5 mL water bottle to clarify sizes).

Section 4: Perceptions of the Malden River: current state of pollution and safety and desires for future river use

16. What is your perception of the current health of the Malden River?
13. Is there anything about the Malden River preventing you from using it more than you currently do?
   a. If yes, how else would you use the river? What other activities would you participate in?

14. In your opinion, what are the main reasons why people do not use the river?
   a. If there are reasons, how do you think other people would use the river if these reasons no longer prevented them?
Appendix B: Survey

Malden River Visitor Use Survey

This survey is designed to collect information regarding two aspects of the Malden River. The first is to characterize recreational use of the river. The second is to gauge your opinion on the potential impact of river restoration on property values along the river. The information you provide will be used by the Mystic River Watershed Association and the Friends of the Malden River to better understand this complex urban waterway.

* Required

Introduction

1. Q1: Have you visited the Malden River in the past year? *
   Mark only one oval.
   
   Yes

   No  
   
   Skip to question 36.

Activity Participation
2. Q2: Over the past year, how many trips have you taken to the Malden River? Please check one.  
Mark only one oval.

☐ 1-5  
☐ 6-10  
☐ 11-15  
☐ 16-20  
☐ 21-30  
☐ 31-40  
☐ 41-50  
☐ 51-75  
☐ 76-100  
☐ Greater than 100

3. Q3: How many times did you participate in the following activities in the last year?  
Mark only one oval per row.

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<th>6-10</th>
<th>11-15</th>
<th>16-20</th>
<th>21-25</th>
<th>26-30</th>
<th>Greater than 30</th>
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Q4: For the activities you participated in, please indicate how long you participated in that activity during a typical trip below.

Please record your activity duration in minutes. For example, if you rowed for 1 hour and 30 minutes, please record "90".

4. Q4: Walking
5. Q4: Running

6. Q4: Biking

7. Q4: Rollerblading

8. Q4: Fishing

9. Q4: Kayaking

10. Q4: Canoeing

11. Q4: Rowing

12. Q4: Birdwatching

13. Q4: Motorboating

14. Q4: Sightseeing

15. Q4: Swimming

16. Q4: Picnicking

17. Q4: Other:
Group Size

18. **Q5:** For a typical trip, how many people are in your group?

.......................................................... ..........................................................

19. **Q6:** How many are people over the age of 18?

.......................................................... ..........................................................

20. **Q7:** How many are children 7 to 17 years old?

.......................................................... ..........................................................

21. **Q8:** How many are children under 7 years old?

.......................................................... ..........................................................

22. **Q9:** Where on the Malden River do you typically visit? (go to www.google.com/maps for help finding the location)

Please refer to a location on the map below.

.......................................................... ..........................................................

Malden River
Interaction with water, soil, or sediment

23. **Q10:** Did you or any member of your group come in contact with the water?  
*Mark only one oval.*  
- [ ] Yes  
- [ ] No

24. **Q11:** Please explain your contact and duration (in minutes) of contact with the water.  
For example: "I had water splashed continuously on me while rowing for 30 minutes" or, "I fell in the water for three minutes".

25. **Q12:** Did you or any member of your group ingest any water from the river, either on purpose or accidentally?  
*Mark only one oval.*  
- [ ] Yes  
- [ ] No  
- [ ] I don't know
26. **Q13:** If either you or a member of your group ingested water, how much did you ingest total?
   If you select "other", please describe your ingestion of water.
   
   *Mark only one oval.*

   - [ ] Less than 5 ml (about one teaspoon)
   - [ ] Between 5 to 10 ml
   - [ ] More than 10 ml (about two teaspoons)
   - [ ] Other:

27. **Q14:** Did you or any member of your group come in contact with the sediment in the river or soil on the banks of the river?
   
   *Mark only one oval.*

   - [ ] Yes
   - [ ] No

28. **Q15:** Please explain your contact and duration (in minutes) of contact with the soil or sediment.
   For example: "I fell into the water while getting into my canoe and had to walk through the sediment for 1 minute."

   ........................................................................................................

**Fish Consumption**

29. **Q16:** Do you fish on the Malden River?
   
   *Mark only one oval.*

   - [ ] Yes
   - [ ] No  
   
   *After the last question in this section, skip to question 36.*

30. **Q17:** Do you eat any fish caught on the Malden River?
   
   *Mark only one oval.*

   - [ ] Yes
   - [ ] No

31. **Q18:** If you have eaten fish from the Malden, please select the fish you consumed:
   
   *Check all that apply.*

   - [ ] Alewife
   - [ ] Carp
   - [ ] Bass (Smallmouth or Largemouth)
   - [ ] Other:

........................................................................................................
Q19: If you consumed fish from the Malden River, please record how many meals of that species you consumed in the last year.

32. Q19: Alewife

33. Q19: Bass (Smallmouth or Largemouth)

34. Q19: Carp

35. Q19: Other

Perceptions of Malden River

36. Q20: If you do, why do you choose to visit the Malden River?
   Check all that apply.
   Check all that apply.
   
   □ Scenic Beauty
   □ Birdwatching
   □ Serene/peaceful
   □ Fishing Opportunities Available
   □ Good Water Quality
   □ Close to Home
   □ Ease of Access
   □ Parking is Convenient
   □ Accessible by T
   □ Pass the river when walking or biking to somewhere else
   □ To get away from the urban environment
   □ Other: .................................................................
37. **Q21: If you never visit the Malden River, or sometimes choose not to visit the Malden River, why do you choose not to?**
Check all that apply.

*Check all that apply.*

- [ ] Too polluted
- [ ] Too much trash
- [ ] Not scenic
- [ ] Difficult to access
- [ ] Didn't know I could/Didn't realize it was there
- [ ] Too far from home
- [ ] Prefer going elsewhere
- [ ] Poor fishing options
- [ ] Not enough wildlife
- [ ] Few birds
- [ ] Don't enjoy recreational activities regarding rivers
- [ ] Don't own a boat
- [ ] Other: .................................................................

**Malden River Perception**

38. **Q22: If you could change something about the Malden River, what would you change?**

........................................................................................................

........................................................................................................

........................................................................................................

........................................................................................................

........................................................................................................

........................................................................................................

39. **Q23: In general, how concerned are you about the level of pollution in the Malden River?**

*Mark only one oval.*

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not at all Concerned</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

https://docs.google.com/forms/d/18VBrpPyXZXN_hijeP255XYF4-Z2505hzCM2NieKm9udl/printform
40. **Q24: If the river was restored or cleaned up, how would you like to use it?**
   Please select all that apply.
   Check all that apply.
   - [ ] Swimming
   - [ ] Boating
   - [ ] Water Skiing
   - [ ] Fishing
   - [ ] I would not change my use
   - [ ] Other:  ........................................................................................................

41. **Q25: Have you participated in any Malden River cleanups in the past year?**
   Mark only one oval.
   - [ ] Yes  *Skip to question 42.*
   - [ ] No  *Skip to question 43.*

**River Cleanup**

42. **Q26: Why did you participate in a Malen River cleanup?**

........................................................................................................
........................................................................................................
........................................................................................................
........................................................................................................
........................................................................................................
........................................................................................................

**Property**

43. **Q27: Do you own a property near the Malden River?**
   Mark only one oval.
   - [ ] Yes
   - [ ] No

44. **Q28: If you own property near the Malden River, do you think the current state of the river has any effect on your property's value?**
   Mark only one oval.
   - [ ] Yes, Positive Effect
   - [ ] Yes, Negative Effect
   - [ ] No
   - [ ] Unsure
45. Q29: If you do own property near the Malden River, do you think river restoration would have an effect on the value of your property?
   *Mark only one oval.*
   - Yes, Positive Effect
   - Yes, Negative Effect
   - No
   - Unsure

46. Q30: Would you buy or invest in property near the Malden River, given the river's current condition?
   *Mark only one oval.*
   - Yes
   - No
   - Unsure

47. Q31: If the Malden River were restored, would you be more inclined to invest or buy property near the river?
   *Mark only one oval.*
   - Yes
   - No
   - Unsure

Demographics (Optional)

48. Q32: What is your sex?
   *Mark only one oval.*
   - Male
   - Female

49. Q33: What is your age?

50. Q34: Are you of Hispanic, Latino, or Spanish Origin?
   *Mark only one oval.*
   - Yes
   - No
51. **Q35: What is your race?**
*Check all that apply.*

- [ ] American Indian or Alaskan Native
- [ ] Asian
- [ ] Black or African American
- [ ] Native Hawaiian or Other Pacific Islander
- [ ] White
- [ ] Other: .................................................................

52. **Q36: What is the highest degree or level of school that you have completed?**
*Mark only one oval.*

- [ ] No schooling
- [ ] Some schooling less than grade 12
- [ ] High school graduate
- [ ] Some college
- [ ] Associate's Degree
- [ ] Bachelor's Degree
- [ ] Master's Degree
- [ ] Professional Degree beyond a Bachelor's
- [ ] Doctoral Degree

53. **Q37: Which of the following best describes your household income last year, before taxes?**
*Mark only one oval.*

- [ ] $10,000 or less
- [ ] $10,001-$20,000
- [ ] $20,001-$30,000
- [ ] $30,001-$40,000
- [ ] $40,001-$50,000
- [ ] $50,001-$60,000
- [ ] $60,001-$75,000
- [ ] $75,001-$100,000
- [ ] $100,001-$125,000
- [ ] $125,001-$150,000
- [ ] $150,001 or more
<table>
<thead>
<tr>
<th>Name</th>
<th>Affiliation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teresa Bello</td>
<td>Friends of the Malden River</td>
</tr>
<tr>
<td>Rick Beinecke</td>
<td>Author of &quot;The Mystic River&quot;</td>
</tr>
<tr>
<td>Karen Buck</td>
<td>Friends of the Malden River</td>
</tr>
<tr>
<td>Gary Caldwell</td>
<td>Head Coach, Tufts University Crew Team</td>
</tr>
<tr>
<td>Shauna Campbell</td>
<td>Malden High School Crew Team</td>
</tr>
<tr>
<td>Elizabeth Debski</td>
<td>Malden Redevelopment Authority</td>
</tr>
<tr>
<td>Patrick Herron</td>
<td>MyRWA</td>
</tr>
<tr>
<td>Sarah Jones</td>
<td>Malden High School Crew Team</td>
</tr>
<tr>
<td>Fred Levy</td>
<td>Gentle Giant Rowing Club</td>
</tr>
<tr>
<td>Rebecca Scofield</td>
<td>Tufts University Crew Team Staff</td>
</tr>
<tr>
<td>Emma Wells</td>
<td>Tufts University Crew Team Rower</td>
</tr>
<tr>
<td>Nick Wright</td>
<td>Mystic Valley Regional Charter School Crew Team</td>
</tr>
</tbody>
</table>

Appendix C: List of individuals interviewed regarding their recreational
<table>
<thead>
<tr>
<th>Activity</th>
<th>Frequency visits/year</th>
<th>Frequency months/year</th>
<th>Frequency days/week</th>
<th>Duration mins/visit</th>
<th>Number of People per Trip</th>
<th>Age Range years</th>
<th>Contact with Water or Sediments</th>
<th>Water Ingested per trip</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tufts Crew Team (3)</td>
<td>A:110 R:100-120</td>
<td>A:5</td>
<td>A:5.5 R:5.5</td>
<td>A:110 R:60-120</td>
<td>72-100</td>
<td>17-23</td>
<td>both</td>
<td>&lt;5 mi water</td>
</tr>
<tr>
<td>Malden High School Crew Team (2)</td>
<td>A:62 R:60-64</td>
<td>A:3</td>
<td>A:5.5 R:5.5</td>
<td>A:135 R:90-180</td>
<td>60</td>
<td>15-19</td>
<td>both</td>
<td>&lt;5 mi water</td>
</tr>
<tr>
<td>Gentle Giant Rowing Club (2)</td>
<td>A:54 R:24-84</td>
<td>A:4.5 R:2-7</td>
<td>A:3</td>
<td>A:90</td>
<td>100</td>
<td>16-70</td>
<td>water</td>
<td>no</td>
</tr>
<tr>
<td>Charter School Crew Team (1)</td>
<td>A:60</td>
<td>A:3</td>
<td>A:5.5 R:5.5</td>
<td>A:105 R:60-150</td>
<td>40-45</td>
<td>13-18</td>
<td>both</td>
<td>no</td>
</tr>
<tr>
<td>Malden Middle School Summer Camp (2)</td>
<td>A:7</td>
<td></td>
<td></td>
<td>A:140 R:180-300</td>
<td>20-30</td>
<td>10-14</td>
<td>both</td>
<td>&lt;5 mi water</td>
</tr>
<tr>
<td>Total Row (7)</td>
<td>A:51 R:7-120</td>
<td>A:51</td>
<td>A:45 R:3-6</td>
<td>A:120 R:60-180</td>
<td>272-305</td>
<td>10-70</td>
<td>both</td>
<td>&lt;5 mi water</td>
</tr>
<tr>
<td>Individual Uses</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kayak (1)</td>
<td>A:2.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Water Chestnut Removal (1)</td>
<td>A:2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fish (1)</td>
<td>A:2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water Sampling (1)</td>
<td>A:4.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Walk (2)</td>
<td>A:7.5 R:5-10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bike (1)</td>
<td>A:10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Appendix D: Information consolidated from interviews. Number in parentheses denotes number of interviewees. “A” represents average and “R” represents range. Information in the “Contact with Water or Sediments” and “Water Ingested per Trip” columns state if any individual from that user group reported ingesting and may not pertain to all individuals in that group.
<table>
<thead>
<tr>
<th>Activity</th>
<th>Frequency visits/year</th>
<th>Duration mins/visit</th>
<th>Number of People per Trip</th>
<th>Age Range years</th>
<th>Contact with Water or Sediments</th>
<th>Water Ingested per trip</th>
</tr>
</thead>
<tbody>
<tr>
<td>Row (11)</td>
<td>A:18.3 R:1-&gt;30</td>
<td>A:98</td>
<td>1-80</td>
<td>&lt;7-adults</td>
<td>both</td>
<td>&lt;5 ml, 5-10 ml water</td>
</tr>
<tr>
<td>Canoe (2)</td>
<td>A:2.5 R:1-5</td>
<td>A:75</td>
<td>1-2</td>
<td>adults</td>
<td>water</td>
<td>no</td>
</tr>
<tr>
<td>Kayak (4)</td>
<td>A:5 R:1-15</td>
<td>A:133 R:60-230</td>
<td>1-12</td>
<td>adults</td>
<td>water</td>
<td>no</td>
</tr>
<tr>
<td>Fish (0)</td>
<td>A:0 R:1-5</td>
<td>A:0</td>
<td>0</td>
<td></td>
<td>neither</td>
<td>no</td>
</tr>
<tr>
<td>Motorboat (2)</td>
<td>A:11.6 R:1-&gt;30</td>
<td>A:50</td>
<td>1</td>
<td>adults</td>
<td>neither</td>
<td>no</td>
</tr>
<tr>
<td>Swim (0)</td>
<td>A:0 R:1-5</td>
<td>A:0</td>
<td>0</td>
<td></td>
<td>neither</td>
<td>no</td>
</tr>
<tr>
<td>Walk (16)</td>
<td>A:9.3 R:1-&gt;30</td>
<td>A:49</td>
<td>1-75</td>
<td>&lt;7-adults</td>
<td>neither</td>
<td>no</td>
</tr>
<tr>
<td>Bike (7)</td>
<td>A:3.3 R:1-10</td>
<td>A:54</td>
<td>1-12</td>
<td>&lt;7-adults</td>
<td>neither</td>
<td>no</td>
</tr>
<tr>
<td>Run (4)</td>
<td>A:10 R:1-&gt;30</td>
<td>A:64</td>
<td>1-2</td>
<td>adults</td>
<td>neither</td>
<td>no</td>
</tr>
<tr>
<td>Birdwatch (1)</td>
<td>A:2.5 R:1-5</td>
<td>A:30</td>
<td>1</td>
<td>adults</td>
<td>neither</td>
<td>no</td>
</tr>
<tr>
<td>Picnic (1)</td>
<td>A:2.5 R:1-5</td>
<td>A:120</td>
<td>2</td>
<td>adults</td>
<td>neither</td>
<td>no</td>
</tr>
<tr>
<td>Sight-seeing (2)</td>
<td>A:12.5 R:1-25</td>
<td>A:120</td>
<td>1-2</td>
<td>adults</td>
<td>neither</td>
<td>no</td>
</tr>
<tr>
<td>Other (4)</td>
<td>A:4.2 R:1-&gt;30</td>
<td>A:60</td>
<td>1-2</td>
<td>adults</td>
<td>neither</td>
<td>no</td>
</tr>
</tbody>
</table>

**Appendix E:** Information consolidated from surveys. Number in parentheses denotes number of responses. "A" represents average and "R" represents range. Information in the "Contact with Water or Sediments" and "Water Ingested per Trip" columns state if any individual from that user group reported ingesting and may not pertain to all individuals in that group.
MEMORANDUM OF UNDERSTANDING
BETWEEN
TUFTS UNIVERSITY FIELD PROJECTS TEAM NO. [___ AND NAME OF TEAM]
AND
MYRWA

I. Introduction

Project (i.e., team) number: ________
Project title: ______________________
Client: Mystic River Watershed Association

This Memorandum of Understanding (the “MOU”) summarizes the scope of work, work product(s) and deliverables, timeline, work processes and methods, and lines of authority, supervision and communication relating to the Field Project identified above (the “Project”), as agreed to between (i) the UEP graduate students enrolled in the Field Projects and Planning course (UEP-255) (the “Course”) offered by the Tufts University Department of Urban and Environmental Policy and Planning (“UEP”) who are identified in Paragraph II(1) below (the “Field Projects Team”); (ii) MyRWA, further identified in Paragraph II(2) below (the “Client”); and (iii) UEP, as represented by a Tufts faculty member directly involved in teaching the Course during the spring 2014 semester.

II. Specific Provisions

(1) The Field Projects Team working on the Project consists of the following individuals:

1. Ryan Bailey  
   email address: rjbailey87@gmail.com
2. Agustin Botteron  
   email address: agustinbotteron@gmail.com
3. Tim Grant  
   email address: timothy.grant@tufts.edu
4. Sondra Lipshutz  
   email address: smlipshutz@gmail.com
5. Susie Bressney  
   email address: sbressney@gmail.com

[You may want to include cell phone numbers here, as well.]

(2) The Client’s contact information is as follows:

Client name: MyRWA
Key contact/supervisor: Patrick Herron
Email address: Patrick@mystic.river.org
Telephone/cell number(s): 781-316-3438
Address: 20 Academy Street, Arlington, MA, 02476
The goal/goals of the Project is/are:

Risk Characterization: The Field Projects Team (hereinafter “the Team”) will be assisting MyRWA with a public health assessment and risk characterization by collecting data on visitor uses, exposure pathways, potential future uses and perceptions of the Malden River. The Risk Characterization portion of this project will be the Team’s first priority.

River Restoration Economic Analysis: The Team will determine the potential impact of river restoration on property values along the Malden River and identify the potential economic benefits to the surrounding cities. This assessment will be our second priority. If time constraints inhibit the completion of this portion of the project as outlined below, the scope will be adjusted appropriately.

The methods and processes – including the methodologies -- through which the Team intends to achieve this goal/these goals is/are:

Risk Characterization: The Team will potentially use surveys, interviews, observation, spatial analysis, and usage patterns associated with development to identify visitor uses. We tentatively propose the following steps to determine visitor uses:

1. Interview key stakeholders to identify general usage groups and where these groups are interacting with the Malden River.
2. Based on interviews, survey each group using online surveys.
3. Supplement the findings from the surveys, interviews, and observations with a GIS analysis of inferred uses based on development and land use types along the Malden River.

River Restoration Economic Analysis: To determine the economic benefits to surrounding cities and property value impacts of river restoration, the Team will take the following steps.

4. Perform a comprehensive literature Review of the impacts of river restoration on property values and the economic benefits of river restoration.
5. Identify comparable river systems for a case study of the property value impacts and economic benefits of river restoration.
6. Determine potential restoration projects for the Malden River in coordination with MyRWA.
7. Identify current and potential ecosystem services provided by the Malden River.
8. Catalogue the property types abutting the Malden River and evaluate their sensitivity (based on literature, case studies) to economic impacts resulting from river restoration.

The work products and deliverables of the Project are (this includes any additional presentations for the client, and may list project elements in order of priority):

Risk Characterization: The Team will provide a report and presentation that summarizes the key Malden River user groups and their interaction with the river. This report will also summarize the relevant literature that characterizes the risks associated with contaminants found in the river and the determined
user groups. The final deliverables will be designed to supplement MyRWA’s proposal for a public health assessment and make recommendations to align river uses with river quality.

River Restoration Economic Analysis: The Team will summarize the results of the literature review, case study, and property value sensitivity analysis in a report that can be used by MyRWA to highlight the potential economic benefits of river restoration on the community surrounding the Malden River.

(6) The anticipated Project timeline (with dates anticipated for key deliverables) is:

02/11: MOU Signing
02/24: Project proposal (interim deliverables are outlined)
04/3: First Draft of deliverables
04/17: Final Draft deliverables
04/28-04/29: Final Presentation to field projects class
05/1: Final deliverable due

(7) The lines of authority, supervision and communication between the Client and the Field Projects Team are (or will be determined as follows):

Patrick Herron will be our main contact with MyRWA. We propose to meet with Patrick once a month and will schedule additional meetings when needed.

(8) The understanding with regard to payment/reimbursement by the client to the Field Projects Team of any Project-related expenses is:[1]

TBD

[1] Note that most clients have agreed to defray the cost of Field Projects materials and other expenses. Nonprofit and agency clients are asked to support the Field Projects effort by contributing $100; for-profit clients are asked to contribute $200.

III. Additional Representations and Understandings

A. The Field Projects Team is undertaking the Course and the Project for academic credit and therefore compensation (other than reimbursement of Project-related expenses) may not be provided to team members.

B. Because the Course and the Project itself are part of an academic program, it is understood that the final work product and deliverables of the Project (the “Work Product”) – either in whole or in part – may and most likely will be shared with others inside and beyond the Tufts community. This may include, without limitation, the distribution of the Work Product to other students, faculty and staff, release to community groups or public agencies, general publication, and posting on the Web. Tufts University and the Field Projects Team may seek and secure grant funds or similar payment to defray the
cost of any such distribution or publication. It is expected that any issues involving MyRWA’s confidentiality or proprietary information that may arise in connection with a Project will be narrow ones that can be resolved as early in the semester as possible by discussion among MyRWA, the Field Projects Team and Penn Loh.

C. The Team, upon completion of the Project, will promptly convey all data, research, materials, documents and audio/video materials directly relating to the Work Product to MyRWA. This includes the right to alter and edit these materials as appropriate. It is understood that the work of the Team will be cited by MyRWA or other entities as “Tufts University Malden River Field Projects Team 2015”.

D. It is understood that this Project may require the approval (either through full review or by exemption) of the Tufts University Institutional Review Board (IRB). This process is not expected to interfere with timely completion of the project.

IV. Signatures

__________________________________
For [NAME OF CLIENT]
By: [PRINTED NAME]
Date: ___________, 2015

__________________________________
Representative of the Field Projects Team
By: [PRINTED NAME – only one team member’s signature is necessary; it doesn’t matter which team member]
Date: ___________, 2015

__________________________________
Tufts UEP Faculty Representative
By: [PRINTED NAME of the Instructor Working With Your Team]
Date: ____________, 2015

[NOTES:]
1. (*) Each text segment in this document that falls within brackets “[ ]” needs to be filled in with specific information (or the existing text reviewed and, if necessary, modified) and the brackets removed. If bracketed material is merely explanatory, it should be removed from the final document (that is, from the document that is signed).

2. Items (3) through (5) in Part II may be addressed at least partially by reference to the Project Description (which does not have to be attached); but all material changes should be noted in the MOU in some fashion. This is particularly important if your project has changed in any significant way since the Project Description was distributed.

3. If necessary, you can complete the signature page in separate pieces (e.g., with the team and instructor signing one copy, and the client signing and faxing in (or scanning and emailing) a second copy).

4. Part III is the place to include other issues that you need to identify and resolve up front.

5. Teams that are completing their project for another course or part of a broader activity (i.e., the WSSS Practicum and the Practical Visionaries Workshop) may need to modify the MOU or choose an alternative approach that better sets forth the detailed understanding of the project as among the team, the client (or supervisor of the activity), and a Course instructor.]
Appendix G: IRB Notice of Action

Title: Risk Characterization and Economic Trends of the Malden River

March 24, 2015 | Notice of Action
IRB Study # 1502030 | Status: EXEMPT

PI: Susan Bresney
Co-Investigator(s): Ryan Bailey, Agustin Botteron, Sondra Lipshutz
Faculty Advisor: Penn Loh
Review Date: 3/24/2015

The above referenced study has been granted the status of Exempt Category 2 as defined in 45 CFR 46.101 (b). For details please visit the Office for Human Research Protections (OHRP) website at: http://www.hhs.gov/ohrp/humansubjects/guidance/45cfr46.html#46.101(b)

- The Exempt Status does not relieve the investigator of any responsibilities relating to the research participants. Research should be conducted in accordance with the ethical principles, (i) Respect for Persons, (ii) Beneficence, and (iii) Justice, as outlined in the Belmont Report.
- Any changes to the protocol or study materials that might affect the Exempt Status must be referred to the Office of the IRB for guidance. Depending on the changes, you may be required to apply for either expedited or full review.

IRB Administrative Representative Initials:

Tufts University
Office of the Vice Provost for Research
Social, Behavioral, and Educational Research
Institutional Review Board
FWA00002063

20 Professors Row, Medford, MA 02155 | TEL: 617.627.3417 | FAX: 617.627.3673 | EMAIL: SBER@tufts.edu