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Visual representations in a choice experiment: valuing preferences for a local dam

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Research

Visual representations in a choice experiment: valuing preferences for a local dam

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ABSTRACT. Making decisions about future environmental alternatives such as aging dams can be complex, technical, and challenging for the public. This study uses a split sample, labeled choice experiment to examine how information delivery method—combinations of text, images, and video—affects willingness to pay (WTP) for alternative scenarios for an aging dam. The results indicate that the still image treatment leads to higher WTP across all dam modification alternatives compared to keeping the dam in its current condition. In contrast, the video treatment leads in lower WTP for most alternatives and results in different preference ranking for dam management, i.e., higher WTP to maintain the dam over removing it. Our study suggests that preferences are sensitive to how information is delivered and reinforces the need for credible and legitimate visualizations that can correctly capture the projected future alternatives.

Key Words: *aging infrastructure; choice experiments; non-market valuation; video; visualizations*

INTRODUCTION

Making decisions about future environmental alternatives can be complex, technical, and challenging to understand (Al-Kodmany 1999, Salter et al. 2009, Hayek 2011, Lovett et al. 2015). Deciding the future of iconic aging dams is a prime example of a complex ecological problem for many communities in the U.S., which can involve multiple trade-offs. Recently studies are exploring how visual representations can help decision makers better comprehend the presented information (e.g., Townsend and Kahn 2014). When future scenarios are visually represented in the form of an image or video, individuals process them in a gestalt manner: quickly and easily as a whole, which in turn increases the perception of the variety among alternatives compared to their textual or verbal representations (Townsend and Kahn 2014).

One of the key tenets of a successful decision-making process is a knowledgeable group of participants. When working with the public, there is the need to translate complex technical ideas into language and decision-relevant information that can allow people without technical expertise to meaningfully consider technical information (Gregory et al. 2012). Visualizations can help facilitate dialogue and develop mutual understanding amongst the group. The visual tools used in this research were aimed to help foster insights not accessible through other, often more quantitative approaches to communicating information.

When discussing a dam, there is the need to understand the site at multiple scales to understand the full ecological impact of a dam on the watershed. This multiscalar understanding is key to helping individuals understand the larger impact of the decision at hand including the upstream and downstream impacts of the barrier. In addition, there is the need to build an understanding of the various dam alternatives, their efficacy, and their potential visual impact to the cultural landscape.

It is important to include the public in dam-related decisions for multiple reasons. Dams often have a significance in the communities in which they exist, e.g., with the change in landscapes over different views and environmental amenities, such as recreation and water sport (fishing). In addition, changes can affect how valuable the dam location is to the public and as such it is important to get the community's feedback in decisions to balance the cost of dam site remediation with the benefits from differing landscapes.

Although there is growing agreement on the importance of engaging citizens in the planning of restoration projects, it is unclear how best this should happen and what form it should take (Fox and Cundill 2018). One of the best ways to incorporate social dimensions into river restoration projects is through direct community participation throughout the restoration planning process (Stringer et al. 2006, Weng 2015, Fox and Cundill 2018). Stringer et al. (2006), summarize some of the values of community engaged restoration projects including: providing insight into local social, ethical, and political values; providing opportunities for social learning; and leading to broader acceptance, legitimacy, and support of the planning process and final decision. Although it is the dam owner or elected officials who may have legal authority to make the final decision about a dam, there have been numerous cases that show that lack of public support "can make or break a restoration opportunity" (Johnson and Graber 2002:1). In the paper, "You kill the dam, you are killing a part of me," Fox et al. (2016), estimate that around 50 dams that were identified for potential removal have been "stalled or delayed due to opposition on a variety of grounds."

The literature on non-market valuation, methods to recover values for goods without market prices, has underutilized visualization as a technique to explore how different forms of the same information affect choice and valuation (Shr et al. 2019). Few choice experiments have systematically tested how visualization affects willingness to pay for land-use changes or environmental attributes. The lack of choice studies on visualization makes it difficult to assess if simpler forms of information transmission (e.g., text or images) are robust to the inclusion of more helpful but costly video or virtual reality modes. Moreover, existing studies testing visualizations in choice experiments have found mixed results with potential trade-offs. Some studies find visualizations of future alternatives in choice

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experiments to increase the participant's ability to comprehend information as indicated by a reduction in gain-loss asymmetry (Bateman et al. 2009, Matthews et al. 2017) and reduction of hypothetical bias (Fang et al. 2021).

We make two key contributions to the literature on the effect of visualizations on environmental public preferences. First, we use video and images as separate treatments in the same choice experiment to compare their effects directly, whereas others have used only images (Shr et al. 2019) or virtual reality (Batemen et al. 2009, Patterson et al. 2017). Matthews et al. (2017) examine the willingness to pay for different coastal erosion management alternatives and find a better in-sample predictive power in the choice experiment containing video treatment. Bateman et al. (2009) use virtual reality to compare the magnitude of asymmetry between willingness to pay (WTP) and willingness to accept among the numeric, virtual reality, and numeric with virtual reality treatments. They conclude that the virtual reality treatments attenuate loss aversion and reduce the variance in WTP. Other studies, such as Patterson et al. (2017) and Rid et al. (2018) have used three-dimensional (3D) films in their choice experiment survey to obtain visual treatment effects. Shr et al. (2019) use visual representations in a choice experiment survey to value landscape attributes in green infrastructure and find that providing images over the text-only option helps participants better focus on the attributes.

Second, this study is conducted in the context of decisions on the future of an aging dam in New England, which is becoming a prevalent and complex issue in the U.S. Specifically, it informs policy makers that the mode of information presentation is critical to dam removal or dam alteration decisions by communities. There are over two million dams in the U.S., a large majority are small and over a century old (Smith et al. 2002), such as the dam in our study. With growing interest in restoring river systems for fish habitat, over 1400 dams have been removed in the U.S. (American Rivers 2018). These decisions, however, can be controversial because of the trade-offs involved. Studies have shown that although removing a dam may have the ecological benefits of restoring a river system, it may permanently take away opportunities for renewable energy (Magilligan et al. 2016). Communities may also perceive a dam as part of the historic cultural landscape and have an emotional attachment to a dam, leading their decisions to ultimately be governed by emotion over science (Fox et al. 2016). Moreover, alterations to dams, including removing the dams, can involve large, semi-permanent alterations to the riverine landscape, creating a complex decision context for the public. To the best of our knowledge, only a few studies have examined the preferences for alternative dam management other than dam removal (Song et al. 2019, Weir et al. 2020). To assist with this decision-making process, we test different modes of information to obtain valuations for multiple dam choice alternatives.

We tested how visualizations affect residents' preferences and values for alternative dam management options and related attributes for a historic New England dam. We designed a between-subjects experiment with a labeled choice experiment to examine the effects of visualization in the context of three treatments: text-only (control group), images with text (henceforth image treatment), and video with text (video treatment). We conducted this study of an aging dam in a New England community that requires decisions about its future. The alternatives include removing the dam; altering the dam to enhance fish habitat; and keeping and repairing the dam to its original state. Our primary hypothesis was that the mode of information delivery about dam removal will impact the valuation of specific alternatives. Our design allowed us to test if the mode of information affects the WTP for dam alternatives and attributes.

STUDY AREA

Our study area is the city of Keene in New Hampshire that contains a small dam found along the mainstem of the Ashuelot River called the West Street dam. Faulkner and Colony mills built the West Street dam in 1775 to supply power to the mills. This dam is 4.8 meters tall and has a 41-meter-long spillway made from cut masonry stone. There is a 518-meter-long earthen dike upstream of the spillway that extends along the western edge of the river. Although micro hydropower is an option for the dam, it is not financially feasible for the dam to generate hydropower (Ropeik 2018). The upstream wetlands created by the impoundment are wetland habitats for rare and endangered species such as the dwarf wedge mussels. Moreover, the dam, the reservoir, and the adjacent Ashuelot River Park provide an opportunity for several recreational activities such as kayaking, hiking, fishing, and bird watching for Keene residents[1]. In 2008, the City of Keene received a Letter of Deficiency (LOD) from New Hampshire, Department of Environmental Services (NHDES) Dam Bureau regarding the West Street dam. This letter highlights three significant concerns about this dam. First, there is water leakage around the gates, which is a common problem among aging dams. Unchecked water leaks can eventually lead to dam failure. Another issue raised is that the inoperable pond drains may fail to open or seize and fail to close, leaving the pond to drain out gradually. The last issue listed in the LOD was the vegetation growing on the earthen dike that can cause serious structural deterioration and distress and eventually lead to the earthen dams' failure.

In 2008, city officials and other community[2] members explored potential future options for this dam. They hired a private firm, VHB[3], to prepare a technical report that describes the feasibility of removing the dam, repairing the dam, or developing a hydropower facility. Although it was determined that hydropower is not financially feasible, the findings from this report on the hydrological and ecological impacts of removal were used in our research. Further investigation was conducted on-site by a team of researchers[4]. The findings from this site assessment report provide adequate background on plausible dam management options and how it affects the ecology, flood levels, and water quality surrounding the dam. We used both the VHB technical report and the site assessment report to identify the dam alternatives and attributes in the choice experiment. In this study, we examine the residents' preferences for the following five alternatives of the West Street dam:

1. Keep and repair the dam: The first alternative is to keep the dam after repairing all the issues identified in the LOD. In this case, the dam's historic structure remains visible and the surrounding wetland habitat stays unaffected. However, there would be no fish passage or habitat connectivity up

and downstream of the dam. And while it is one of the least expensive alternatives in the short term, this alternative would require long-term maintenance.

2. Technical Denil fish ladder: The second alternative is to add a technical Denil fish ladder. This allows limited fish passage and habitat connectivity up and downstream of the dam. Although the dam would still be visible, a portion of it would be blocked by the Denil fish ladder.
3. Nature-like fishway: The third alternative involves gradually increasing the elevation of the river downstream of the dam through a series of rock pools. Nature-like fishways provide improved fish passage and habitat connectivity up and downstream, but the dam is no longer visible.
4. Pool and weir bypass channel: In the fourth alternative, a channel is constructed to the west of the dam to bypass the dam and connect the river upstream of the dam to the river downstream of the dam. In this case, the dam would remain in place without obstructing its view.
5. Remove the dam: Dam removal provides full habitat connectivity and fish passage up and downstream. A portion of the dam structure could remain on either side of the river channel to mark the dam's historic location. As a result of removing the dam, the upstream water elevation would be lowered, potentially draining the upstream wetlands, impacting rare species in the wetland, and reducing the impoundment's recreational opportunities. Although this alternative is more expensive up-front there is no long-term cost or maintenance required once the dam is removed.

The three alternatives (2–4) involve upgrading or modifying the dam after undertaking the necessary repairs. Higher upfront cost, along with long-term maintenance, makes them relatively more expensive. In the alternatives (1–4), the upstream water elevation would remain the same, maintaining the park's wetlands and recreational opportunities.

METHODOLOGY

We use a labeled choice experiment to understand how site-specific dam alternatives are valued under different visual modes of delivery. In labeled choice experiments, each dam alternative in a choice set has a label that depicts a policy scenario, a location, or a brand name. The labels in the choice experiment represent the five management options applicable to the West Street dam. Previous studies testing visualizations use unlabeled choice experiment designs, where they listed the policy options without descriptive labels (Bateman et al. 2009, Matthews et al. 2017, Shr et al. 2019). Defining each choice alternative with a label is expected to increase the model's predictive validity because it is more relatable to an actual policy scenario (Blamey et al. 2000). Also, labels allow a recoverable value for options rather than only for the attributes. In the non-market valuation literature, studies often use labels to represent locations to account for spatial heterogeneity (Upton et al. 2012, Lizin et al. 2016).

We obtained Institutional Review Board approval for all content in the flyer, email invite, survey invitation, focus group questions, as well as for the survey itself. The survey began with an informed consent form and for the focus group we obtained signed consent forms from each participant. We recruited 302 residents of Keene, NH for the survey using flyers, invitation cards, and emails. The survey was deployed online using Qualtrics.

Visualization treatments

We construct two types of visual treatments: rendered still images and a video. The first visual treatment involved using three-dimensional (3D) visualizations of the dam alternatives (Appendix 1). Within this treatment, two types of images were used to describe the alternatives. The first image type was a photo-realistic image at eye-level that aimed to give the viewers a sense of the physical, experiential, and aesthetic qualities of the alternatives (Appendix 1, right images). The second image type was a bird's-eye-view diagram that aimed to provide a larger geographic frame and understanding of how the alternatives would impact the river upstream and downstream of the dam (Appendix 1, left images).

Both visuals were developed using data available from GIS (Geographic Information Systems) and the City's computer-aided design file that was then modeled in the 3D modeling program, Rhinoceros. Water elevation data was brought in from the VHB technical report to model the projected impact of removal on the water elevation. Once the physical landscape features were modeled in Rhinoceros, two views were exported for the final visualizations. The eye-level view was brought into Adobe Photoshop to add photographs of the surrounding context and textures that could capture the material qualities of the projected future landscapes. The bird's-eye-view diagram was rendered in Rhinoceros using VRAY before being exported. Both the bird's-eye-view and the eye-level view were brought into Adobe InDesign to provide annotations of the alternative's various impacts.

The second visual treatment was a six-minute video.[5] This video had three sections. The first section provided a broad regional context about dams. The second visual treatment was a six-minute video. The video was produced using Adobe After Effects and offered a voice-over guided narration to communicate key issues at the regional, watershed, and site scale. This video had three sections. The first section provided a broad context about dams in New England and its functional use. The impact these dams have as a potential source of energy and freshwater and the role it plays in obstructing migratory fish passage and implications behind its aging infrastructure were included in this section. The second section included information about the watershed, river, and downstream dams surrounding our study area (West Street Dam in Keene, NH). The third section showed the two images (eye-level and bird's-eye-view) and descriptions of the five dam alternatives. We maintained consistency of information across all three treatments by ensuring that the video's narration exactly matched the text used in both text-only and the text with image survey. For the first two sections of the video (regional and watershed-scale) the information was communicated through 2D maps created using GIS software. For the third section, the same 3D images that were used in the image treatment were used for the video. In addition, during the transition from the regional scale to the site scale, drone footage provided a visual image of the surrounding site context. The video allowed for a panoramic view of each alternative that moved in a way that images do not capture. Video may allow subjects to process the information in a different way than still images allow. We acknowledge that there

Table 1. Attributes and attribute levels used in the choice experiment.

Attributes	Dam Alternatives	Attribute Levels
Percentage increase in fish passage up and down the stream	Repair	0%
	Bypass, Fishway and Ladder	30%, 40%, 50%, 60%, 70%
	Remove	90%, 100%
The acreage of upstream wetland	Repair, Bypass, Fishway and Ladder	36 hectares, 39 hectares, 42 hectares
	Remove	26 hectares, 31 hectares
Visibility of historic dam structure	Repair	100%
	Bypass	90%, 100%
	Ladder	60%, 70%, 80%
	Fishway and Remove	0%, 10%, 20%, 30%
Number of recreation days per year	Repair, Bypass, Fishway, Ladder and Remove	60 days, 92 days, 153 days, 184 days
Percentage of the total cost funded by external sources	Repair	0%
	Bypass, Fishway and Ladder	30%, 40%
	Remove	80%, 90%
Annual cost per household	Repair	$20, $25, $30, $35, $45
	Bypass, Fishway and Ladder	$25, $30, $35, $45, $65, $75, $80, $90
	Remove	$15, $20, $25, $30, $35

may be differences based on narration versus text, or other information based on the scale of images.

Attributes

The six attributes in the choice experiment were: percentage increase in movement of fish passage up and down the stream, preserving wetland habitat, percentage of historical dam structure's visibility, the annual number of days available for access to recreational activities (mostly water sports since activities such as hiking and birdwatching remain unaffected), the percentage of the total cost funded by external sources, and the annual cost per year. These attributes were selected for the choice experiment based on previous literature on projects related to dams (Song et al. 2019; B. Blachly and E. Uchida 2020, *unpublished manuscript*), minutes from previous public meetings, a steering committee of town officials and regional experts, and a focus group session conducted with residents from Keene, NH. The focus group discussion, hosted at the local public library, provided information on the type of attributes related to the West Street dam that are valued by the residents of Keene. More details of the focus group are available in Appendix 2. The actual costs for each time are adjusted to current value using the consumer price index. In addition to valuing the aesthetics associated with wetland habitat and the recreational activities surrounding the dam, participants also expressed the importance of this dam to Keene's history and culture.

We assigned levels associated with each attribute based on the VHB technical report and from other on-site investigations conducted as a part of the multi-state New England Sustainability Consortium (NEST) research project known as "The Future of Dams"[6] (Hubbard 2018, Ropeik 2018). The attribute's levels were categorized into separate ranges to emulate a realistic scenario for each dam alternative label as shown in Table 1 (Adamowicz et al. 1998). For instance, the alternative to keep and repair the dam (repair) is the least-cost option with no fish movement, lack of funding sources, better visibility of the dam's historic structure, and more wetland area relative to dam removal. Removing the dam (remove), on the other hand, promotes fish passage, reduces the wetland area, has more funding opportunities. The attributes for the three dam modification alternatives pool and weir bypass channel (bypass), nature-like fishway (fishway), and technical Denil fish ladder (ladder) are based on the site assessment report and consultations with experts in this field[7].

The site assessment report provided information on wetland acreage upstream and how they differed with dam modification and/or removal options. The attribute representing recreation captured the number of viable days for hiking, birdwatching, canoeing, kayaking, swimming, and fishing. The number of recreation days per year were calculated based on the average air and water temperature, precipitation, and water elevations for the study area. The information on weather for Keene, NH, were obtained from NOAA's (National Oceanic and Atmospheric Administration) National Centers for Environmental Information (NCEI)[8]. Because of the dam's small size, findings from the technical report revealed a limited change to water elevation. Therefore, no alternative specific ranges are provided for this attribute. However, the focus group findings reveal that this dam has a high recreational value. A common perception among Keene residents is a loss in recreation opportunity if the dam is removed or altered. The attribute for funding was introduced as a within-subject treatment. Each respondent was presented with the same choice experiment question twice, one with no information about the percentage of cost covered by external funding sources and the other with the information about the percentage of cost covered by external funding sources.

The choice experiment was designed using Ngene software with a Bayesian efficient design following the framework adapted from Scarpa and Rose (2008) that minimizes the D-error for a multinomial logit model. In designing a discrete choice experiment, analysts can choose from a suite of design approaches (Johnston et al. 2017). For experiments with five or more attributes with two or more levels, a full factorial or a fully orthogonal design and balance are not practical or desirable (Lancsar and Louviere 2008). In such cases, experiments can be designed using a D-efficient design, which increases the precision of parameter estimates while allowing some limited correlation between attributes (Johnson et al. 2013). Among the D-efficient designs, the Bayesian efficient design is appropriate when the parameters are not known with certainty, but reasonable assumptions can be made about the probability distributions of the parameters (Bliemer et al. 2008). The prior estimates and expected signs of parameters used in this design were based on literature review and the focus group findings. Conditional constraints were included in the design to account for the varying attribute levels according to the dam alternative. The design generated 24 choice sets categorized into four choice set groups. Each survey participant was asked to make 12 decisions corresponding to six pairs of choice sets (each pair containing one with funding attribute and one without the funding attribute). The option to keep and repair the dam (or repair), the status quo alternative, was present in every choice set. Figure 1 provides an example of a sample choice set. Summary statistics show that the collected survey dataset's demographic distribution reasonably resembles the population estimates for Keene from the U.S. Census (Table 2) compared to the census districts in the study area.[9] We find that many residents are familiar with this dam and are aware of the debate about its future. Additional details on the survey design and recruitment can be found in Appendix 2.

Fig. 1. Sample choice experiment.

DAM ALTERNATIVE	Repair Dam	Fish Ladder	Nature-like Fishway
FISH PASSAGE percentage increase in fish passage up and down the stream	0%	30%	60%
WETLAND area of upstream wetlands	42 hectares	36 hectares	39 hectares
VISIBILITY OF HISTORIC DAM STRUCTURE percentage of dam structure visible	100%	80%	10%
RECREATION DAYS PER YEAR number of days available per year for water sports	153 days	184 days	92 days
FEDERAL FUNDING. percentage of total cost funded by external sources	0%	40%	40%
ANNUAL COST TO YOU amount paid each year for the next 5 years	$20	$65	$75

Table 2. Socioeconomic characteristics of survey participants (in percentage).

Variable	Percentage	Survey Sample (n = 302)	U.S. Census Bureau (N = 23,056)
Gender	Male	46.7	47.1
Income groups	Less than $25,000	10.1	10.8
	$25,000 to $49,999	17.1	13.2
	$50,000 to $74,999	19.8	23.4
	$75,000 to $99,999	22.8	17.7
	$100,000 to $149,999	15.8	17.8
	$150,000 to $199,999	7.7	8.6
	$200,000 or more	6.7	8.6
Education	High school or higher	97.3	93.2
Employment	Employed	54.9	60.1
	Unemployed	0.99	2.9
Housing Tenure	Renter-occupied	33.7	46.4
	Owner-occupied	65.6	53.6
Age	Median	47	36

Notes: The third and fourth columns are in percentage except for *Age*, which is the median. The population statistics are derived from the U.S. Census Bureau (2018). Since our data only includes those who are at least 21 years of age, we expect a variation in median age between our sample and ACS.

Econometric model

The discrete choice modeling approach used in this study is based on the random utility framework adapted from McFadden and Train (2000). The random utility theory presumes that an individual compares the expected utility among the given set of alternatives and chooses the alternative, which provides him with maximum utility (McFadden 2001). The utility function for individual *n* when choosing the alternative $j \in \{1, ..., J\}$ from a choice set $t \in \{1, ..., T\}$ depends on observable (or deterministic) and unobservable (or stochastic) components:

$$U_{njt} = V_{njt} + \epsilon_{njt} \tag{1}$$

The unobservable random component, ε_{njt}, is assumed to be identically and independently distributed (iid) and follows the extreme value type 1 distribution (Hensher and Greene 2003). The observable component in the utility function, V_{njt}, is a linear additive combination of explanatory variables (x) that determines the utility of the chosen alternative. The standard logit probability, conditional on the coefficient vector β_n, for the multinomial logit specification for individual *n* choosing alternative *k* among the *j* alternatives, where $j,k \in \{1, ..., J\}$, in choice set *t*, is provided in equation 2:

$$L_{nkt}(\beta_n) = \frac{\exp(V_{nkt})}{\sum_{j \in jnt} \exp(V_{njt})} \tag{2}$$

To accommodate correlations across choices made by the same individual and to account for individual heterogeneity, we use a panel mixed multinomial logit model. Panel models are often used in longitudinal data sets where repeated choices made by the same person are recorded. This method, also called the error-component logit, relaxes the assumption that choices are independent within the same individual (Revelt and Train 1998, Scarpa et al. 2005, Greene and Hensher 2007, Bliemer and Rose 2010). The mixed logit probability is defined as the integral of the conditional probabilities over the distribution density of parameters. The parameters are estimated by maximizing the simulated log-likelihood function, where the likelihood function is the joint density of conditional probabilities sampled across the choice sequences (Revelt and Train 1998).

The mixed logit probability is provided in equation 3:

$$P_{njt} = \int \prod_{t=1}^{T} (\beta_n) f(\beta) d\beta \quad (3)$$

By including the mixing distribution, $f(\beta)$, we assume that the coefficient estimates of the attributes vary across individuals (Train 2003). The explanatory variables specified in the observed component include binary indicators for each dam alternative (D_{alt}), the attributes used in the choice experiment (X_{att}), and binary indicators representing visual and funding treatments (D_T). To test the treatment effects on the choice of dam alternative, we interact the binary indicators for each alternative with the treatment indicators.

The general utility specification for our model is defined as:

$$U_{ijt} = \beta_c Cost_{ijt} + \beta_0 D_{ALTj} + \beta_T D_{ALTj} D_T + [\beta_{att} X_{att}][\mu_{ijt} + \sigma_i] + \epsilon_{ijt} \quad (4)$$

The β's (apart from the cost coefficient) represents a vector of coefficients where β_0 is the vector of alternatives specific constants (ASC) pertaining to each dam alternative, β_T represents image, video, and funding treatment effects and β_{att} are coefficient estimates for attributes. In our analysis, we specify all attributes used in the choice experiment as random parameters while keeping the remaining variables including cost as fixed. The application of mixed logit allows us to estimate mean (μ) and standard deviation (σ) for the random parameters. In discrete choice models that use conditional probabilities, only variables that vary across choice within a group (individual) can enter directly into the utility function. Because the treatment dummies are constant across individuals (like socio-demographic variables, they do not change across choice for an individual), therefore they can only enter the utility as interactions.

The coefficient estimates obtained from discrete choice models are then used to derive welfare measures. Given the linear nature of parameters and assuming constant marginal utility for price (or cost coefficient), we estimate the willingness to pay (WTP) for a unit change in an attribute (x) by taking the negative ratio between the coefficient estimate of the attribute and the cost coefficient as provided in equation 5:

$$WTP = -\frac{\beta_x}{\beta_{cost}} \quad (5)$$

We use the delta method to estimate the confidence intervals for the welfare measures (Hole 2007, 2016, StataCorp 2019). The estimated marginal welfare amounts for each attribute are expressed in dollars per household per year. We calculate the willingness to pay for an attribute taking the ratio of the coefficient of the attribute of interest divided by the negative of the cost coefficient. Because most of the attributes do not vary across dam alternative (e.g., fish passage is always 90% for dam removal) we do not interact treatments with attributes.

The main hypothesis in this study is to examine the visual treatment effects. Based on the framework provided in equation 4, we define our hypothesis as: $H_A : \beta_{MT,} \beta_{VT} \neq 0$, where β_{MT} and β_{VT} are the estimated image and video treatment effects, respectively. We assess the difference between text and image treatment groups as well as between text and video treatment groups by interacting the indicator for dam labels (D_{ALT}) with the image (D_{MT}) and video (D_{VT}) treatment indicators ($D_{MT,} D_{VT}$ are included in D_T). The text treatment group is used as the base category in this model.

Given the severity of dam conflicts in New England, this research provides insight on residents' value toward attributes and different management options available for a dam in their neighborhood with the estimated ASCs ($\beta_{0j} \neq \beta_{0k}$; j $\neq$ k) and attribute effects ($\beta_{att} \neq 0$). The ASCs (β_0) are estimated by including dam alternatives as labels in the choice experiment representing the marginal utility or preference for the alternative j, over the status quo alternative to repair and maintain the dam. We also explore funding treatment effects ($\beta_{F,} \beta_{FT} \neq 0$) where we interact D_{ALT} with the binary indicator for the within-subject funding treatment group (D_F). In this specification, we include D_F and an additional attribute X_F denoting the "percentage of cost covered by external funding sources," to equation 4.

To explore variation among residents' preferences, we attempt further interactions. Proxy variables that measure residents' connection, or place attachment, with the dam and study area are taken from the survey data and interacted with DALT to examine their effect on choice. The proxy variables are (i) the number of years the resident lived in the study area (ii) the level of knowledge the resident claims to have related to this dam, (iii) how often the resident sees the dam (iv) how often the resident visits the dam, and (v) the level of attachment the resident claims to have toward this dam. Survey questions used to obtain these variables are included in Appendix 4.

RESULTS

Main results

The parameter estimates from the mixed logit models with visual treatment effects based on equation 4 are provided in Table 3 (Model 1(b)). We find that introducing images in the choice experiment increases the marginal preference for dam modification alternatives, that is, fishway, ladder, and bypass, compared to the text treatment. In contrast, we find no statistically significant difference between the text and video treatment for the same alternatives. However, for the dam alternative, remove, we find no difference between text and image treatments but find a significant reduction in marginal utility in the video treatment.

The subsequent willingness to pay (WTP) estimates compared to the text treatment are calculated using the negative significant cost coefficient based on Model 1 in Table 3 and are provided in Figure 2. The vertical line parallel to y-axis in this figure represents the status quo alternative to keep and repair the dam to its original state. The significance mentioned in this figure is based on the confidence intervals estimated using the delta method and implies that the WTP calculated is significantly different from zero. Among the dam modification alternatives, the positive impact on WTP in the image treatment is the largest for nature-like fishway.

The WTP increases from $52 in the text treatment to $130[10] in the image treatment for fishway. The image treatment also increased WTP for a bypass channel from $45 for text treatment to $98 for image treatment. Likewise, the image treatment raised the WTP for the fish ladder from $71 with a text description to $107. An important finding with image treatment is the switch in most preferred dam alternatives from the Denil fish ladder to a nature-like fishway.

Table 3. Mixed logit results with treatment effects.

Variables	Model 1	Std. Err.	Model 2	Std. Err.
Cost ($)	-0.028***	(0.002)	-0.028***	(0.002)
(a) Attributes				
Fish Passage (%)	0.029***	(0.010)	0.028***	(0.010)
Wetland (acres)	0.029***	(0.009)	0.030***	(0.009)
Historical Structure (%)	-0.008	(0.007)	-0.009	(0.007)
Recreation Days	0.004***	(0.001)	0.004***	(0.001)
External Funding[1] (%)			0.011	(0.011)
(b) Standard deviation (S.D.) of random parameters				
Fish Passage (%)	0.108***	(0.008)	0.109***	(0.008)
Wetland (acres)	0.116***	(0.008)	0.117***	(0.008)
Historical Structure (%)	0.045***	(0.006)	0.046***	(0.005)
Recreation Days	0.016***	(0.002)	0.016***	(0.002)
(c) ASCs associated with binary indicators for each dam alternative (D_{ALT})				
Bypass (Yes=1)	1.231***	(0.468)	1.154**	(0.475)
Fishway (Yes=1)	1.439*	(0.831)	1.144	(0.830)
Ladder (Yes=1)	1.955***	(0.459)	1.916***	(0.462)
Remove (Yes=1)	-2.051*	(1.094)	-2.417**	(1.098)
(d) D_{ALT} interacted with image and video treatment				
Image*Bypass	1.473***	(0.563)	1.498***	(0.561)
Image*Fishway	2.145***	(0.793)	2.177***	(0.782)
Image*Ladder	1.008**	(0.511)	1.025**	(0.506)
Image*Remove	1.256	(1.081)	1.294	(1.069)
Video*Bypass	-0.464	(0.526)	-0.462	(0.512)
Video*Fishway	-1.33	(0.883)	-1.334	(0.836)
Video*Ladder	-0.729	(0.502)	-0.731	(0.478)
Video*Remove	-2.919***	(1.126)	-2.940***	(1.086)
(e) D_{ALT} interacted with funding treatment				
Funding*Bypass			-0.177	(0.450)
Funding*Fishway			0.122	(0.469)
Funding*Ladder			-0.280	(0.427)
Funding*Remove			-0.286	(1.019)
Loglikelihood	-2335.95		-2328.72	
Observations	10,872		10,872	

Notes: Number of individuals = 302. The chosen dam alternative is the dependent variable and standard errors (Std. Err.) are in parentheses. ***, **, and * denotes significance at 1, 5, and 10%. We use standard normal errors for each random parameter.

The image treatment had no statistically significant treatment effect on WTP for dam removal, the video treatment reduced WTP from -$74 for the text description down to -$108 for dam removal. The full dam removal is less preferred than keeping and repairing the dam to its original state when based on the text or video treatments.

The estimated alternative specific constants (ASC) are statistically significant, indicating that the average WTP differs across dam alternatives (Table 3 (Model 1(c)). In general, we find the dam modification alternatives to be more likely chosen than the status quo option, i.e., to keep and repair the dam to its original state. This preference is denoted in Figure 2, where the WTP for all three dam modification options is to the right of the reference line indicating the status quo. The estimated WTP (text treatments in Fig. 2) is $71/household/year on average for the fish ladder, followed by nature-like fishway and bypass channel at $52 and $45, respectively. Conforming to early literature (Fox et al. 2016), we observe that dam removal is least preferred, with a negative WTP of -$74. A negative WTP is important economically because it ensures a preference ordering, rather than forcing WTP to be strictly positive. In our setting, it is perfectly rational for subjects to have negative or positive WTP because it is all relative to the default to keep and repair a dam. Apart from the switch in the most preferred dam alternatives, a general rank order of dam alternatives from most preferred to least preferred was found to be fishway or ladder depending on the presentation of choice, bypass, repair (status quo), and remove. We also provide an analysis of how valuations vary across resident's connectedness to the dam in Appendix 5. We have presented the differences from the perspective of the marginal willingness to pay. The differences found here would also be the same treatment differences to total willingness to pay for a dam alternative. For reference, the median annual cost to repair a dam is $30 per respondent.

Model 2(c) presented in Table 3 includes the funding attribute representing the percentage of the cost funded from external sources and the funding treatment effects on dam alternatives. External funding is found to have no significant effect on choice. We also find that the presence of funding does not impact the choice of dam alternatives as denoted by the insignificant effect in Table 3.

Our model assumes the cost variable to enter the utility function linearly. We test the assumption of a fixed cost parameter by estimating a random cost coefficient and find similar results in the Appendix 5. We also find that estimating the results in the willingness to pay space (Daly et al. 2012) and find consistent results.

WTP for attributes

We observe a positive marginal utility in most attributes (Table 3). The results reveal an important tradeoff when choosing a dam alternative between wetland habitat preservation and improving fish passage up and down the river. On average, the subjects are willing to pay $1.02 for a 1% increase in fish passage whereas for an additional acre of wetland, they are willing to pay $1.08 (Table 4). We also find the marginal WTP associated with an additional day of recreational activities is statistically significant ($0.15). Surprisingly, despite the West Street dam being identified as part of history for the city of Keene (Ropeik 2018), the marginal WTP estimate for the percentage increase in visibility of historic dam structure is insignificant.

We also find the presence of preference heterogeneity across attributes as denoted by their significant standard deviations. The presence of preference heterogeneity supports our use of the mixed logit model and leads us to further examine the effect of individual perception of connection to this dam and study area on the choice of dam alternative. Further results of this examination are presented in Appendix 5.

DISCUSSION

Our results suggest that visualizations play an important role in decision making around dams and affect the valuation of dam design options. Dammed landscapes are complex social and

Fig. 2. Willingness to pay (WTP) per year for different dam alternatives with visual interactions. Note: The confidence intervals are shown at the 95% level.

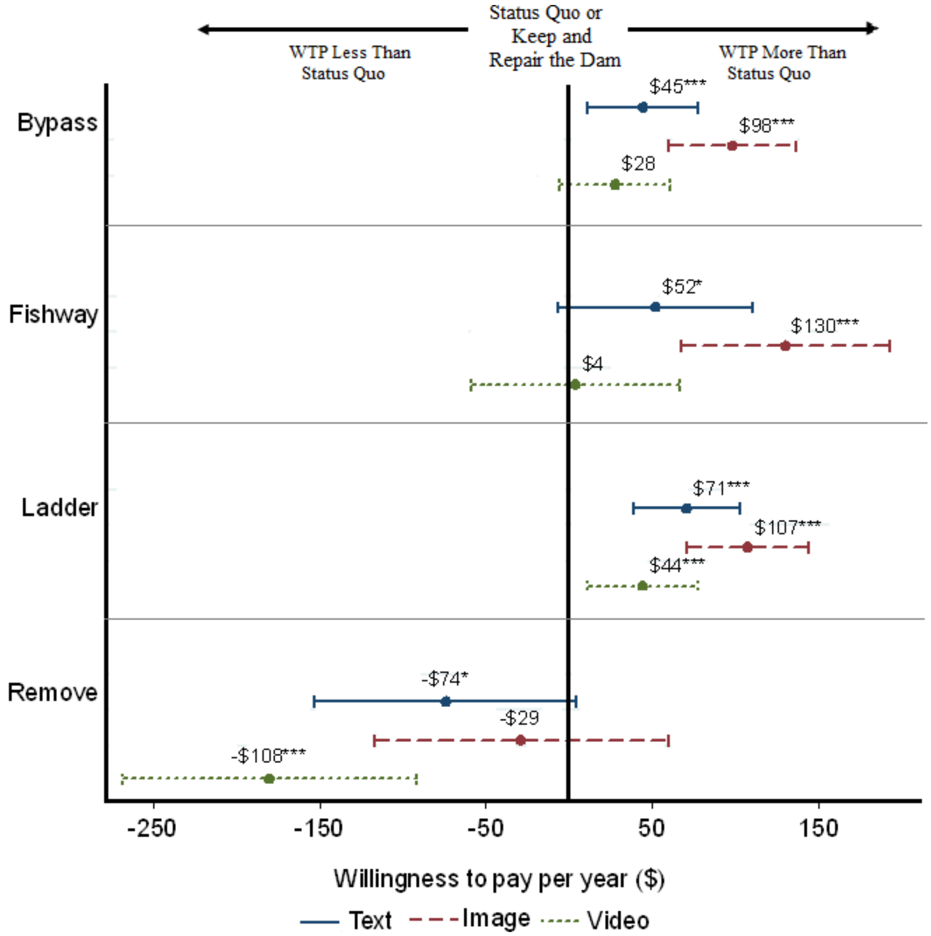

Table 4. Annual marginal willingness to pay (WTP) per household.

Attributes	Dollar ($) per unit
Percentage increase in fish passage	1.02***
Acreage increase in the upstream wetland area	1.08***
Percentage increase in visibility of historic dam structure	-0.32
Increase in available days for recreation	0.15***

Notes: WTP estimates are based on Model 2 from Table 3. ***, **, and * denotes significance at 1, 5, and 10%.

ecological systems where social dimensions such as history, aesthetics, recreation, and sense of place are intertwined with perceptions and values around nature and ecological services (Johnson and Graber 2002, Fox et al. 2016). When considering various dam alternatives, it is important to incorporate these multiple dimensions in the decision-making process. Within our study, the participants who received the text treatment were primarily responding to the effect of the alternative on the ecological and socioeconomic attributes and had to rely on their imagination. Visualizations help communicate the visual and aesthetic impact of the alternatives by encouraging a critical comparison between reality and the viewers' perception of these hypothetical future landscapes (Wissen et al. 2008, Salter et al. 2009, Lovett et al. 2015) and add to the degree of realism (Davies et al. 2002, Townsend and Kahn 2014, Shr et al. 2019).

Introducing images when describing dam alternatives allows survey respondents to focus more on the visually salient features present in each alternative when making choices (Rid et al. 2018, Shr et al. 2019). This may be the reason why dam alternatives, especially the modification alternatives, are given a higher preference in the image treatment. We find a switch in the most preferred dam alternative from the Denil fish ladder to nature-like fishway when introducing images. The use of images may have led to an improved understanding of the nature-like fishway, a less known dam alternative compared to Denil fish ladder (Wissen et al. 2008). Between 1992 and 2017, NOAA funded 85 Denil fish ladders and 17 nature-like fishways within the Northeast Region [11]. Some of the survey participants may have been more familiar with the fish ladder alternative, allowing them to imagine the fish ladder's visual impact with only the text description.

One of the key tenets of a successful decision-making process is a knowledgeable group of participants. When working with the general public, there is the need to translate complex technical ideas into language and decision-relevant information that can allow people without technical expertise to meaningfully consider technical information (Gregory et al. 2012). Visualizations can help facilitate dialogue and develop mutual understanding amongst the group. The visual tools used in this research were aimed to help foster insights not accessible through other, often more quantitative approaches to communicating information.

When discussing a dam, there is the need to understand the site at multiple scales in order to understand the full ecological impact of a dam on the watershed. This multiscalar understanding is key to helping individuals understand the larger impact of the decision at hand including the upstream and downstream impacts of the barrier. In addition, there is the need to build an understanding of the various dam alternatives, their efficacy, and their potential visual impact to the cultural landscape.

The video treatment with guided narration allowed respondents to retrieve information in a gestalt manner (Townsend and Kahn 2014). Similar to Shr et al. (2019) and Rid et al. (2018), we find no statistically significant differences between the estimates of this treatment and the text treatment for dam modification alternatives. The video treatment, however, reinforces the community's aversion to dam removal. The overall decrease in average willingness to pay for each dam alternative in the video treatment is contrary to the image treatment results. This divergent result may stem from the way respondents comprehend information retrieved from the video as opposed to images. The effect of video on WTP could have foundations from cognition, where the information presentation may affect how people process that information and imbed that information into economic preferences. This work suggests that being able to process dam alternatives through video visualization allows for a difference in preferences expressed in WTP. Another possible explanation behind the overall lower willingness to pay across dam alternatives in the video treatment might be that video may have drawn out respondent's true willingness to pay. Visual aids in decision making can help decision makers comprehend the decision task (Townsend and Kahn 2014). Stated preference methods such as choice experiments sometimes overstate the respondents' willingness to pay (Johannesson et al. 1998, Carlsson and Martinsson 2001, Lusk and Schroeder 2004), not that images cause an overstatement or bias, rather the video helps reduce stated preference bias in decision making.

We find that dam modification alternatives that improve fish passage while still maintaining the dam and impoundment are more preferred than the status quo option to keep and repair the dam to its original state. Although residents value migratory fish passage, dam removal, which is most suitable for fish passage, is consistently the least preferred alternative. This finding supports previous studies that suggest that resistance to dam removal is more than just an aversion to change, but rather in direct response to the perceived threat of removal to the historic cultural landscape and individual and collective sense of place (Devine-Wright and Howes 2010, Fox et al. 2016, Masterson et al. 2017). Whereas many decisions about dams tend to focus on the binary options of keeping or removing the dam, our study suggests the importance of introducing dam modification alternatives to achieve multiple objectives.

The visibility of the historical dam structure is insignificant for the West Street dam. Place attachment can extend beyond the visual to include other affective, experiential, and cognitive ways of relating to landscapes (Jorgensen and Stedman 2001, Browne 2007, Devine-Wright and Howes 2010, Fox et al. 2016, Masterson et al. 2017, Newell and Canessa 2018). Our findings are further supported by correspondence with Keene residents, via focus group sessions, that reveal the importance of their experiences with this dam such as fishing (often with family), swimming at the dam, eating lunch next to the dam daily, skating on the pond in the winter, canoeing, and duck races. Regarding any changes to this dam, the participants are concerned about how these recreational activities, experiences, and memories may be impacted when the change is made. Future work can explore the relationship between place attachment and historical landscapes surrounding dams using other measures of sense of place (Jorgensen and Stedman 2001, Devine-Wright and Howes 2010, Newell and Canessa 2018).

The study finds that the willingness to pay for dam alternatives is sensitive to the media used to communicate what those alternatives are. Although we cannot identify the "true" preferences for dam alternatives we suggest that dam removal discussion include visual representations of alternatives if possible. This may change the outcome of support for specific alternatives. Identifying the "true" preferences is particularly difficult because it may be conditional on information, such as additional visual information. Therefore, we cannot reject a set of survey responses as being inaccurate.

CONCLUSION

We find significant differences in the WTP for specific dam alternatives between the three modes of information. When images are used, the mean WTP is $56 higher compared to text-only for all dam alteration scenarios over keeping the dam, except for the scenario to remove the dam. Conversely, when a video is used, WTP is $34 higher compared to text-only for keeping and repairing the dam over removing the dam. Among all treatment groups, the image treatment has a higher WTP across all alternatives compared to the status quo option of keeping and repairing the dam to its original state. In comparison, the video treatment leads to lower WTP for all alternatives. However, not all coefficients for the video treatment are statistically significant, indicating high variability in the treatment effect. We also find a change in the preference ranking of dam alternatives in the image treatment. Although the subjects' true preferences and WTP are unknown, the results suggest that modes of information create significant differences in preference elicitation. Provided that visualization is enabling a better assessment of the available alternatives because of increased comprehension (Townsend and Kahn 2014), we expect this shift in valuation to be closer to the decision maker's true preference and ordering of alternatives.

Our study adds new empirical evidence to the choice experiment literature that providing visual representation of future alternatives makes statistically robust differences in the preference estimates. However, unlike Batemen et al. (2009) and Matthews et al. (2017), we found that increasing richness of the media (from image to video) does not lead to preference differences in the same direction. Moreover, our finding of high variability in the treatment effect of video is consistent with Eppink et al. (2019) who found that visualization led to less choice consistency. Although further research is needed, our results may be pointing to either cognitive overload of rich media (Townsend and Kahn 2014) or a more technical problem of subjects navigating through videos embedded in an online voice experiment.

Our study tests how modes of information delivery impact the willingness to pay for dam management alternatives. Our results confirm previous findings that the method of communicating information has significant impacts on non-market valuation in choice studies (Matthews et al. 2017, Rid et al. 2018, Eppink et al. 2019, Shr et al. 2019). Specifically, we find that location specific alternatives are salient to the mode of information delivery. Joining the emerging literature on visualization, our study provides support to dam policy makers who use visualization to help respondents value land use change and choose between specific alternatives. Given the sheer number of dam structures throughout the U.S. in need of repair or removal careful consideration must be given to how information is presented to stakeholders. Considering the differences in valuation of dam alternatives we suggest visualizations are used in future community outreach because it may provide a more comprehensive view of future site options.

Our study reinforces the need for credible and legitimate visualizations that can correctly capture the projected future alternatives. Because of the increased recognition accompanied by less reliance on idiosyncratic processing, visualizations help survey respondents better perceive the differences between each dam alternative and subsequent attribute levels. In addition, our findings are consistent with visualizations impacts valuations when the options are more unfamiliar. Incorporating visual representation of policy alternatives in a label choice experiment allows participants to make informed decisions that are likely to be closer to their true preferences (Blamey et al. 2000, Townsend and Kahn 2014).

By emulating actual dam policy scenarios as labels in a choice experiment, the findings from this research have valuable policy implications. In our experiment the video treatment induces a type of loss aversion for completely removing a dam. Drastic changes to landscapes may be difficult to envision in a textual or image processing, therefore video or other visual representations should be incorporated in drastic land use change scenarios. Visualizations of projects can allow policy makers to gain more accurate feedback about stakeholders' preferences and aid the process of land use management.

[1] This information was obtained from a focus group session and charrette conducted as a part of this research. The participants were members of the community in our study area, Keene.
[2] Group of residents from Keene formed the West Street Hydro Inc., a nonprofit organization, with the aim to investigate the possibility of developing a hydropower facility at the dam.
[3] Company website: https://www.vhb.com/
[4] West Street Dam Investigative report was prepared by a team of researchers from Keene State College (KSC) as part of the multi-state New England Sustainability Consortium (NEST) research.
[5] The video is available upon request from the authors. To make sure the video is completely watched by the participants in this treatment, we enforced a timer on the video section of the survey that allows them to move forward only after the video is finished.
[6] The project website: https://www.newenglandsustainabilityconsortium.org/dams
[7] Academic researchers who are a part of this collaborative project (NEST: Future of Dams) were consulted to provide an approximate range for attributes such as visibility, cost, external funds, and habitat connectivity for each dam alternative.
[8] The website: https://www.ncei.noaa.gov/ provides details about the NCEI and details about how to obtain weather data and information.
[9] Given that we used non-probability sampling, the sample is not representative of the study population in a statistical sense. In general, however, the stated preference literature has found that WTP for environmental goods and services tend to correlate with age and income. We therefore conjecture that the findings are generalizable to the limited study area.
[10] Change in WTP from text to video/image = WTP for text - WTP for video/image; both image and video treatments already contain text description so the change in WTP can be obtained by taking the direct difference between the two.
[11] This information is obtained from the NOAA database and was shared by an expert in this field as a part of this collaborative project (NEST: Future of Dams).

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Data Availability:

The data/code that support the findings of this study are openly available in figshare at https://doi.org/10.6084/m9.figshare.15023418.v1, and https://doi.org/10.6084/m9.figshare.15023436.v1. Ethical approval for this research study was granted by URI IRB 778925.

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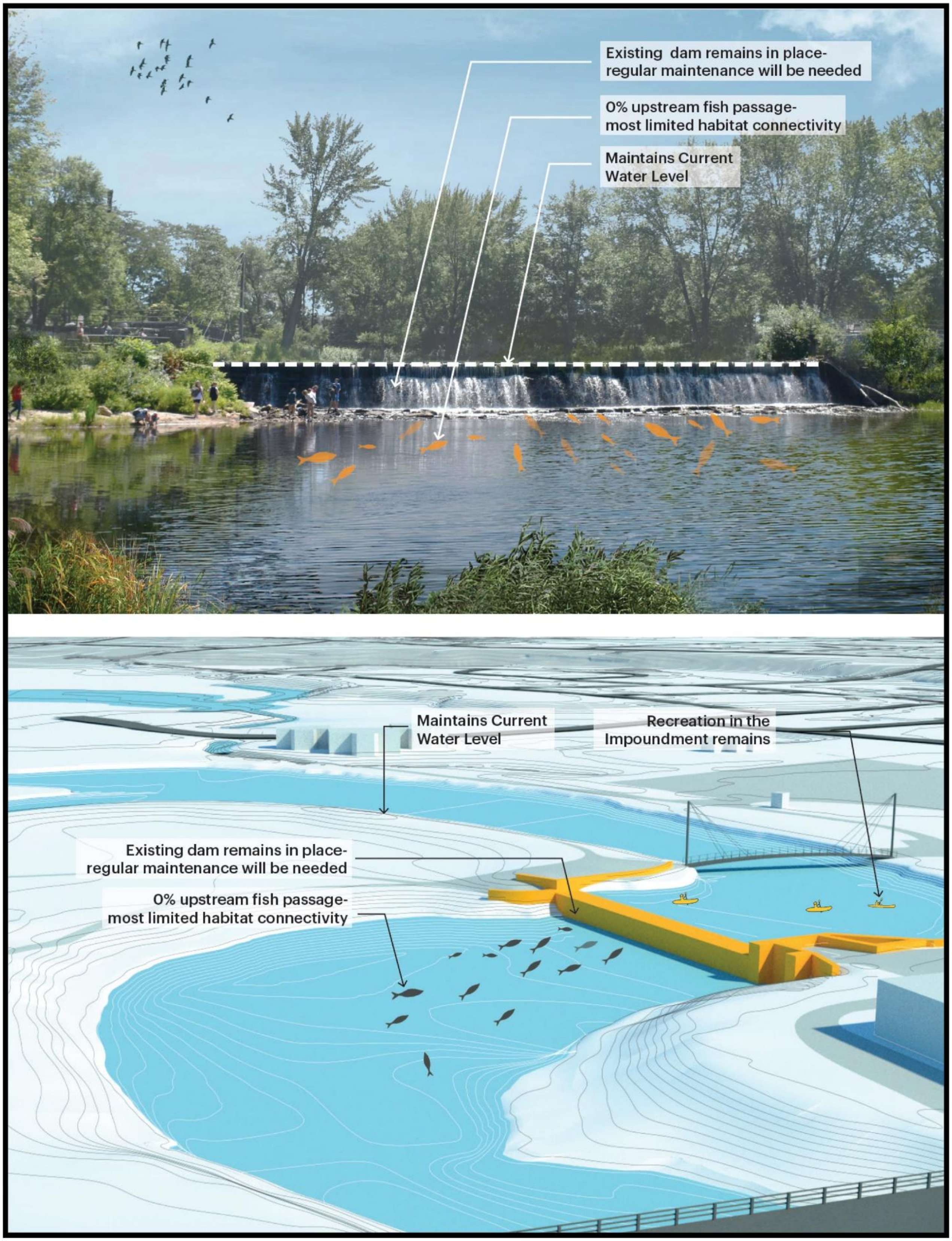
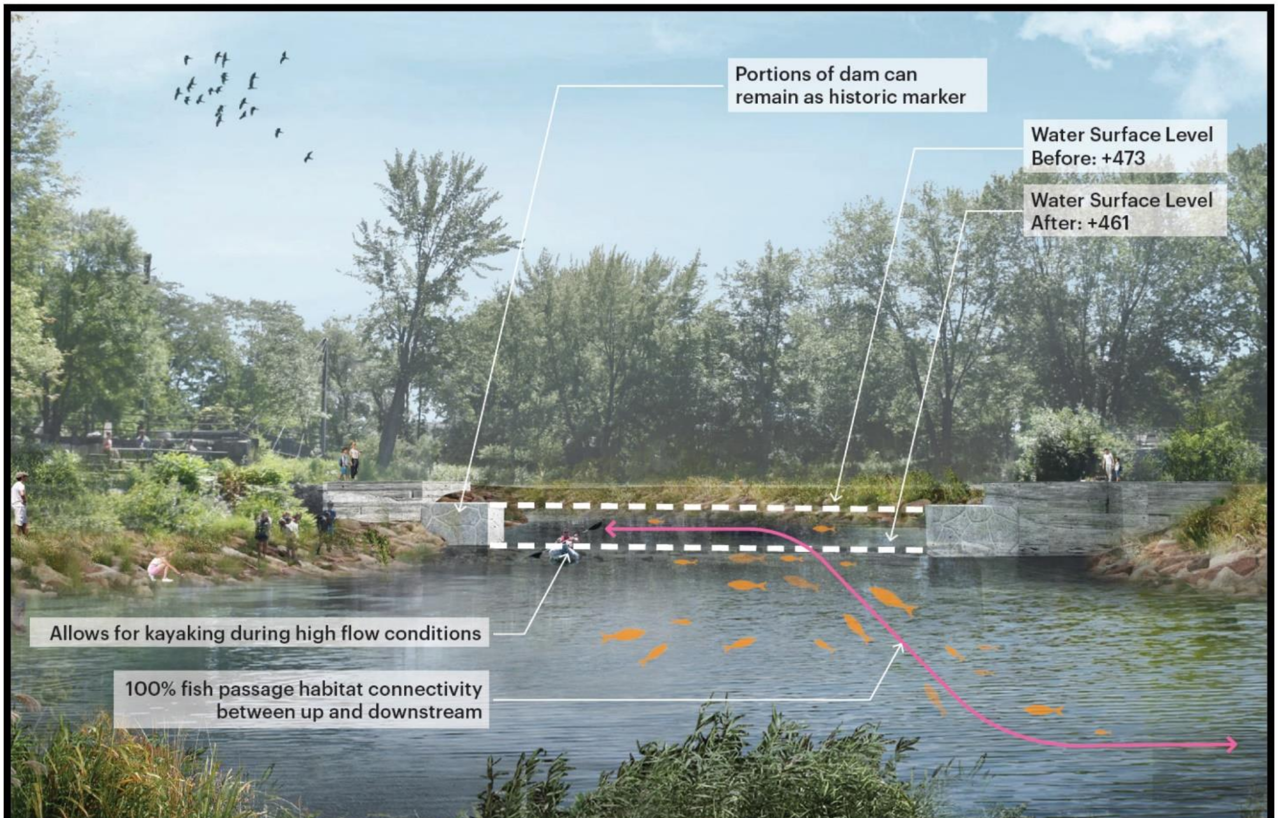
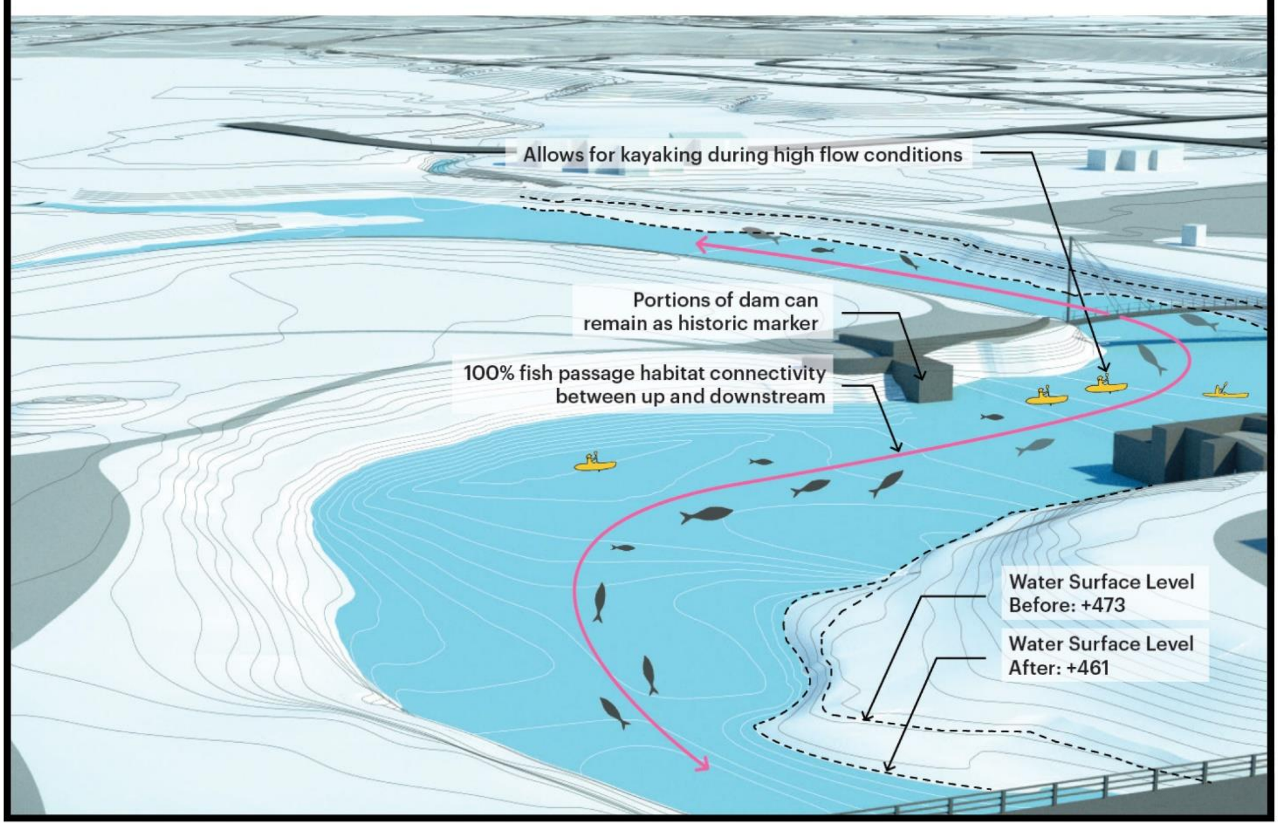
Appendix 1

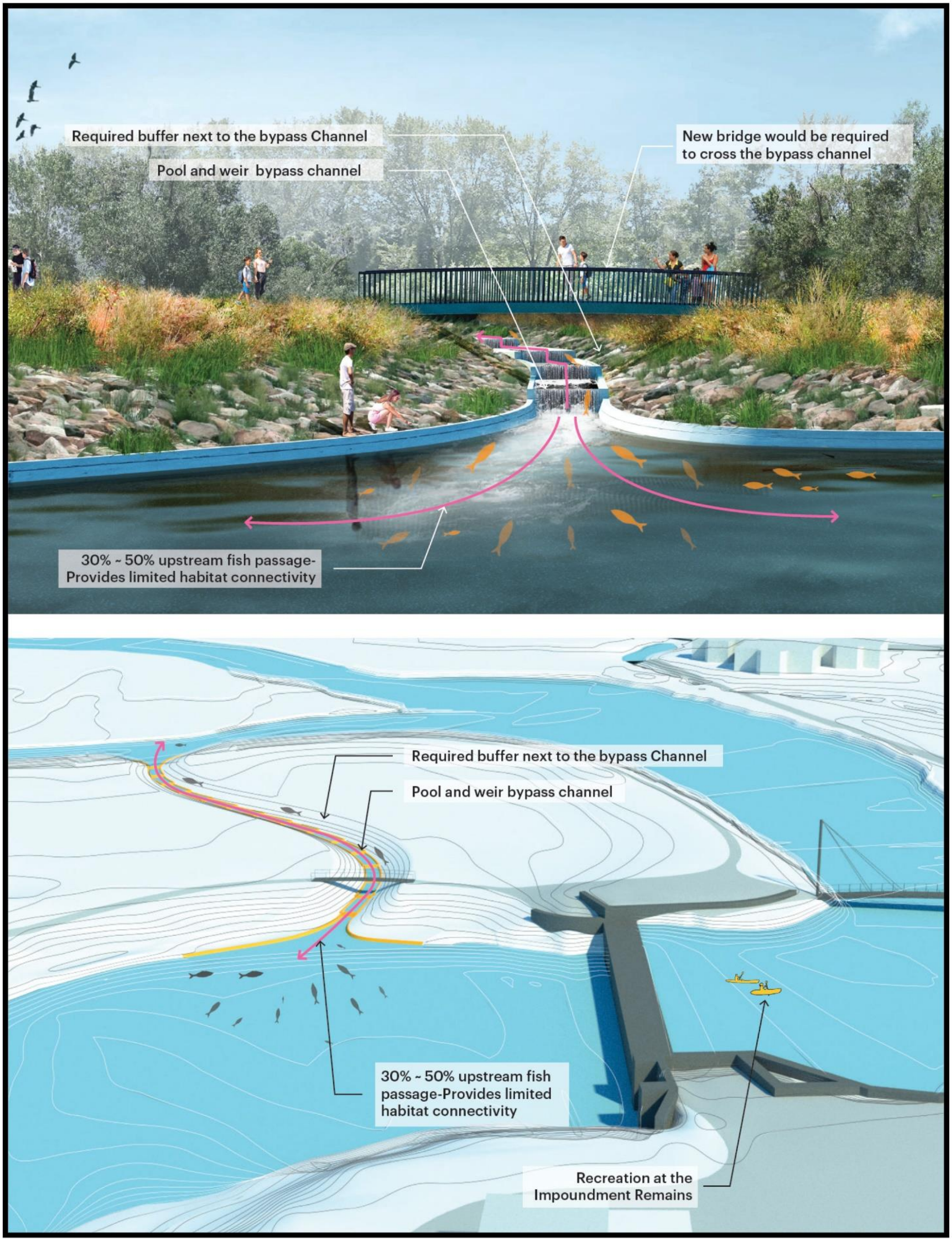


Repair Dam

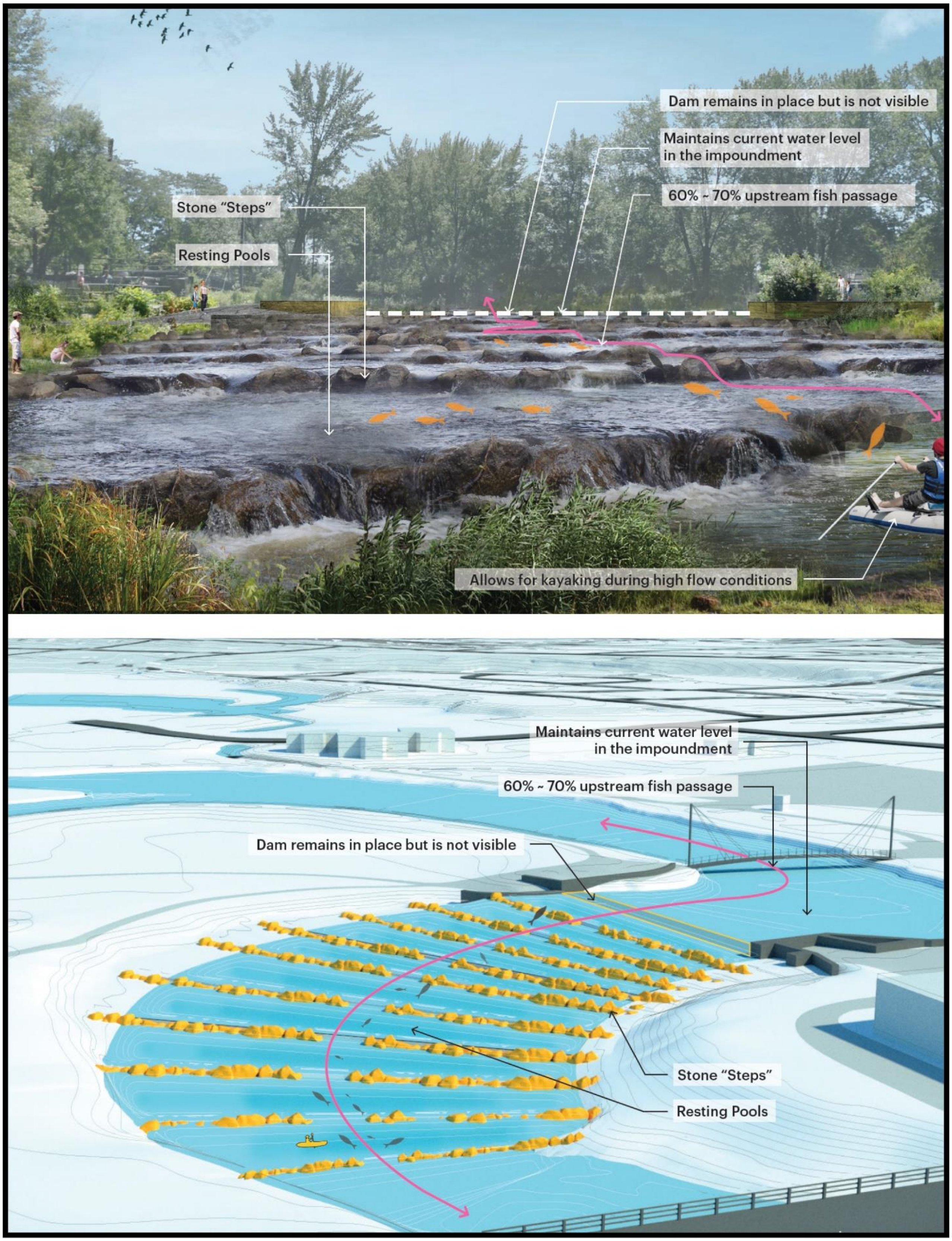

Portions of dam can
remain as historic marker
Water Surface Level
Before: +473
Water Surface Level
After: +461
Allows for kayaking during high flow conditions
100% fish passage habitat connectivity
between up and downstream


Allows for kayaking during high flow conditions
Portions of dam can
remain as historic marker
100% fish passage habitat connectivity
between up and downstream
Water Surface Level
Before: +473
Water Surface Level
After: +461

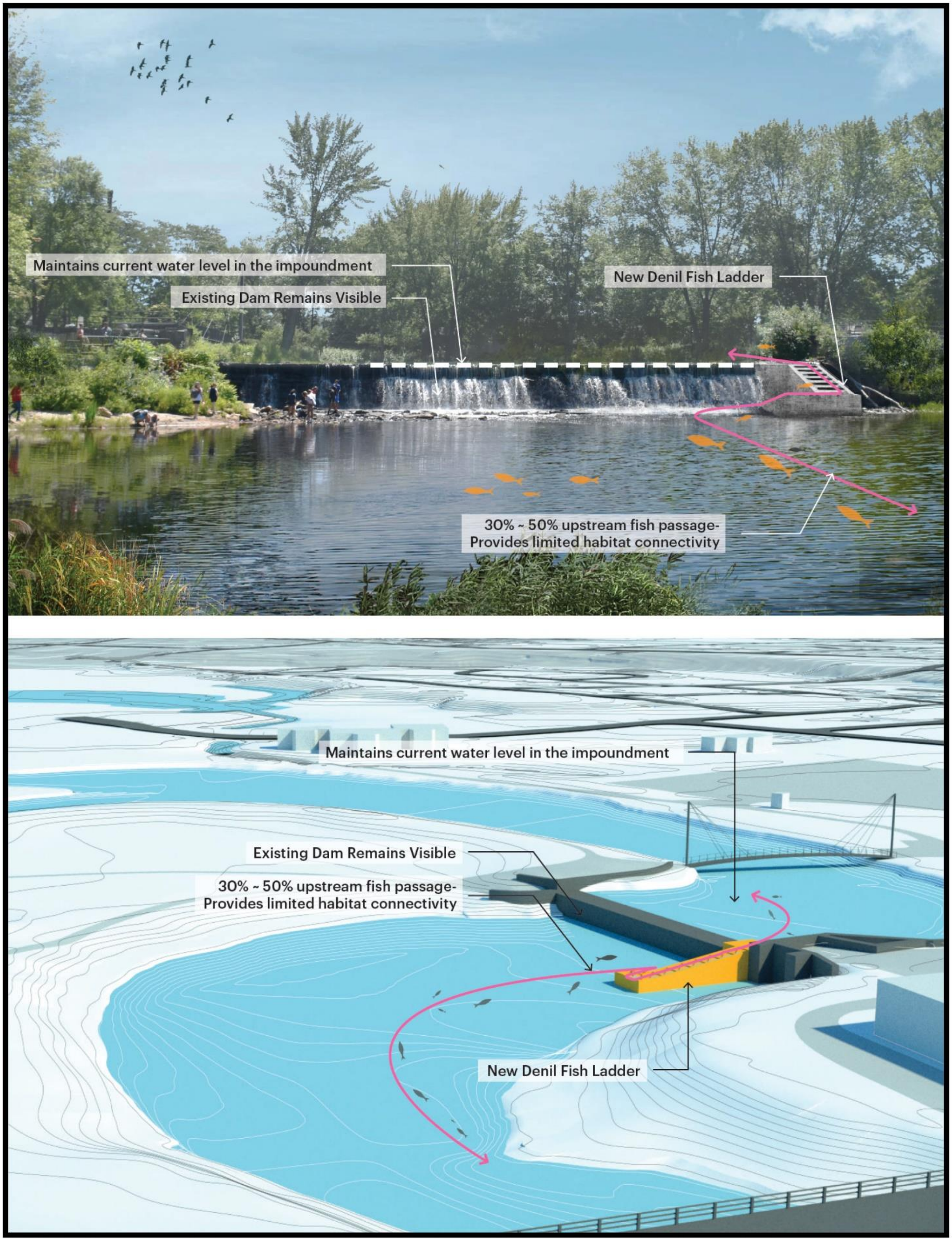
Remove Dam



Pool and Weir Bypass Channel



Nature-Like Fishway



Technical Denil Fish Ladder

Appendix 2: Survey design and recruitment

The online survey was designed using Qualtrics, a professional survey platform. Since we are interested in learning about residents' preferences, the participants eligible for taking this survey were Keene residents and at least 21 years of age. We chose this age limit to minimize college student responses since they are more likely to be out-of-state, temporary residents. The survey has four main sections. The first section includes questions about awareness and connection to the West Street dam including the number of visits, interactions, and attachment with the dam. The next section provides the participants with adequate background information about dams in New England, the West Street dam, and Letter of Deficiency (LOD) concerns. The following section provides treatment-specific descriptions (text-only, text with image, or text with video) about the five possible alternatives for the dam, along with choice experiment questions on alternative management options for the dam. Each choice set is followed by the question, "Which option do you think is the BEST?". The final section includes demographic questions. With four choice set groups and three treatment groups, we had twelve online survey versions. We randomly assigned participants to treatment groups to maintain treatment balance (refer to Table D1 in Appendix 4).

A mixed-mode, non-probability sampling was employed to recruit participants for this survey. The first method is a two-step approach involving the face-to-face distribution of invitation cards, followed by an internet survey. We distributed survey invitation cards (included as a supplementary file) at frequently visited places in Keene, such as grocery stores, farmers' markets, town fairs, and churches. The invitation cards were distributed by researchers from regional universities, using a script for a thirty-second explanation of the importance of participating in the survey. The researchers distributed the invitation cards during the period spanning from September

2019 to December 2019, including both week and weekend days, events, and non-event days. For example, on two occasions, researchers distributed invitations during major events in Keene: The Fall Fest and the Pumpkin Fest. Researchers gave invitation cards to subjects who met the eligibility criteria and agreed to participate in a 20-minute online survey. The invitation card includes a web address to the survey and a one-time password necessary to access the survey and avoid repeated participants. Monetary compensation in the form of an eGift card was promised to all those who completed the survey. A total of 1,203 invitation cards were distributed, of which we received 316 completed responses that met the eligibility criteria. This survey data collection approach received a response rate of 26.2%, which is above average for a web survey. A response rate of this magnitude usually requires prenotification or reminders (Kaplowitz et al., 2012; Porter and Whitcomb, 2007, 2003).

To attain an adequate sample size, we employed two other survey distribution modes. First, we recruited via flyers. Flyers with project contact information for those interested in partaking in the survey were distributed via a community listserv and in popular cafes in Keene. We received 17 completed surveys among the participants who responded to the flyer. We do not know how many people gained knowledge of the survey via the flyer; hence we cannot provide a response rate. Second, we recruited via email. We purchased resident email addresses and distributed customized survey links through Qualtrics. The email distribution method resulted in a 3.5% (49 out of 1,384 emails) response rate. After eliminating incomplete and spurious surveys we have a total of 302 usable surveys. Of the 302 responses, 98 responses were from the text-only treatment, 104 from the text with image treatment, and the remaining 100 from the text with video treatment.

Summary statistics show that the collected survey dataset's demographic distribution reasonably resembles the population estimates for Keene from the US Census (Table 2). The survey respondents are slightly older and more educated than the target population. We also observe a higher proportion of the respondents who are homeowners and fall in the mid-income categories. We find that many residents are familiar with this dam and are aware of the debate about its future. About 40% of residents are aware that efforts are being taken to alter the dam and 31% have experienced alterations pertaining to dams other than the West Street Dam. Our indicators to measure the levels of connection with the dam includes 1) how well the participant knows the dam, 2) how often they see or visit the dam, and 3) how attached they are to the dam. We find that 59% of subjects indicated that they know the dam well. Nearly 90% agree that they often see the dam and about 40% visit the dam frequently, while 24% claim to be attached to this dam.[1] We expected a high percentage of residents to see the dam often since it is at the heart of the city of Keene.

These varying degrees of connections with the dam may explain preference heterogeneity.

Appendix 3: Select Survey Questions

How many years have you lived in Keene, NH?

- ○ 0 – 5 years
- ○ 6 – 10 years
- ○ 11 – 15 years
- ○ More than 15 years

Please indicate your level of agreement or disagreement with each of the following statements by checking ONE box per line.

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
I **know** the West Street Dam very well	○	○	○	○	○
I often **see** the West Street Dam	○	○	○	○	○
I frequently **visit** the West Street Dam	○	○	○	○	○
I am very **attached** to the West Street Dam	○	○	○	○	○

Appendix 4: Sub sample balance across treatments

Table D1: Socioeconomic characteristics of survey participants across treatment

Variable	Percentage	Text (n = 98)	Image with text (n = 104)	Video with text (n = 100)
Gender	Male	44.9	47.1	48
Education	High school or higher	80.6	87.4	84
Employment	Employed (full time)	53.1	52.9	59
	Unemployed	1.02	0.96	1
Housing Tenure	Renter-occupied	37.76	24.04	40
	Owner-occupied	61.22	74.96	59
Age	Median	47.5	51	42

Notes: The total sample is 302. The estimates provided in the third, fourth and fifth columns are in percentage (%) except for *Age* which is the median age.

Appendix 5: Other results: Effect of connection to the dam and study area

Table E1 includes dam alternative interactions with the number of years the resident has lived in the study area. Our findings reveal that those who lived in the study area for five years or less (also considered as base category when comparing years lived as a resident) have a higher marginal preference for fishway and ladder compared to status quo.

By comparison to this baseline, those who lived as residents in the 6 to 10 years show less of a preference for fishway and removal but a larger preference for bypass. We find that this effect strengthens with longer residency length; those in the 11 to 15 years category show stronger preference towards the bypass alternative. Our results also indicate that those who lived in the study area for more than 15 years, experience a significant fall in marginal preference for removal compared to keep and repair. Irrespective of the number of years lived, we find that including image treatments consistently increases the marginal preference for the dam modification alternatives.

Table E1: Mixed Logit Results: D_{ALT} interacted with number of years as a resident

VARIABLES		Std. Err.
Cost ($)	- 0.029***	(0.002)
(a) ASCs for D_{ALT} and represents base category: Years as a Resident (0 to 5)		
Bypass (Yes=1)	0.448	(0.569)
Fishway (Yes=1)	1.947**	(0.950)
Ladder (Yes=1)	1.503***	(0.543)
Remove (Yes=1)	-1.514	(1.356)
(b) D_{ALT} interacted with image and video treatments		
Image*Bypass	1.583***	(0.542)
Image*Fishway	2.189***	(0.752)
Image*Ladder	0.839*	(0.470)
Image*Remove	1.312	(1.256)
Video*Bypass	0.279	(0.470)
Video*Fishway	0.167	(0.624)
Video*Ladder	0.001	(0.390)
Video*Remove	-0.705	(0.953)
(c) Years as a Resident		
Years as a Resident (6 to 10)*Bypass	1.772***	(0.583)
Years as a Resident (6 to 10)*Fishway	-1.549**	(0.779)
Years as a Resident (6 to 10)*Ladder	0.246	(0.504)
Years as a Resident (6 to 10)*Remove	-2.009*	(1.115)
Years as a Resident (11 to 15)*Bypass	2.277***	(0.669)
Years as a Resident (11 to 15)*Fishway	-0.436	(0.871)
Years as a Resident (11 to 15)*Ladder	0.927	(0.585)
Years as a Resident (11 to 15)*Remove	-0.250	(1.359)
Years as a Resident (more than 15)*Bypass	-0.242	(0.472)

Years as a Resident (more than 15)*Fishway	-1.860***	(0.617)
Years as a Resident (more than 15)*Ladder	0.172	(0.398)
Years as a Resident (more than 15)*Remove	-2.486***	(0.956)
Observations	10,872	

Notes: Number of individuals = 302. Standard errors (Std. Err.) are in parentheses. ***, ** and * denotes significance at 1, 5 and 10 percent. All variables in Table 4 (Model 1) are estimated in the model.

Tables E2 presents the mixed logit results when accounting for participants' degree of connection with the neighborhood dam. Variables such as the level of knowledge about the dam (Model 1), the incidence of seeing the dam (Model 2), the incidence of visiting the dam (Model 3) and the level of attachment towards the dam (Model 4) were interacted with dam alternatives and included as four separate models.

Table E2: Mixed Logit Results: Connection to the Dam

VARIABLES	Model 1 Know	Model 2 See	Model 3 Visit	Model 4 Attach
Cost ($)	-0.028***	-0.028***	-0.028***	-0.028***
	(0.002)	(0.002)	(0.002)	(0.002)
D_{ALT} interacted with levels of connection with the dam				
Level of connection*Bypass	0.312*	0.561***	-0.204	-0.228
	(0.184)	(0.193)	(0.175)	(0.184)
Level of connection*Fishway	0.764***	0.485*	-0.023	-0.923***
	(0.259)	(0.261)	(0.256)	(0.272)
Level of connection*Ladder	0.572***	0.349**	0.087	-0.267
	(0.162)	(0.159)	(0.156)	(0.162)
Level of connection*Remove	0.269	-0.101	-0.596*	-2.139***
	(0.351)	(0.434)	(0.340)	(0.400)
Loglikelihood	-2325.77	-2322.25	-2323.93	-2313.81
Observations	10,872	10,872	10,872	10,872

Notes: Number of individuals = 302. Standard errors (Std. Err.) are in parentheses. ***, ** and * denotes significance at 1, 5 and 10 percent. Due to possible correlations between levels of connection, four separate models for each of the levels, that is., level of knowledge about the dam (Know), the incidence of seeing the dam (See), the incidence of visiting the dam (Visit) and the level of attachment towards the dam (Attach) that are interacted with dam alternatives (D_{ALT}) are included column wise from left to right, respectively. All variables in Table 4 (Model 1) are included in this model.

We find that the residents who have claimed to have a higher level of knowledge and more incidence of seeing the dam to have a significantly higher marginal preference for all dam modification alternatives, compared to the status quo option to keep and repair the dam. On the other hand, there is a fall in marginal preference for remove among those who have a higher incidence of visiting and attachment to the dam. Additionally, we notice an overall negative marginal preference for all dam alternatives among those who have a higher level of connection to the dam, out of which we find the negative estimate significant for both fishway and remove compared to keeping and repairing the dam to its original state.

This finding leads us to speculate that residents prefer alternatives that meet both the objective of improving habitat connectivity as well as preserving the dammed landscape that is familiar to them. On the other hand, we find a steep fall in the preference for removing the dam among those who have a higher recurrence of visiting the dam. This pattern was observed among those who claimed a higher level of connection to the dam, however, this group constitutes a smaller section of the community, perhaps more vocal, compared to those who are willing to support alternatives that can achieve multiple objectives.