2021

CMMPO WATER MODULE:

An Introduction to CMMPO Regional Culvert Program

CMRPC
Central Massachusetts Regional Planning Commission

CMMPO

CMMPO Regional Environmental Toolbox Series

Produced by Staff of Central Massachusetts Regional Planning Commission

One Mercantile Street, Worcester, MA 01608

TABLE OF CONTENTS

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ABSTRACT

The continuity of streams and rivers is vital for the health of the Commonwealth's road network, as well as the fish and other wildlife who depend on streams and rivers. Cumulatively, streams provide more habitat than larger rivers, support species not found in larger streams and rivers, are highly productive, and provide important spawning and nursery habitat for fish and wildlife. With so many stream and river miles throughout the Commonwealth (nearly 28,000 miles), transportation projects are commonly in close proximity to, or cross environmentally sensitive areas. It is clear that transportation projects, specifically culverts, pose a big impact on the natural environment and stream continuity. Historically, culverts and other road-stream crossings (small bridges) have been built without much consideration for stream continuity, fish and other wildlife, as well future climate trends. On top of this, an overwhelming number of these culverts were constructed more than 50-years ago and are nearing the end of their life-stage and becoming increasingly vulnerable to failure, especially during increasingly frequent and severe storms and rainfall due to the climate change crisis. Despite this, a large majority of culverts around the Commonwealth and within the Central Massachusetts Regional Planning Commission (CMRPC) region have not been assessed for condition or continuity. While the Massachusetts Department of Environmental Restoration (MassDER) has collaborated with other regional efforts, like the North Atlantic Aquatic Connectivity Collaborative (NAACC), to develop an understanding of culverts and standards for improved design, the Massachusetts Department of Transportation (MassDOT) has only recently convened a working group to approach the challenge of state-owned culverts. Currently MassDER partners with NAACC to provide training and guidance for municipalities to develop a culvert inventory and assess their aquatic passability and condition. Moreover, many municipalities lack the capacity and expertise to assess and replace culverts within their jurisdiction. Given the regional importance of stream continuity for both transportation and the environment, a regional approach – led by the Central Massachusetts Regional Planning Commission (CMRPC) staff to the Central Massachusetts Metropolitan Planning Organization (CMMPO)– to identify, assess, and assist towns with culvert repair or replacement designs that meet current design requirements (i.e. Massachusetts Stream Crossing Standards) is necessary. In alignment with the goals and objectives of the Mobility2040, the regional long range transportation plan (LRTP), this module explains culvert challenges and the importance of developing a regional effort to improve the overall resilience of our transportation system and its impacts on climate change.

INTRODUCTION

Transportation projects are commonly in close proximity to, or cross environmentally sensitive areas. For example, bridges and culverts span rivers and streams, roads divide the landscape while connecting multiple destinations, and trails run through environmentally sensitive areas. In many ways, transportation infrastructure poses a big impact on the natural environment, particularly by causing changes in land cover, forest fragmentation, impacts to water quality, high levels of noise, and increased air pollution, to name a few. More specifically, road-stream crossings, like culverts and small bridges, play a vital role in the region's transportation network, providing the ability to maintain connections within watersheds, as well as protecting property and other infrastructure from flood, storm damage, and so on. While MassDOT has an existing program for Small Bridge's that provides financial support to communities for small bridge replacement, preservation, and rehabilitation projects, they have only recently convened a working group to approach the challenge of state-owned culverts. Currently, the inspection of MassDOT Highway and municipally-owned small bridges and an inventory is in progress. Therefore, **this Module will focus primarily on culverts**, but will also include language on small bridges due to their similarity to support stream continuity. As can be seen below, existing culverts may be re-defined as small bridges due to their size. This report will use the MassDOT terminology to define the difference between a small bridge and a culvert [1]:

SMALL BRIDGE	**a structure that spans between 10 and 20 feet in length**
CULVERT	**a structure less than 10 feet in length**

Currently there are over 25,000 culverts and small bridges throughout the Commonwealth that provide roadway and trail passage over rivers and streams. While the Massachusetts Department of Transportation (MassDOT) own about 6,500 culverts and small bridges – with other entities owning about another 1,100 structures – it can be assumed that the other 17,000 or so culverts and small bridges are responsible to a kaleidoscope of municipal, private, or other agency ownership. For the CMMPO region, there are 866 structures identified in the MassDOT Bridge Inspection Management System (BIMS) categorized as a bridge (NBI) or small bridge (BRI), with an additional 767 culverts identified through the ongoing MassDOT culvert inventory effort as owned by MassDOT. On top of this, there are another 5,094 culverts and potential culverts that have been identified by the CMMPO, through a partnership with NAACC, as a mix of municipal, private, or other agency ownership.

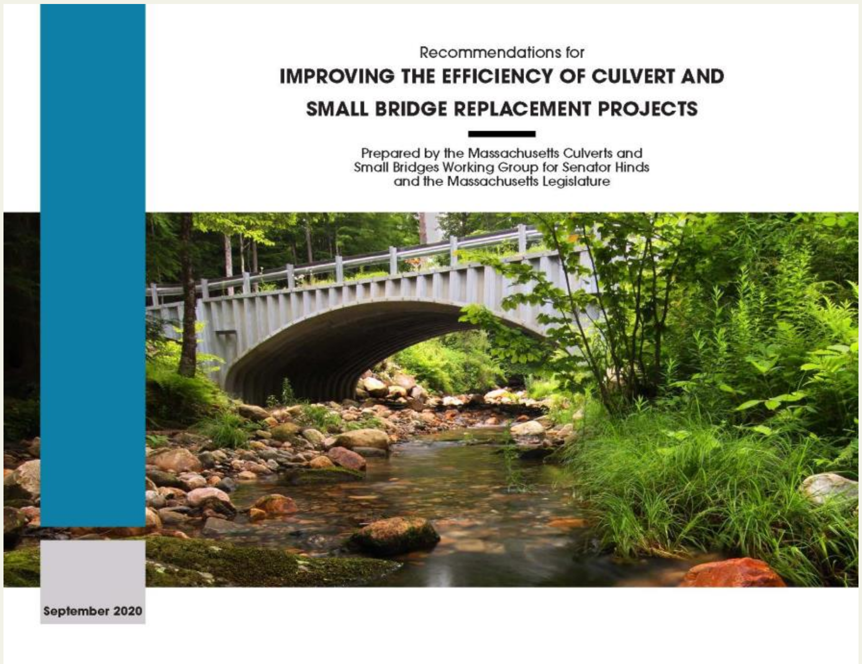
An overwhelming number of culverts and small bridges throughout the state were built 50 or more years ago and are reaching their anticipated useful life. Combine this with the understanding that many of these structures were not designed to current design standards, and it becomes clear that there is an urgent need to replace or repair these structures with more cost-efficient, resilient structures [1]. Common problems with poorly designed culverts and small bridges (i.e. undersized, shallow, and/or perched) will eventually lead to flooding or failure during severe precipitation events. Failure of these structures can block the movement of traffic and access to emergency services, not to mention the cost to replace with appropriately designed structures. Similarly, poorly designed culverts and small bridges pose a negative impact to the natural environment, impacting fish and wildlife by affecting stream continuity for aquatic organism passage and movement of wildlife [1]. For example, as rivers and streams become further impacted and fragmented by poorly designed culverts and small bridges, this can impact access to Coldwater habitats; feeding areas; breeding and spawning areas; and natural dispersal [2]. With that, it becomes obvious that culverts and small bridges intersect both transportation and stream continuity needs.

Furthermore, the impacts of climate change increasingly exacerbate the issues and consequences related to poorly designed and aging culverts and small bridges. Per *Mobility2040*, the CMMPO Long Range Transportation plan (LRTP), states, "Communities should also consider the structural, operational, and safety impacts to roadways, **bridges and culverts**, as well as overall impact on the system capacity" [3]. In general, the Commonwealth will experience more days with precipitation with storms carrying heavier precipitation, leading to higher volumes of rain or snow within increasingly shorter time periods [1]. The Fixing America's Surface Transportation (FAST) Act, signed into law by Congress in December 2015, requires agencies to take resiliency into consideration during the transportation planning process. At the core of this new planning rule is the improvement of the resiliency and reliability of the transportation system, like culverts and small bridges [3].

Despite growing concern on the condition and resiliency of culverts, many municipalities and communities lack the overall capacity to replace or repair a culvert or small bridge to meet improved project design criteria, and also require technical/funding assistance from early stage of project development through to project construction. This has led to many in-kind replacement structures that are nonetheless **still** vulnerable to failure or damage. As was previously mentioned, MassDOT has a comprehensive process to prioritize the repair and replacement of bridges, and have recently created a 'Small Bridge Program' to meet community needs to repair or replace small bridges. For culverts, MassDOT has only recently begun to inventory state-owned culverts, as well as formed a working group to approach the challenge of state-owned culvert structures that are undersized or at most risk of failure (**see Figure 1 for Cover Page**). But, as has been stated above, many municipalities lack the capacity and expertise to inspect and prioritize municipally-owned culverts [1]. Thus the need for a regional approach to partner municipalities and regional agencies together to inspect and prioritize crossings for repair or replacement is necessary.

This report is the result of a growing concern about the relationships between transportation projects and their impacts to the environment in the CMMPO region. *Mobility2040* **(see Figure 2)** identifies the protection and enhancement of the environment as one of the factors considered in planning activities in the region. In order to discuss potential environmental mitigation activities and areas to carry out these activities that may have the greatest potential to restore and maintain the environmental functions affected by the *Mobility2040*, an Environmental Consultation process has been hosted annually. The Consultation process serves a two-fold goal: 1) inform the environmental community about the compilation of the LRTP, and 2) encourage feedback regarding their ongoing involvement in the overall transportation process. Experience has shown the importance of practicing transportation planning in tandem with environmental stewardship. The CMMPO has come a long way since early consultation steps, using Geographic Information Systems (GIS) for mapping environmental data layers that depict areas of environmental concern. Additionally, the CMMPO developed a Nature-Based Solutions (NBS) Toolkit for Transportation Planning and have created metrics related to stream connectivity with an inventory of culvert and their condition [3]. This report is the next step in this direction, primarily to inform the decision-making process and to assist in project selection activities.

Figure 1: MassDOT Culvert Working Group Cover Page [1]



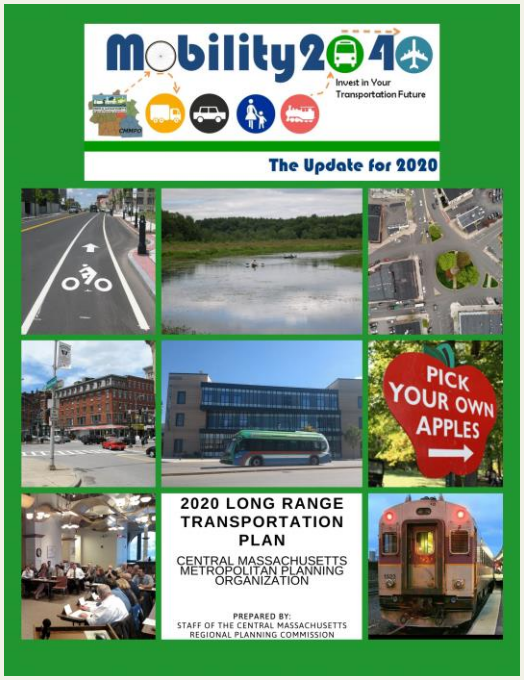
This report will (1) focus on the water features in the CMMPO region and the major transportation-related challenges, primarily culvert structures; (2) highlight the regional water features of the CMMPO region; (3) explore major challenges and limitations to repair or replace culvert structures that meet improved design criteria; (4) explore current methodologies and a regional approach to assess and prioritize community needs to repair or replace culvert structures; and (5) identify next steps for this report and the development of a regional culvert program. In some cases, where available, baseline information and maps are included.

BACKGROUND

Past experience has demonstrated the limitations of project-based mitigation arising from transportation projects. The “postage-stamp” approach does not promote ecosystem sustainability. More often than not the expected environmental benefit is not achieved, and the return on investment of funding for mitigation activities is not maximized. The current transportation bill, Fixing America’s Surface Transportation Act (FAST Act), states that “an MPO may develop a programmatic mitigation plan on a local, regional, ecosystem, watershed, statewide or similar scale” [5]. The regional environmental mitigation activities are related to the following: wetlands, streams, rivers, stormwater, parklands, cultural resources, historic resources, farmlands, archaeological resources, threatened or endangered species, and critical habitats [4].

In addition to regional environmental mitigation activities, the FAST Act added resiliency and stormwater mitigation as new planning factors to the scope of the metropolitan planning process [5]. FHWA Order 5520 defines resilience as "the ability to anticipate, prepare for, and adapt to changing conditions and withstand, respond to, and recover rapidly from disruptions" [6].

Figure 2: CMMPO 2020 LRTP Cover Page [3]



The CMMPO recognizes that a regional ecosystem approach would help ensure that regional conservation goals and objectives are accomplished. These goals and objectives are given by each one of the environmental agencies in concert with the *Mobility2040* main goals. The purpose of this Module, then, is to present an array of possible mitigation practices for a "typical transportation project" (frequently programmed project types: bridges, resurfacing, intersection improvements, road widening, etc.) based on the possible impacts to the region's natural features and ecosystems.

The definition of mitigation used in this report is consistent with the definition expressed by the Council on Environmental Quality (CEQ) *Title 40: Protection of the Environment*. In this, mitigation encompasses five actions distinctive in scope [7]:

a) **Avoiding** the impact altogether by not taking a certain action or parts of an action.

b) **Minimizing** impacts by limiting the degree or magnitude of the action and its implementation.

c) **Rectifying** the impact by repairing, rehabilitating, or restoring the affected environment.

d) **Reducing** or eliminating the impact over time by preservation and maintenance operations during the life of the action.

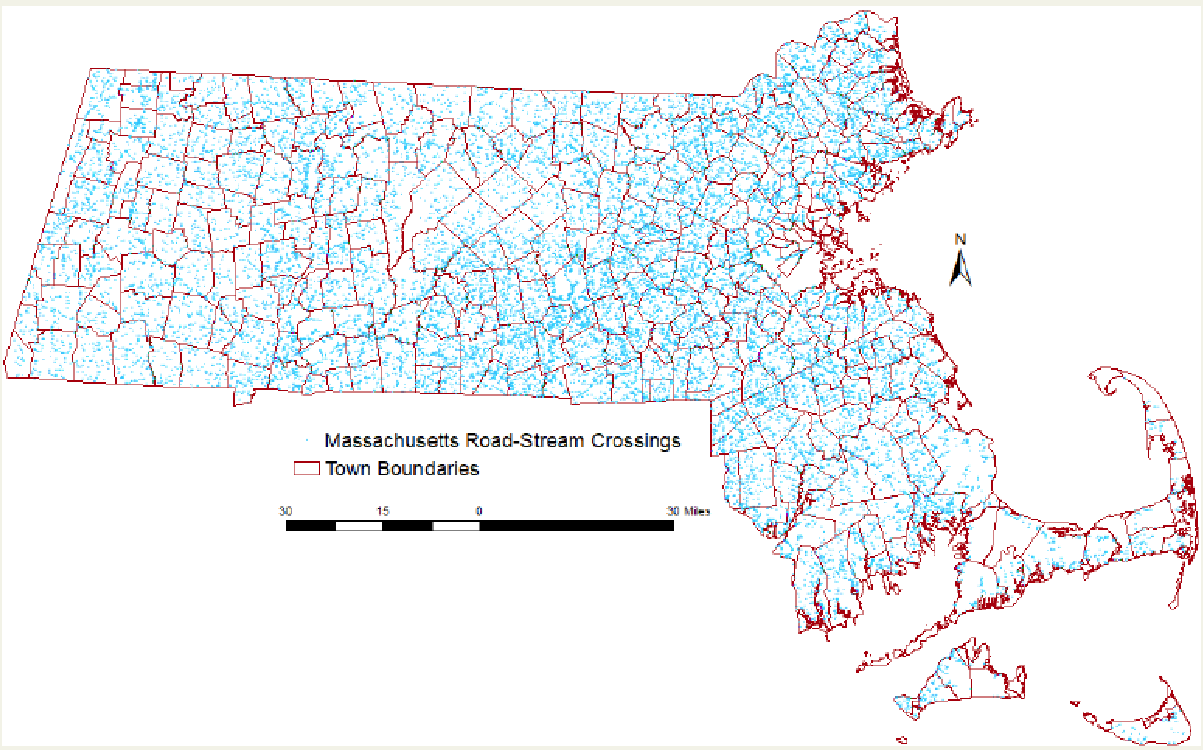
e) **Compensating** for the impact by replacing or providing substitute resources or environments.

It is important to note the importance of identifying possible action types – avoiding any type of impact will be the ideal scenario. But in in cases where compensation for a given impact is needed (i.e. culvert failure), the type of mitigation to be used should comply with regulatory requirements (federal or state), should yield the greatest benefit for the ecosystem, and should be of proper economic magnitude in view of the likely impacts of planned transportation improvements. For example, culvert replacements which meet the Massachusetts Stream Crossing Standards meet these regulatory requirements to achieve mitigation and resiliency.

The Stream Crossing Standards were developed by the River Continuity Partnership with contributions from state agencies, local and regional nonprofits, and private consultants. Currently, the US Army Corps of Engineers' (ACOE) Massachusetts General Permit and the Massachusetts 401 Water Quality Certification require these or similar standards to be met [8]. Additionally, the Wetland Protections Act also requires **ALL** new crossings meet the Stream Crossing Standards, with replacement structures meeting the standards to the 'maximum extent practicable' [2][9]. Moreover, specific grant funding opportunities, like the MassDER Culvert Replacement Municipal Assistance Grant Program (CRMA), require that all new crossings meet the Stream Crossing Standards, among others [10].

With a large portion of culverts across the Commonwealth reaching their limit and becoming further vulnerable to storm and flooding events, as well a lack of state and local programs to inspect and prioritize culvert structures for repair or replacement, this report is an essential step in a process to understand our region and the condition of its culverts, as well as current methodologies to inspect and prioritize culverts; how a regional program could help; the challenges and limitations to completing these projects. While a concrete conclusion has not been met to solve the increasing problems and consequences associated with culverts, this report is open to further interpretation and editing following a more thorough understanding of culverts in the Central Massachusetts region.

Figure 3: Massachusetts Road Stream Crossings [17]



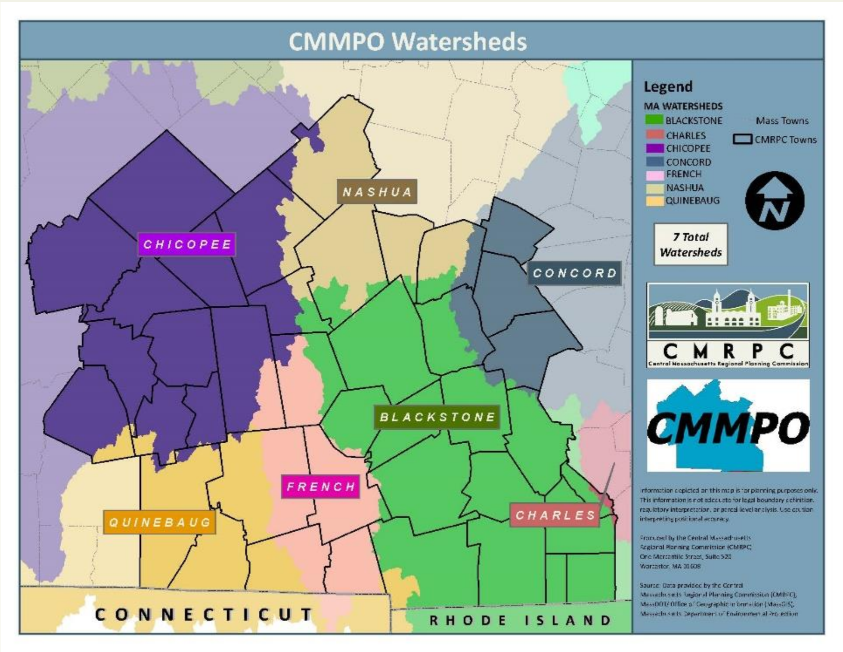
REGIONAL FEATURES AND CULVERTS

A REGIONAL OVERVIEW

Water resources are mainly concentrated on fresh waters, which are comprised of ground waters and surface waters like lakes, rivers and swamps. Surface water is naturally lost by evaporation and replenished by precipitation (water cycle). They work as a system, in which smaller streams connect to larger tributaries, then connect to rivers or lakes, and eventually to the ocean. As a result, a small impact on headwaters can grow in magnitude, affecting miles downstream to the ocean. This characteristic also applies to a watershed, where sub watersheds or sub basins are part of larger watershed. The water basins are the catchment area of a river, lake, estuary, reservoir, wetland, sea or the ocean. All surface waters in Massachusetts can be assigned to a river basin or watershed.

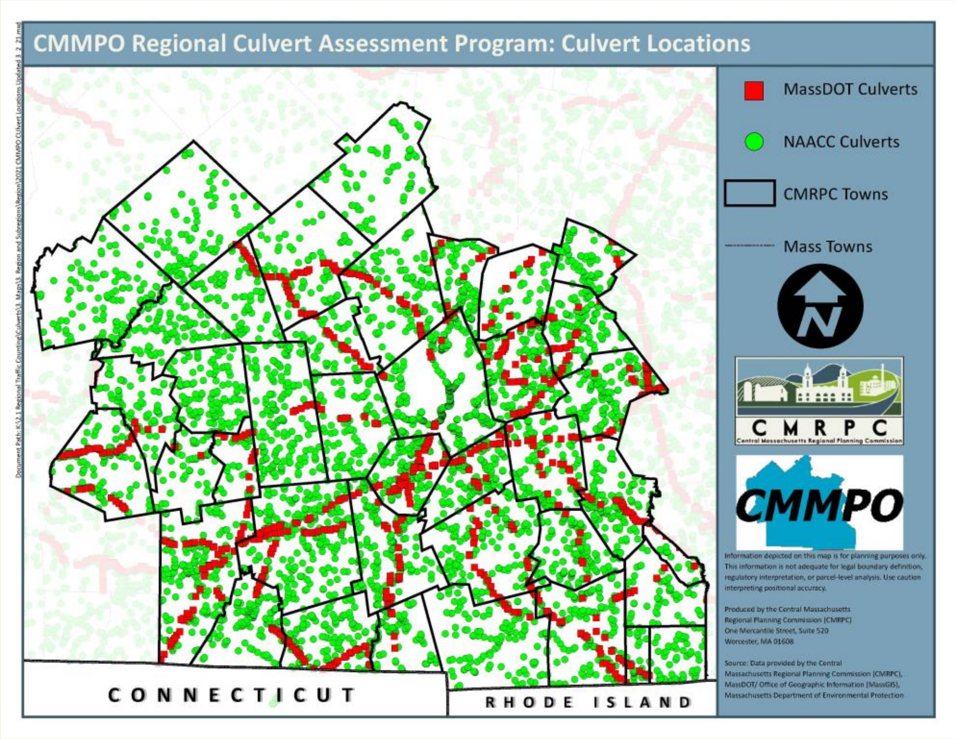
To provide an overview of the state, there are six major basins (Upper Hudson, Connecticut Coastal, Connecticut, Merrimack, Saco, and Massachusetts Road Island Coastal) with 20 primary watersheds. There are about 28,000 miles of rivers or streams, 1,250 US Highways, 1,150 US Interstates, and 7,500 miles of MA state roads. Considering that, there is a road-stream crossing (i.e. culvert) for every 1.2 road miles and every 0.5 stream miles [11]. Therefore, it can be estimated that around 29,000 culvert and small bridges exist in the state. On the previous page, **Figure 3** displays a map showing the location of known road-stream crossings across the state [12]. In order to maintain the state's transportation network and hydraulic connections within watersheds, as well as help protect nearby homes, businesses, and other infrastructure from flood damage, road-stream crossings serve an important purpose [1]. The NAACC, which partners with MassDER to provide training at the local and state level to assess culverts from an ecological perspective, has assessed about 6,400 culverts in the state with about 43% of culverts being a moderate to severe barrier to fish and wildlife passage [12]. Similarly, DER has estimated that about half of the states culverts and small bridges are undersized and/or vulnerable to failure. On top of this, MassDOT predicts that about 80% of state-owned culverts are undersized or vulnerable to failure [1].

Figure 4: CMMPO Watersheds



As we look at the CMMPO Region, there are seven watersheds. These watersheds are: Nashua River Basin (North), Concord River Basin (East), French River Basin (South), Blackstone River Basin (South-East), Chicopee River Basin (West), Quinebaug River Basin (South-West), and a small portion of the Charles River Watershed (South-East).

Figure 5: CMMPO Watersheds



All of these watersheds are part of larger basins or hydrological units, as identified by the U.S. Geological Survey. These basins are the Merrimack River Basin, the Coastal Basin, the Thames River Basin, and the Connecticut River Basin. **Figure 4** on the previous page displays a more clear view of the region's watersheds. As has been mentioned previously, there are 866 structures identified in the MassDOT Bridge Inspection Management System (BIMS) categorized as a bridge (NBI) or small bridge (BRI), with an additional 767 culverts identified through the ongoing MassDOT culvert inventory effort as owned by MassDOT in the CMMPO region. On top of this, there are another 5,094 culverts and potential culverts that have been identified in the region by the CMMPO, through a partnership with NAACC, as a mix of municipal, private, or other agency ownership. See **Figure 5** to see a map of all NAACC and MassDOT identified culvert locations.

COMMON PROBLEMS AND CONSEQUENCES OF AGING CULVERTS

As has been mentioned in this report, a large portion of the Commonwealth's culverts and small bridges were constructed more than 50 years ago and are vulnerable to failure or other consequences. Furthermore, past culvert and small bridge design focused primarily on traffic operations, structural integrity, and typical hydraulic flow without much consideration as to the impacts to fish and wildlife or stream continuity. Overtime, this has led to unintentional negative impacts to fish and wildlife, as well as stream processes (i.e. debris transport) [1]. Rivers and streams, particularly small streams, are especially critical for fish and wildlife. They make up a large percentage of stream miles; cumulatively provide more habitat than large rivers; support species not found in larger streams and river; are highly productive; and provide important spawning and nursery habitat for fish and wildlife [11].

It is important to understand the main problems associated with road-stream crossings and the potential consequences they can lead to. By reaching this understanding, it can help make an initial determination on if a culvert should be replaced or repaired. The ultimate goal is to create a sustainable transportation infrastructure that does not fragment or undermine the essential ecological infrastructure of the land [3].

In general, there are three main road-stream crossing problems.

Undersized Crossings [2] – Crossings that are too small can eventually restrict natural stream flow, especially during high flow events. It is important to be large enough to pass fish, wildlife, and high flows. Through an FHWA funded research project, MassDOT predicted that about 80% of MassDOT culverts (around 6,000) are undersized [1]. See **Figure 6**. Undersized crossings can lead to several consequences, including:

- Scouring and Erosion
- High Flow Velocities
- Clogging
- Ponding
- Washouts

Figure 6: Undersized Crossings [2]

Shallow Crossings [2] **–** Crossings with water depths that are too low for many organisms to move through them. These crossings may also often lack the appropriate bed material to match the natural stream. Crossings should have an open bottom or buried into the streambed to allow for substrate and water dcepths to mirror the surrounding stream. See **Figure 7**. Shallow crossings can lead to several common consequences, including:

- Low Flow
- Unnatural Bed Materials

Figure 7: Shallow Crossing [2]

Perched Crossings [2] **–** Crossings that are above the level of the stream bottom at the downstream end. Crossings can become perched as a result of improper construction or from years of downstream bed erosion. Crossings should be open-bottomed or sunk into the streambed to prevent this issue. See **Figure 8**. Perched crossings can lead to several common consequences, including:

- Low flow
- Unnatural Bed Materials
- Scouring and Erosion
- Ponding

Figure 8: Perched Crossing [2]

As these three main culvert problems have pointed out, there are a variety of common consequences that can occur as a result of these problems. These include:

Low Flow [2] **–** May lead to stagnant conditions within the crossings and become a problem for species within the stream. Some fish and other aquatic organisms require sufficient water depths in order to access and pass through the crossing. See **Figure 9**.

Figure 9: Low Flow [2]

Unnatural Bed Materials [2] **–** When the substrate (rocks and other material on the bed of the crossing) does not match the natural substrate of the surrounding stream to maintain natural conditions and stream continuity. Metal and concrete, for example, are not appropriate materials for species that travel along the streambed. See **Figure 10**.

Figure 10: Unnatural Bed Materials [2]

Scouring and Erosion [2] **–** High water velocities have the capability to scour natural substrates in and downstream of the crossing. This in turn, degrades habitat for fish and other wildlife. High water velocities and other flow alterations can also erode streambanks. See **Figure 11**.

High Flow Velocity [2] **–** When water velocity is higher in a constricted crossing than both upstream and downstream. High flow velocities can degrade wildlife habitat and weaken structural integrity of culverts. See **Figure 12**.

Figure 11: Scouring and Erosion [2]

Figure 12: High Flow Velocity [2]

Clogging [2] **–** When crossings become clogged by woody debris, leaves, and other material. This can exacerbate the impact of high flows and make a crossing impassable to wildlife. Costly routine maintenance is often used to prevent clogging from arising. See **Figure 13**.

Figure 13: Clogging [2]

Ponding [2] **–** The unnatural backup of water upstream of an undersized crossing. This can occur year round, seasonally, or when they become clogged (see above). Ponding can result in property damage, road and bank erosion, severe changes in upstream habitat, as well as new and undesirable wetlands. See **Figure 14** for an example.

Figure 14: Ponding [2]

As this section has displayed, stream crossings and culverts have been historically designed for the sole purpose of accommodating transportation continuity over a stream channel, which has led to a myriad of problems and associated consequences for fish, wildlife and stream continuity. As the *Recommendations for Improving the Efficiency of Culvert and Small Bridge Replacement Projects: Prepared by the Massachusetts Culverts and Small Bridges Working Group for Senator Hinds and the Massachusetts Legislature* report, released in September 2020, points out, many of the Commonwealth's existing culverts and bridges were constructed in the 1950s and 1960s – before environmental regulations were put into place. With that, many of these culverts and bridges are failing due to common problems and consequences laid out in this section. By adhering to certain design standards and requirements, like the Wetlands Protection Act or the Massachusetts Stream Crossing Standards, this can increase the ecological quality and structural integrity of culvert projects, in turn making structures more resilient. Furthermore, when culverts and small bridges are in need of replacement, these projects should take advantage of opportunities to improve crossings for the conditions of today and the future, especially climate change impacts [1]. This next section will unpack the impact climate change poses to road-stream crossings.

IMPACTS FROM CLIMATE CHANGE

As this report focuses on the problem of aging road-stream crossings, like culverts and small bridges, it is imperative to incorporate the impacts from climate change as it increasingly threatens to disrupt transportation systems. Per the 2018 National Climate Assessment, rainfall intensity throughout the Northeast region are forecast to exceed those in other regions of the United States. For example, days with precipitation over 1 inch will increase over time as well [13]. To understand the CMMPO region more specifically and understand climate change impacts CMMPO communities will be exposed to, the Massachusetts Climate Change Projections (2018) – supported by the Executive Office of Energy and Environmental Affairs – developed downscaled projections for changes in temperature, precipitation, and sea level rise for the Commonwealth of Massachusetts throughout the 21st century. While some parts of the CMMPO region have slightly different projection specifics, the region are projected to share a similar experience of climate change impacts [14].

In regards to changes in temperature, the region is projected to experience increased average temperatures throughout the 21st century. Furthermore, maximum and minimum temperatures are also projected to increase. Due to these changes in average and maximum temperatures the region is projected to experience an increase in days with daily maximum temperatures (over 90 F, 95 F, and 100 F), while average and minimum temperatures are projected to result in a decrease in days with minimum temperatures (below 32 F and 0 F). Projected increases in average, maximum, and minimum temperatures also has an impact on changes in heat, precipitation, and consecutive dry days. In regards to heat, the region is projected to experience a decrease in heating degree-days, and increases in cooling degree-days and growing degree-days. For precipitation, projections for expected number of days receiving precipitation over one inch are variable and fluctuate between loss and gain of days. Lastly, seasonal projections for consecutive dry days with precipitation less than 1 mm (0.04 inches) are variable throughout the century [14].

Rising temperatures and extended heat waves could have large impacts on the health of plants, animals, and ecosystems like wetlands. Despite small rises in average temperatures, this can cause major impacts like the relative proportion of precipitation that falls as snow or rain, especially as winter temperatures rise at a faster rate per decade on average. Put more simply, heat and rising temperatures can directly impact roads and bridges, and other critical infrastructure [14].

Figure 15: Example of a Failed Culvert [12]

Changes in precipitation are expected to increase rainfall in spring and winter months, with increasing consecutive dry days in the fall and summer. More rainfall impacts the frequency of minor and disruptive flooding events, **“especially in areas where storm water infrastructure has not been adequately sized to accommodate higher levels. Increased rainfall will also affect agriculture, forestry and natural ecosystems”**. Moreover, these climate projections suggest that the frequency of high-intensity rainfall will continue to trend upwards. Even a single intense downpour can easily cause flooding and widespread damage to property and other critical infrastructure (See **Figure 15**). While these projections show that winter precipitation could increase, this is more likely to fall as rain instead of snow due to the warming winters, as mentioned above. These changes in precipitation that impact rainfall and the frequency of flooding events have the potential to damage roads and stormwater infrastructure, like poorly designed culverts. Furthermore, as average summer precipitation decreases and is combined with higher temperatures, this can increase the frequency of episodic droughts. An increased frequency in drought damages vegetation that naturally helps mitigate flooding impacts, exacerbating the impacts from flooding events [14].

As the Mobility2040 states, “transportation systems have mostly been built to withstand weather under the current and past climate. Unfortunately the Northeastern United States is experiencing more frequent extreme weather events that damage roads and bridges. Repairs to our transportation networks are costly to repair, not to mention the cost to the economy from disrupted travel. What has been considered extreme weather will be more commonplace in the future and it is vital that states and regions improve the resiliency of their transportation systems by integrating climate change considerations into agency actions” [3]. As our region experiences increased precipitation, rainfall, storm intensity, and flooding events, poorly designed and aging road-stream crossing infrastructure are increasingly at risk of failure – contributing to local flooding and damaging roadways and property [15]. See **Figure 16** for another example of the consequence to a poorly designed culvert. When appropriately constructed and sized, culverts and small bridges can be more resilient and mitigate flood risk to nearby infrastructure and buildings.

In response to these threatening impacts, several communities – including the Towns of Brookfield, Princeton, Warren – have already pursued and received grants or other sources of funding to replace culverts and improve transportation infrastructure and storm resilience by mitigating flood impacts [3]. Other communities, like the Town of Sturbridge, have pursued funding for culvert replacements through the Central Massachusetts Metropolitan Planning Organization (CMMPO) Transportation Improvement Program (TIP) to replace a structurally deficient culvert that was further damaged by Hurricane Irene (2011). Similarly, the Town of Upton is looking to replace a culvert using TIP money with a design that can accommodate the 50-year flood frequency storm event.

Figure 16: Example of a Failed Culvert [1]

A study by USGS, in cooperation with MassDEP in 2014, came to a consensus that when meeting or exceeding the Massachusetts Road Stream Crossing Standards, road stream crossings are more beneficial for being resilient to flooding events or changes in flood flows, as well as improving fish and wildlife passage, than existing or other stream crossing structures and designs [1]. As has been previously mentioned, several grant opportunities require culvert repairs or replacements to meet the Stream Crossing Standards. Most recently, the Town of Westborough received funding through the CRMA grant program to replace a culvert on Jackstraw Brook to benefit the whole community by reducing flood risk, improving climate resiliency, and providing stream continuity to reconnect fish and wildlife passage

This section has showed that the evolving conditions of climate change will have a direct impact on the region’s infrastructure. By understanding these impacts the urgency of replacing or repairing these structures becomes ever so obvious. Poorly designed and aging culverts and small bridges that are unable to pass high flows can have a direct impact to the safety of roadway users; the transport of goods, services, and emergency services; the economy; as well as stream continuity to maintain natural stream processes and allow fish and wildlife passage upstream and downstream. As culverts and small bridges have been recently designed and constructed to meet the Massachusetts Stream Crossing Standards it has been evident that there is a dual benefit between transportation and natural processes by becoming more resilient to climate change, as well as allowing for natural fish and wildlife passage [1].

CURRENT METHODOLOGIES

This report has shown that the overall public awareness regarding the design and construction of culverts and small bridges has grown over the past several years. Additionally, there have been a number of organizations that offer technical assistance training programs to assess and identify replacement projects. As was mentioned earlier in this report, MassDOT and MassDER are currently involved in creating a programmatic response to vulnerable culverts and small bridges. While MassDOT has responsibility for about 1,700 culverts and small bridges in the CMMPO region, there are around 5,000 other culverts that are owned by either municipal, private, and/or other agency ownership[1]. These totals were identified by the CMMPO through the NAACC partnership. Unfortunately – as this report has noted – many of these structures are poorly designed, nearing the end of their lifecycle, and vulnerable to failure. To build more resilient transportation infrastructure by replacing culverts and small bridges, the MA Stream Crossing Standards were developed. The first edition was released in 2005, with a second edition released in 2012 and recently reprinted in 2018 [2].

The Stream Crossing Standards were developed by the River Continuity Partnership with contributions from state agencies, local and regional nonprofits, and private consultants. Several Massachusetts regulations require culvert replacements to meet the Stream Crossing Standards in order to help protect the Commonwealth's natural resources and communities. Currently, the US Army Corps of Engineers' (ACOE) Massachusetts General Permit and the Massachusetts 401 Water Quality Certification require these or similar standards to be met [2][8]. The Wetland Protections Act also requires **ALL** new crossings meet the Stream Crossing Standards, with replacement structures meeting the standards to the 'maximum extent practicable' [2][9].

In order to assess the overwhelming number of road-stream crossings, the DER partners with the North Atlantic Aquatic Connectivity Collaborative (NAACC) to provide training on how to evaluate if a road-stream crossing are a barrier to fish and wildlife passage [2] [16]. NAACC utilizes the Stream Crossing Standards to assess and prioritize culverts for replacement or repair.

With that, the next couple of section will unpack what the Massachusetts Stream Crossing Standards are, as well as how the NAACC can be used as a resource to assess culverts and prioritize repairs or replacements within the CMMPO region. Following that, this paper will identify a regional approach to assessing and prioritizing culvert projects to help protect the region's natural resources and transportation infrastructure.

MASSACHUSETTS STREAM CROSSING STANDARDS

As was mentioned above, the Massachusetts Stream Crossing Standards were developed by a kaleidoscope of stakeholders, including the River Continuity Partnership, to address wildlife passage issues at new and replacement culverts and small bridges, and meet regulatory standards. In Massachusetts, "regulations require that all new and, where feasible, replacement crossings adhere to stream crossing guidelines similar to those presented" with the Stream Crossing Standards Handbook [1]. Since its development in 2005, the Handbook serves as a primary tool to communicate and inform local decision makers and advocates about the importance of properly designed and maintained stream-crossings are for fish and wildlife passage [2]. As has been previously noted, state and federal regulations of stream crossing replacements apply requirements based on the Massachusetts River and Stream Crossing Standards. An understanding of the Stream Crossing Standards is therefore essential to developing a regional program to assess culverts. With that, this section will make use of the Stream Crossing Standards Handbook to develop an understanding of the standards and when to think about replacing or retrofitting a crossing.

The purpose behind the Stream Crossing Standards is to provide real, feasible solutions to poorly designed and constructed crossings. The standards are required for new permanent crossings on fish-bearing streams and rivers and used as a guideline to upgrade existing crossings. The standards are specifically designed for non-tidal rivers and streams. They are not designed for temporary crossings or drainage systems for stormwater/wastewater. When crossings are designed with streams in mind and meet the Stream Crossing Standards, this has been found to safely pass larger volumes of water, sediment, and debris during high flow events, in addition to sustaining safe passage for emergency services and residents [2].

Mentioned previously in this report, the Stream Crossing Standards Handbook recognize three primary stream crossing problems: undersized crossings, shallow crossings, and perched crossings. These problems, among others, can lead to a variety of consequences (clogging, scouring and erosion) that impact both natural resources and chances of structural failure. In order to create safe and stable stream crossings that can accommodate wildlife and protect stream health while decreasing expensive structural damage costs, the Stream Crossing Standards provide a minimum criteria that is generally necessary to facilitate fish and wildlife movement, along with maintaining stream continuity [2].

Two sets of standards are outlined to help balance the cost and logistics of crossing designs and stream protection required for sensitive habitats: General and Optimum [2].

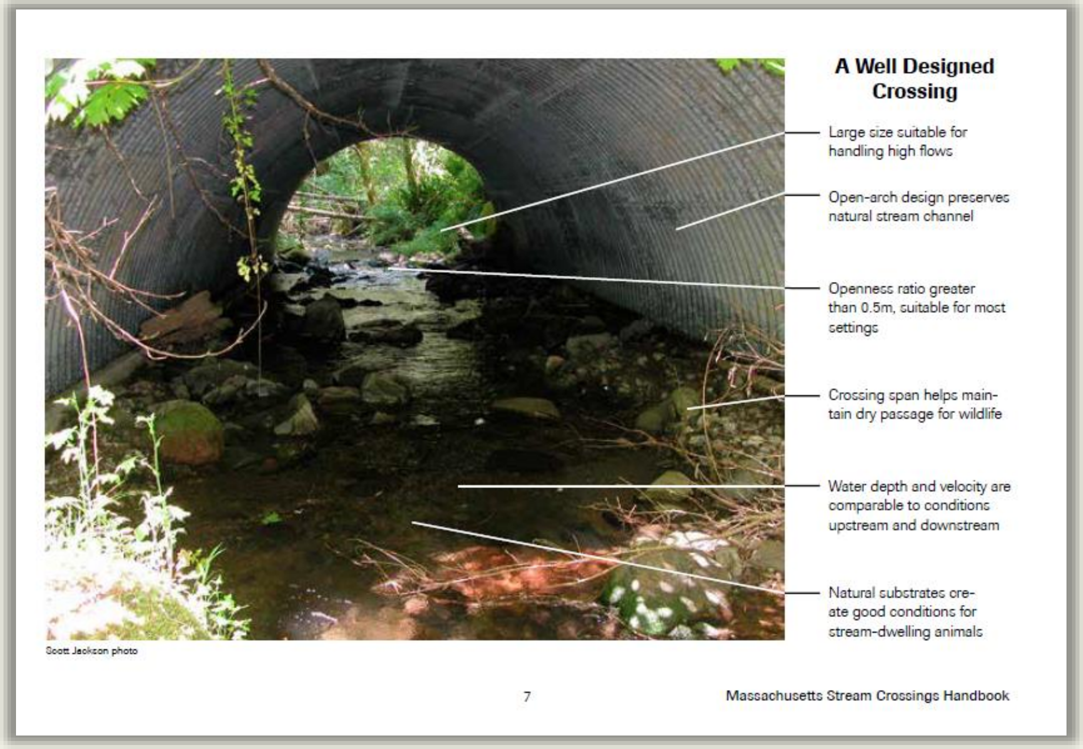
- **General Standards:** "provide for fish passage, stream continuity, and some wildlife passage. All new permanent crossings and, where feasible, replacement crossings must meet general standards"
- **Optimum Standards:** "provide for fish passage, stream continuity, and wildlife passage. Optimum standards should be used in areas of statewide or regional significance for their contribution to landscape connectedness or in streams that provide critical habitat for rare or endangered species"

From these two sets, the Stream Crossing Standards are then based on six important variables [2].

Type of Crossing	• *General* – spans are strongly preferred, like 3-sided box culverts, open-bottom culverts, bridges). • *Optimum* – use a bridge
Embedment	• All culverts should be embedded a minimum 2 feet. • Round pipe culverts at least 25%. • Do not use pipe culverts if they cannot be embedded as deep as noted above.
Crossing Span	• *General* – spans channel width at a minimum of 1.2 times the bankfull width of the stream. • *Optimum* – spans the stream bed and banks to at least 1.2 times the bankfull width with appropriate headroom to provide dry passage for wildlife.
Openness	• *General* **–** the openness ratio should be at least 0.82 feet. The crossing should be wide and high enough in relation to its length. • *Optimum* **–** the openness ratio should be at least 1.64 feet with a minimum height of 6 feet. If current conditions are severely limiting wildlife passage near a crossing, maintain a minimum crossing height of 8 feet and an openness ratio of 2.46 feet.
Substrate	• The natural bottom substrate material should be used throughout the crossing, matching upstream and downstream substrate material. The substrate and design of the crossing should thwart displacement during floods while also maintaining an appropriate floor/bottom during normal flows.
Water and Depth Velocity	• Ensure that water depths and velocities are comparable the natural channel at a variety of flows.

See **Figure 17** below for an example of a 'well designed crossing' based on these sets of standards and variables.

Figure 17: A Well-Designed Crossing [2]



From this, the Handbook lays out how to approach the decision to replace or retrofit a crossing. Simply put, repairing or replacing deteriorating culverts with a larger pipe is not an appropriate solution. Streams have the power to naturally adapt to the problems caused from poorly designed crossings. When thinking about replacing or repairing a crossing, one should understand the existing conditions and potential consequences from flow changes at the culvert. While repairing a culvert can be appropriate, the Stream Crossing Standards recommend replacing a culvert whenever feasible [2].

There are several outcomes to consider when analyzing a crossing for replacement or repair, like the potential for downstream flooding; the effect on upstream, downstream and riparian habitat; the potential for erosion and headcutting; and overall effect on stream stability. With that, the Handbook outlines how to approach the decision to either replace or retrofit a crossing. See **Figure 18**.

Replace…

- If a crossing is structurally poor or degraded
- If a crossing is undersized for high flows
- If a crossing cannot be fixed to allow wildlife passage
- If replacement will not impact critical wetlands

Retrofit…

- If a crossing is structurally sound
- If a crossing is large enough for high flows
- If a retrofit will allow wildlife passage
- If replacement will negatively affect critical wetlands

Figure 18: Replace or Retrofit? [2]

When replacing, the standards for new crossings should be followed as much as possible and be designed to withstand a large flood safely or else the crossing will likely need to be fixed or replaced again. Although less likely due to requiring maintenance activities, retrofitting a crossing can be more appropriate to do if the culvert is crossing an ecologically important stream or if the existing culvert is already large enough to withstand flood flows [2].

Finally, the Handbook outlines a number of conservation resources, or tools that can be used when replacing and choosing a crossing design – especially if a stream has statewide or regional significance for connectivity or provides critical habitat for rare or endangered species [2]:

- The Massachusetts Division of Fisheries and Wildlife's *BioMap2: Conserving the Biodiversity of Massachusetts in a Changing World*
- The Conservation Assessment and Prioritization System (CAPS)
- Critical Linkages

From this section, it is clear that "by adhering to the crossing standards in the *Massachusetts Stream Crossing Handbook*, town conservation commissioners, highway departments, and town engineers can play a vital role in protecting and restoring stream continuity in Massachusetts" [2]. However – as this paper has made clear – an overwhelming number of culverts have not been assessed to current protocols, or have never been assessed at all. Therefore, how can one come to a decision of whether to replace or a repair a culvert?

In an effort to begin assessing the more than 25,000 culverts and small bridges in Massachusetts, the DER has partnered with the North Atlantic Aquatic Connectivity Collaborative (NAACC) to provide training that helps determine when a crossing is a barrier to fish and wildlife passage [17]. Considering this, an understanding of the NAACC is necessary in order to approach municipally-owned culvert assessments within the CMMPO region.

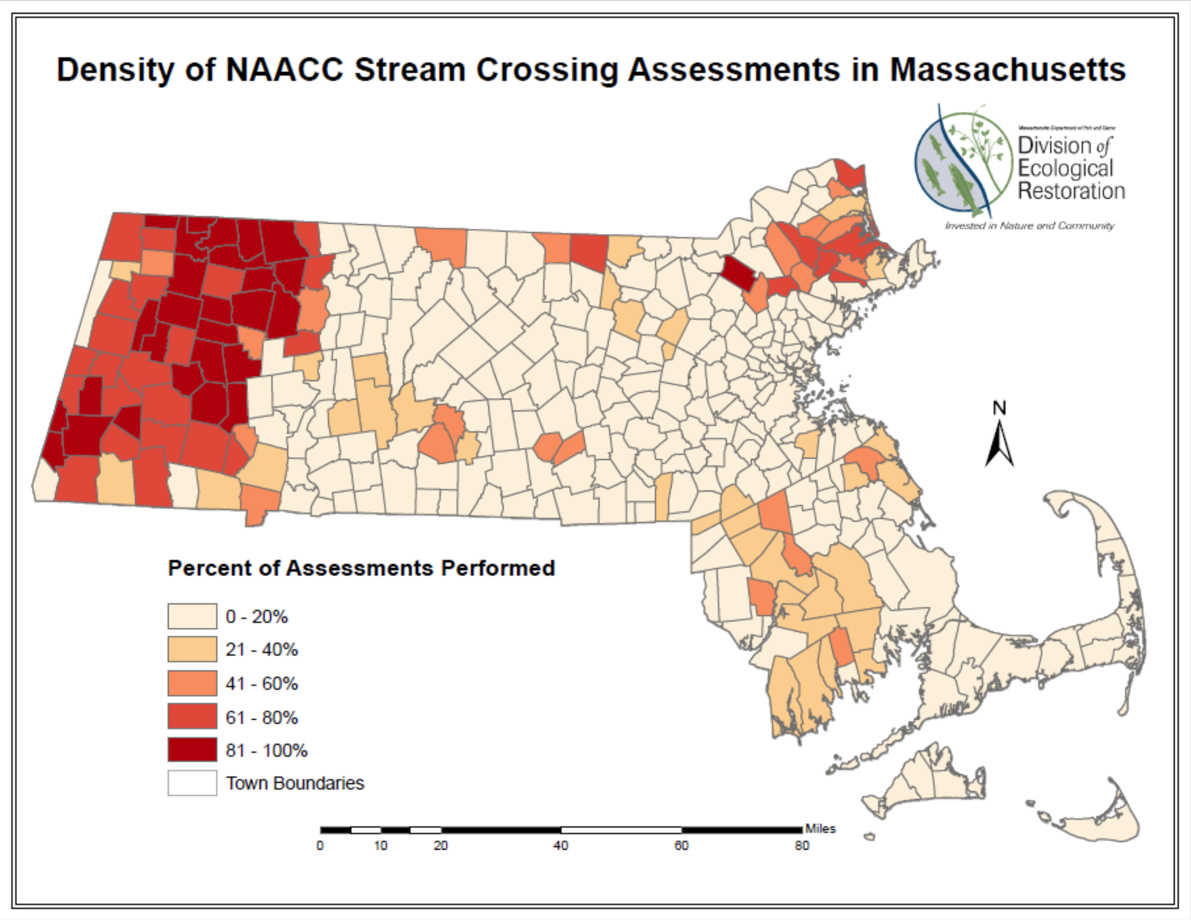
NORTH ATLANTIC AQUATIC CONNECTIVITY COLLABORATIVE (NAACC)

Beginning in 2015, the NAACC was funded by the North Atlantic Landscape Conservation Cooperative (NALCC) and US Department of the Interior (DOI) Hurricane Sandy mitigation funds. The University of Massachusetts Amherst used these funds to create a group of experienced people from the Northeastern US, as well as a technical advisory committee with over 70 partners. From this group, a unified protocol was developed to assess aquatic passability at road-stream crossings and a programmatic infrastructure (NAACC) to support crossing assessments throughout the North Atlantic region [17].

Figure 19: NAACC Logo [17]

Since its start, the NAACC has been able to develop a unified protocol with an electronic data form, scoring system, and database for road-stream crossing assessments. This database serves as a common archive of crossing assessment data (including data from protocols that pre-date the NAACC). To complete assessments across the region, NAACC has also launched an in-person and online training and certification program to ensure assessment data is accurate. As was mentioned previously in this report, the DER has partnered with NAACC to provide assessment training. In addition to this, the NAACC

Figure 20: Density of NAACC Stream Crossing Assessments in Massachusetts [12]



provides a number of web-based tools to identify high priority watersheds and crossings for assessments, including tools to prioritize crossings for repair or replacement. So far, the NAACC has assessed over 6,400 culvert and small bridges across the Commonwealth, which have been used to support many restoration projects that restore aquatic connectivity and provide resiliency benefits[17][12]. As can be seen in **Figure 20**, a small amount of NAACC crossing assessments have been completed in the CMMPO region.

The NAACC offers several different training protocols one can complete. These protocols include [18]:

- Aquatic connectivity in non-tidal streams,
- Aquatic connectivity in tidal streams,
- Criticality

∗ *The NAACC also includes information for assessing for 'terrestrial connectivity' and 'culvert condition', although official protocol and training has not yet been offered.*

Not every road-stream crossing is the same, which is why the NAACC standardizes several methodologies. Considering the purpose of this report and the location of the CMMPO region, this section will highlight what non-tidal aquatic connectivity assessments are, as well as what training is required in order to appropriately assess under the protocol and add data to the NAACC Data Center. For more information on other types of stream-crossing assessments, please visit this link.

In order to appropriately assess non-tidal road-stream crossings, the NAACC has created a protocol that includes assessments of crossings (i.e. crossing alignment) and of the structure itself (i.e. shape and dimensions. See **Appendix A** to see the NAACC assessment form for non-tidal road-stream crossings [19].

Following an assessment, the NAACC provides an online database to enter the assessment data. By entering data into the database, the crossings are automatically scored through a classification scoring approach with and a numerical scoring approach [20]:

- **Classification Scoring Approach:** each crossing is assigned to a category based on the degree of aquatic organism passage (AOP) through the crossing.
- **Numerical Scoring Approach:** formulas take the assessment data and compute a numeric score for the crossing, ranging from 0 (no aquatic passability) to 1 (full aquatic passability).
- For more information on the scoring system, please visit this link.

From this, the NAACC updates a database of layers, which can be downloaded for states, towns, and watersheds showing the condition of each culvert. The data collected will help identify priority culverts for upgrade or replacement [20].

In order to begin assessing non-tidal road-stream crossings and uploading to the NAACC database, the NAACC requires – at minimum – that individuals complete training to become certified as a 'Lead Observer'. **Lead Observers** are certified to assess stream crossings. They have a list of responsibilities, including [21]:

- Leading survey teams
- Coordinating survey materials and schedules
- Collecting field data (paper or electronic)
- Matching survey locations to XY coordinates
- Ensure assessments are done safely
- Entering data into the online database

To gain this certification, the NAACC requires an individual to pass a classroom training (either online or in-person, pass an online test, complete an in-person field day, and finally shadow a certified Lead Observer (at least 20 crossings). Becoming a certified NAACC Lead Observer gives one the ability to begin assessing the aquatic connectivity and resilience of stream-crossings in their town, watershed, and/or state [21].

The NAACC provides further training to gain increasing responsibility over lead observers, data, and training at a local or regional level. Once being certified as a Lead Observer, an individual has the option to be trained as a *'L1 (Level 1) Coordinator'*, *'L2 (Level 2) Coordinator'*, or 'L3 (Level 3) Coordinator' [21]:

L1 (Level 1) Coordinator – Local coordinators who manage Lead Observers.

- *Responsibilities include:*
  1) Recruit and supervise lead observers to assess road-stream crossings
  2) Create maps and determine survey locations
  3) Establish adherence to protocols and QA/QC procedures
  4) Field audit 10% of a Lead Observer's first 50 records
  5) Review and approve data entered into database
- *Training requirements include:*
  1) Certified as Lead Observer
  2) Pass online coordinator training unit
  3) Pass online coordinator training unit test

L2 (Level 2) Coordinator – Regional coordinators who manage surveys across a large geographic area (state, watershed).

- *Responsibilities include:*
  1) Manage surveys in one's geographic area
  2) Recruit and supervise L1 coordinators
  3) Coordinate training
  4) Ensure QA/QC procedures are updated
- *Training requirements include:*
  1) Certify as a Lead Observer
  2) Pass online coordinator training unit
  3) Pass online coordinator training unit test

L3 (Level 3) Coordinator – Central coordinators who manage key components of the NAACC

- *Responsibilities include:*
  1) Update field protocols
  2) Create and update scoring systems
  3) Develop QA/QC procedures
  4) Maintain the online database
  5) Disseminate news and updates to the NAACC community.

With this, the use of NAACC is critical to developing a regional approach for assessing culverts within the CMMPO region.

THE CMMPO APPROACH TO CULVERT ASSESSMENTS

The CMMPO region is home to 40 communities and seven watersheds. These watersheds are: Nashua River Basin (North), Concord River Basin (East), French River Basin (South), Blackstone River Basin (South-East), Chicopee River Basin (West), Quinebaug River Basin (South-West), and a small portion of the Charles River Watershed (South-East). All of these watersheds are part of larger basins or hydrological units. These basins are the Merrimack River Basin, the Coastal Basin, the Thames River Basin, and the Connecticut River Basin.

With thousands of stream miles connecting between each watershed, a regional and local effort is required to manage the assessments of culverts. To do this, the CMMPO has created a Regional Culvert Assessment Program, which will coincide with existing transportation data collection efforts and schedules, like traffic counting and pavement condition surveys. The only difference will be that the culvert program will focus on each individual watershed per data collection season, as preferred by NAACC [22]. Other projects, for example a Corridor Profile Study or TIP project, can also be used to prioritize assessments. As has been shown previously, very few NAACC assessments have been completed in the CMMPO region.

In order to help prioritize and decide where to survey, NAACC provides a variety of tools to do so. Other than NAACC assessment data, the main tools to prioritize surveys are the Conservation Assessment and Prioritization System (CAPS), Critical Local Linkages, and the Massachusetts Wildlife Climate Action Tool.

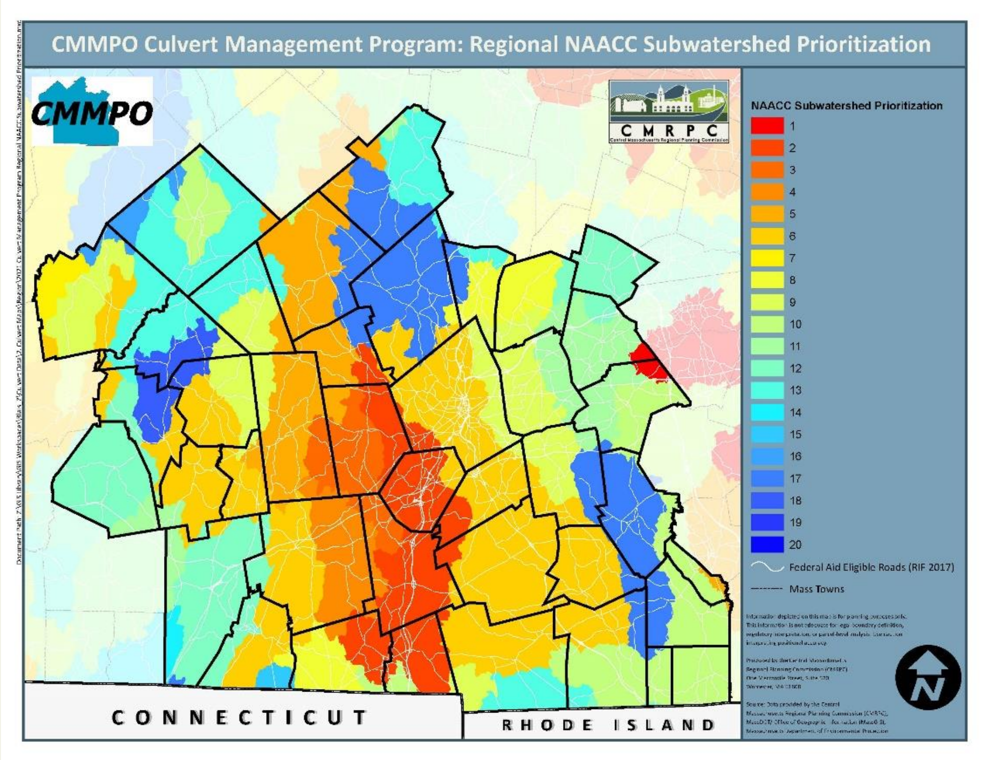


Figure 21: NAACC HUC12 Sub watershed Prioritization Tool [23]

Another tool that can be used to prioritize areas within a watershed to assess, NAACC also uses the TNC HUC12 Prioritization Tool, which prioritizes sub watersheds based on where culvert surveys should be focused according to the consensus-based objectives of NAACC. Objectives include brook trout, diadromous fish, risk of failure, and uncertainty of passability (see **Figure 21**) [23]. Beyond this, there are a number of other tools that the program can use to prioritize assessments. For example, transportation data (i.e. pavement condition, federal aid road status) and other environmental data (i.e. Areas of Critical Environmental Concerns, Coldwater fisheries, and dams). All in all, these tools will help shape the assessment cycle with transportation goals while also highlighting the most vulnerable ecological areas to focus on within each watershed. Every culvert assessment completed by staff will be uploaded to the NAACC data center for review and approval.

Before the CMMPO staff can begin assessing culverts across the region under NAACC assessment protocol, it is imperative staff become trained as Lead Observers. Being that the CMMPO region is land locked, CMMPO staff will train to become Lead Observers for Non-Tidal Aquatic Connectivity Assessments. By having several CMMPO staff trained as Lead Observers, this will ensure that more culverts can be assessed during each data collection season. To manage and maintain culvert assessments across the region, at least one staff member will train to become a L1/L2 Coordinator. Currently, the data collection season for culverts is expected to be between early spring and late fall to avoid higher flow conditions.

Currently, CMMPO Regional Culvert Assessment Program is a pilot-program, focusing on small-scaled areas to assess culverts under NAACC protocol. During fall 2020, CMMPO assessed about 15 culverts along Central Turnpike in Sutton, MA and Sutton Avenue in Oxford, MA – a developing Corridor Profile Study location. Over the course of the winter season, CMMPO will further shape this program and prepare for it to start assessing culverts within a watershed during the 2021 data collection season. The choice of this watershed and assessments will depend on results from the tools mentioned above.

In addition to completing Non-Tidal Aquatic Connectivity culvert assessments, CMMPO plans to use the data to create individual town maps and reports to share with towns; create a map dashboard, or story maps; identify and prioritize culverts for upgrades or replacement; identify connections between culvert assessments and the TIP or other transportation funded projects. More uses for the culvert assessments will be identified over time. As culverts are identified for upgrade or replacement, CMMPO will work with our communities to compete for funding opportunities to complete culvert projects.

MAJOR CHALLENGES AND LIMITATIONS

As this report has pointed out, there are an overwhelming amount of culverts and small bridges that are owned by municipalities and other entities within communities that are poorly designed and aging, becoming increasingly vulnerable to failure. Poorly designed and aging road-stream crossings face a variety of problems and can face serious consequences that lead to failure of the road-stream crossing, impacting transportation services and the natural environment. While the issue is clear, replacing or repairing these structures is not as straightforward for communities to complete due to a variety of permitting challenges and funding limitations.

Like other transportation infrastructure projects, culvert and small bridge projects often require local, state, and/or federal permits and reviews prior to construction. The complexity of these permits and reviews is dependent on the size of the structure, the potential impact to the environment, and the sensitivity of the project location. With that, many environmental permitting processes are tied to the protection of wetland and water resources. **For example, all culvert and small bridge projects that cross streams within the jurisdiction of the MA Wetlands Protection Act require review by the municipal conservation commission and MassDEP. Work subject to Wetlands Protection Act are subject to comply with the Stream Crossing Standards** [1].

On top of this, many municipalities have local bylaws or ordinances that further regulates work in these areas. Projects that fall within rare species habitat, exceed certain impact thresholds, and/or require sediment removal require further permitting and reviews. As was mentioned above, the ability to identify and complete the appropriate permits and approvals to replace these structures can be a challenge and drive up project costs. Each permit type has its own application process, forms, review timelines, prerequisites, and requirements. Many municipalities require technical support and resources to identify and complete necessary permits, leading to hiring qualified consultants to assist, which on its own can be expensive. To understand more about the variety of permits and the approximate time to review them, refer to the table on **Appendix B** [1].

To compound issues with permitting, the ability to fund a culvert or small bridge replacement poses even more challenges and limitations for a municipality to complete a culvert or small bridge project. While most municipalities rely on state and federal funding for transportation infrastructure improvements, or Chapter 90 funds for capital improvements like roadway maintenance, preservation, and improvement projects, overall funding is limited and most of these funds are used for other municipal priorities. Therefore, funding to replace or repair culverts and small bridges that are not part of a larger transportation project can be difficult to source [1].

To help fill municipal funding gaps to replace or repair culverts and small bridges, there are several programs to provide state funding and technical assistance for these projects. While these funding resources have been successful over the years, applications are increasingly higher than available grant funding available, highlighting the growing concern for these structures and the need to expand funding programs. To become more aware of funding opportunities for culvert and small bridge projects and their capacity, refer to the table on **Appendix C,** summarizes all current federal, state, and local programs. Moreover, when it comes to communities undertaking culvert and small bridge replacement projects, there are technical support resources available. The table on **Appendix D**, summarizes key funding opportunities and resources available to help communities through culvert replacement projects [1].

CONCLUSION & NEXT STEPS

As this paper has shown, there are an overwhelming number of culverts across the Commonwealth and the CMMPO region that are poorly designed and are nearing the end of their anticipated life cycle. With this, many culverts are on the verge of failure and are left increasingly vulnerable to climate change-related weather events. There is clearly a need to either repair or replace culverts to current standards and increase their resiliency to storms and flooding events.

While MassDOT is developing a Working Group to inventory and assess many of these structures, it is necessary to use other existing resources and methodologies, like the NAACC and Stream Crossing Standards, to assess and prioritize culverts for upgrade or replacement before a failure occurs. But as this paper has also shown, upgrading or replacing these structures is not as straightforward given permitting, funding, and technical challenges. Therefore, assisting our communities throughout the process of completing a culvert project is important to help them overcome permitting, funding and technical challenges. Doing so is a positive step forward to ensure that transportation systems, residents, and stream continuity are more sustainable and resilient to increased storm frequency and intensity across the CMMPO region.

As the CMMPO Regional Culvert Assessment Program moves forward, this report will be updated to reflect current conditions of the program. The CMMPO staff will continue to follow the developments from MassDOT regarding culverts and their Working Group, and implement changes into the program as necessary. Furthermore, CMMPO will have several staff members completing NAACC Lead Observer training for non-tidal aquatic connectivity assessments, with at least one staff member becoming trained as a L1 (Level 1) Coordinator to help manage and expand culvert assessments across the region. Beyond training to become NAACC protocol certified, the CMMPO Regional Culvert Assessment Program will work to organize an asset management plan that coincides with other data collection efforts. From there, other next steps will be pursued and expanded upon, including tools for prioritization, scheduling of assessments, and integrating assessments into proposed projects and grant opportunities (i.e. TIP, MVP, and Corridor Profile projects).

For more information about the CMMPO Regional Culvert Assessment Program, please contact Zachary Blais, Transportation Assistant Planner, zblais@cmrpc.org

APPENDIX A

See following page

NAACC — North Atlantic Aquatic Connectivity Collaborative

AQUATIC CONNECTIVITY

Stream Crossing Survey

DATA FORM

DATABASE ENTRY BY ____________ ENTRY DATE ____________

DATA ENTRY REVIEWED BY ____________ REVIEW DATE ____________

CROSSING DATA

Crossing Code ____________ **Local ID** (Optional) ____________

Date Observed (00/00/0000) ____________ **Lead Observer** ____________

Town/County ____________ **Stream** ____________

Road ____________ **Type** ☐ MULTILANE ☐ PAVED ☐ UNPAVED ☐ DRIVEWAY ☐ TRAIL ☐ RAILROAD

GPS Coordinates (Decimal degrees) ☐☐.☐☐☐☐☐ °N Latitude — ☐☐.☐☐☐☐☐ °W Longitude

Location Description

Crossing Type ☐ BRIDGE ☐ CULVERT ☐ MULTIPLE CULVERT ☐ FORD ☐ NO CROSSING ☐ REMOVED CROSSING ☐ BURIED STREAM ☐ INACCESSIBLE ☐ PARTIALLY INACCESSIBLE ☐ NO UPSTREAM CHANNEL ☐ BRIDGE ADEQUATE

Number of Culverts/ Bridge Cells ____________

Photo IDs INLET ____________ OUTLET ____________ UPSTREAM ____________ DOWNSTREAM ____________ OTHER ____________

Flow Condition ☐ NO FLOW ☐ TYPICAL-LOW ☐ MODERATE ☐ HIGH

Crossing Condition ☐ OK ☐ POOR ☐ NEW ☐ UNKNOWN

Tidal Site ☐ YES ☐ NO ☐ UNKNOWN

Alignment ☐ FLOW-ALIGNED ☐ SKEWED (>45°)

Road Fill Height (Top of culvert to road surface; bridge = 0) ____________

Bankfull Width (Optional) ____________ **Confidence** ☐ HIGH ☐ LOW/ESTIMATED

Constriction ☐ SEVERE ☐ MODERATE ☐ SPANS ONLY BANKFULL/ ACTIVE CHANNEL ☐ SPANS FULL CHANNEL & BANKS

Tailwater Scour Pool ☐ NONE ☐ SMALL ☐ LARGE

Crossing Comments

STRUCTURE 1

Structure Material ☐ METAL ☐ CONCRETE ☐ PLASTIC ☐ WOOD ☐ ROCK/STONE ☐ FIBERGLASS ☐ COMBINATION

OUTLET

Outlet Shape ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ FORD ☐ UNKNOWN ☐ REMOVED

Outlet Armoring ☐ NONE ☐ NOT EXTENSIVE ☐ EXTENSIVE

Outlet Grade (Pick one) ☐ AT STREAM GRADE ☐ FREE FALL ☐ CASCADE ☐ FREE FALL ONTO CASCADE ☐ CLOGGED/COLLAPSED/SUBMERGED ☐ UNKNOWN

Outlet Dimensions **A. Width** ______.___ **B. Height** ______.___ **C. Substrate/Water Width** ______.___ **D. Water Depth** ______.___

Outlet Drop to Water Surface ______.___ **Outlet Drop to Stream Bottom** ______.___ **E. Abutment Height** (Type 7 bridges only) ______.___

L. Structure Length (Overall length from inlet to outlet) ______.___

INLET

Inlet Shape ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ FORD ☐ UNKNOWN ☐ REMOVED

Inlet Type ☐ PROJECTING ☐ HEADWALL ☐ WINGWALLS ☐ HEADWALL & WINGWALLS ☐ MITERED TO SLOPE ☐ OTHER ☐ NONE

Inlet Grade (Pick one) ☐ AT STREAM GRADE ☐ INLET DROP ☐ PERCHED ☐ CLOGGED/COLLAPSED/SUBMERGED ☐ UNKNOWN

Inlet Dimensions **A. Width** ______.___ **B. Height** ______.___ **C. Substrate/Water Width** ______.___ **D. Water Depth** ______.___

ADDITIONAL CONDITIONS

Slope % (Optional) ____________ **Slope Confidence** ☐ HIGH ☐ LOW

Internal Structures ☐ NONE ☐ BAFFLES/WEIRS ☐ SUPPORTS ☐ OTHER ____________

Structure Substrate Matches Stream ☐ NONE ☐ COMPARABLE ☐ CONTRASTING ☐ NOT APPROPRIATE ☐ UNKNOWN

Structure Substrate Type (Pick one) ☐ NONE ☐ SILT ☐ SAND ☐ GRAVEL ☐ COBBLE ☐ BOULDER ☐ BEDROCK ☐ UNKNOWN

Structure Substrate Coverage ☐ NONE ☐ 25% ☐ 50% ☐ 75% ☐ 100% ☐ UNKNOWN

Physical Barriers (Pick all that apply) ☐ NONE ☐ DEBRIS/SEDIMENT/ROCK ☐ DEFORMATION ☐ FREE FALL ☐ FENCING ☐ DRY ☐ OTHER

Severity (Choose carefully based on barrier type(s) above) ☐ NONE ☐ MINOR ☐ MODERATE ☐ SEVERE

Water Depth Matches Stream ☐ YES ☐ NO-SHALLOWER ☐ NO-DEEPER ☐ UNKNOWN ☐ DRY

Water Velocity Matches Stream ☐ YES ☐ NO-FASTER ☐ NO-SLOWER ☐ UNKNOWN ☐ DRY

Dry Passage through Structure? ☐ YES ☐ NO ☐ UNKNOWN **Height above Dry Passage** ____________

Comments

5/26/16

STRUCTURE 2

Structure Material ☐ METAL ☐ CONCRETE ☐ PLASTIC ☐ WOOD ☐ ROCK/STONE ☐ FIBERGLASS ☐ COMBINATION

OUTLET

Outlet Shape ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ FORD ☐ UNKNOWN ☐ REMOVED **Outlet Armoring** ☐ NONE ☐ NOT EXTENSIVE ☐ EXTENSIVE

Outlet Grade (Pick one) ☐ AT STREAM GRADE ☐ FREE FALL ☐ CASCADE ☐ FREE FALL ONTO CASCADE ☐ CLOGGED/COLLAPSED/SUBMERGED ☐ UNKNOWN

Outlet Dimensions **A. Width**________.___ **B. Height**________.___ **C. Substrate/Water Width**________.___ **D. Water Depth**________.___

Outlet Drop to Water Surface_________.___ **Outlet Drop to Stream Bottom**_________.___ **E. Abutment Height** (Type 7 bridges only)______________.___

L. Structure Length (Overall length from inlet to outlet)____________.____

INLET

Inlet Shape ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ FORD ☐ UNKNOWN ☐ REMOVED

Inlet Type ☐ PROJECTING ☐ HEADWALL ☐ WINGWALLS ☐ HEADWALL & WINGWALLS ☐ MITERED TO SLOPE ☐ OTHER ☐ NONE

Inlet Grade (Pick one) ☐ AT STREAM GRADE ☐ INLET DROP ☐ PERCHED ☐ CLOGGED/COLLAPSED/SUBMERGED ☐ UNKNOWN

Inlet Dimensions **A. Width**________.___ **B. Height**________.___ **C. Substrate/Water Width**________.___ **D. Water Depth**________.___

ADDITIONAL CONDITIONS

Slope % (Optional)________ **Slope Confidence** ☐ HIGH ☐ LOW | **Internal Structures** ☐ NONE ☐ BAFFLES/WEIRS ☐ SUPPORTS ☐ OTHER________

Structure Substrate Matches Stream ☐ NONE ☐ COMPARABLE ☐ CONTRASTING ☐ NOT APPROPRIATE ☐ UNKNOWN

Structure Substrate Type (Pick one) ☐ NONE ☐ SILT ☐ SAND ☐ GRAVEL ☐ COBBLE ☐ BOULDER ☐ BEDROCK ☐ UNKNOWN

Structure Substrate Coverage ☐ NONE ☐ 25% ☐ 50% ☐ 75% ☐ 100% ☐ UNKNOWN

Physical Barriers (Pick all that apply) ☐ NONE ☐ DEBRIS/SEDIMENT/ROCK ☐ DEFORMATION ☐ FREE FALL ☐ FENCING ☐ DRY ☐ OTHER

Severity (Choose carefully based on barrier type(s) above) ☐ NONE ☐ MINOR ☐ MODERATE ☐ SEVERE

Water Depth Matches Stream ☐ YES ☐ NO-SHALLOWER ☐ NO-DEEPER ☐ UNKNOWN ☐ DRY

Water Velocity Matches Stream ☐ YES ☐ NO-FASTER ☐ NO-SLOWER ☐ UNKNOWN ☐ DRY

Dry Passage through Structure? ☐ YES ☐ NO ☐ UNKNOWN **Height above Dry Passage**__________

Comments

STRUCTURE 3

Structure Material ☐ METAL ☐ CONCRETE ☐ PLASTIC ☐ WOOD ☐ ROCK/STONE ☐ FIBERGLASS ☐ COMBINATION

OUTLET

Outlet Shape ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ FORD ☐ UNKNOWN ☐ REMOVED **Outlet Armoring** ☐ NONE ☐ NOT EXTENSIVE ☐ EXTENSIVE

Outlet Grade (Pick one) ☐ AT STREAM GRADE ☐ FREE FALL ☐ CASCADE ☐ FREE FALL ONTO CASCADE ☐ CLOGGED/COLLAPSED/SUBMERGED ☐ UNKNOWN

Outlet Dimensions **A. Width**________.___ **B. Height**________.___ **C. Substrate/Water Width**________.___ **D. Water Depth**________.___

Outlet Drop to Water Surface_________.___ **Outlet Drop to Stream Bottom**_________.___ **E. Abutment Height** (Type 7 bridges only)______________.___

L. Structure Length (Overall length from inlet to outlet)____________.____

INLET

Inlet Shape ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ FORD ☐ UNKNOWN ☐ REMOVED

Inlet Type ☐ PROJECTING ☐ HEADWALL ☐ WINGWALLS ☐ HEADWALL & WINGWALLS ☐ MITERED TO SLOPE ☐ OTHER ☐ NONE

Inlet Grade (Pick one) ☐ AT STREAM GRADE ☐ INLET DROP ☐ PERCHED ☐ CLOGGED/COLLAPSED/SUBMERGED ☐ UNKNOWN

Inlet Dimensions **A. Width**________.___ **B. Height**________.___ **C. Substrate/Water Width**________.___ **D. Water Depth**________.___

ADDITIONAL CONDITIONS

Slope % (Optional)________ **Slope Confidence** ☐ HIGH ☐ LOW | **Internal Structures** ☐ NONE ☐ BAFFLES/WEIRS ☐ SUPPORTS ☐ OTHER________

Structure Substrate Matches Stream ☐ NONE ☐ COMPARABLE ☐ CONTRASTING ☐ NOT APPROPRIATE ☐ UNKNOWN

Structure Substrate Type (Pick one) ☐ NONE ☐ SILT ☐ SAND ☐ GRAVEL ☐ COBBLE ☐ BOULDER ☐ BEDROCK ☐ UNKNOWN

Structure Substrate Coverage ☐ NONE ☐ 25% ☐ 50% ☐ 75% ☐ 100% ☐ UNKNOWN

Physical Barriers (Pick all that apply) ☐ NONE ☐ DEBRIS/SEDIMENT/ROCK ☐ DEFORMATION ☐ FREE FALL ☐ FENCING ☐ DRY ☐ OTHER

Severity (Choose carefully based on barrier type(s) above) ☐ NONE ☐ MINOR ☐ MODERATE ☐ SEVERE

Water Depth Matches Stream ☐ YES ☐ NO-SHALLOWER ☐ NO-DEEPER ☐ UNKNOWN ☐ DRY

Water Velocity Matches Stream ☐ YES ☐ NO-FASTER ☐ NO-SLOWER ☐ UNKNOWN ☐ DRY

Dry Passage through Structure? ☐ YES ☐ NO ☐ UNKNOWN **Height above Dry Passage**__________

Comments

STRUCTURE 4

Structure Material ☐ METAL ☐ CONCRETE ☐ PLASTIC ☐ WOOD ☐ ROCK/STONE ☐ FIBERGLASS ☐ COMBINATION

OUTLET

Outlet Shape ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ FORD ☐ UNKNOWN ☐ REMOVED **Outlet Armoring** ☐ NONE ☐ NOT EXTENSIVE ☐ EXTENSIVE

Outlet Grade (Pick one) ☐ AT STREAM GRADE ☐ FREE FALL ☐ CASCADE ☐ FREE FALL ONTO CASCADE ☐ CLOGGED/COLLAPSED/SUBMERGED ☐ UNKNOWN

Outlet Dimensions **A. Width**__________.____ **B. Height**__________.____ **C. Substrate/Water Width**__________.____ **D. Water Depth**__________.____

Outlet Drop to Water Surface____________.____ **Outlet Drop to Stream Bottom**____________.____ **E. Abutment Height** (Type 7 bridges only)__________________.____

L. Structure Length (Overall length from inlet to outlet)________________.____

INLET

Inlet Shape ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ FORD ☐ UNKNOWN ☐ REMOVED

Inlet Type ☐ PROJECTING ☐ HEADWALL ☐ WINGWALLS ☐ HEADWALL & WINGWALLS ☐ MITERED TO SLOPE ☐ OTHER ☐ NONE

Inlet Grade (Pick one) ☐ AT STREAM GRADE ☐ INLET DROP ☐ PERCHED ☐ CLOGGED/COLLAPSED/SUBMERGED ☐ UNKNOWN

Inlet Dimensions **A. Width**__________.____ **B. Height**__________.____ **C. Substrate/Water Width**__________.____ **D. Water Depth**__________.____

ADDITIONAL CONDITIONS

Slope % (Optional)__________ **Slope Confidence** ☐ HIGH ☐ LOW | **Internal Structures** ☐ NONE ☐ BAFFLES/WEIRS ☐ SUPPORTS ☐ OTHER__________

Structure Substrate Matches Stream ☐ NONE ☐ COMPARABLE ☐ CONTRASTING ☐ NOT APPROPRIATE ☐ UNKNOWN

Structure Substrate Type (Pick one) ☐ NONE ☐ SILT ☐ SAND ☐ GRAVEL ☐ COBBLE ☐ BOULDER ☐ BEDROCK ☐ UNKNOWN

Structure Substrate Coverage ☐ NONE ☐ 25% ☐ 50% ☐ 75% ☐ 100% ☐ UNKNOWN

Physical Barriers (Pick all that apply) ☐ NONE ☐ DEBRIS/SEDIMENT/ROCK ☐ DEFORMATION ☐ FREE FALL ☐ FENCING ☐ DRY ☐ OTHER

Severity (Choose carefully based on barrier type(s) above) ☐ NONE ☐ MINOR ☐ MODERATE ☐ SEVERE

Water Depth Matches Stream ☐ YES ☐ NO-SHALLOWER ☐ NO-DEEPER ☐ UNKNOWN ☐ DRY

Water Velocity Matches Stream ☐ YES ☐ NO-FASTER ☐ NO-SLOWER ☐ UNKNOWN ☐ DRY

Dry Passage through Structure? ☐ YES ☐ NO ☐ UNKNOWN **Height above Dry Passage**______________

Comments

STRUCTURE 5

Structure Material ☐ METAL ☐ CONCRETE ☐ PLASTIC ☐ WOOD ☐ ROCK/STONE ☐ FIBERGLASS ☐ COMBINATION

OUTLET

Outlet Shape ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ FORD ☐ UNKNOWN ☐ REMOVED **Outlet Armoring** ☐ NONE ☐ NOT EXTENSIVE ☐ EXTENSIVE

Outlet Grade (Pick one) ☐ AT STREAM GRADE ☐ FREE FALL ☐ CASCADE ☐ FREE FALL ONTO CASCADE ☐ CLOGGED/COLLAPSED/SUBMERGED ☐ UNKNOWN

Outlet Dimensions **A. Width**__________.____ **B. Height**__________.____ **C. Substrate/Water Width**__________.____ **D. Water Depth**__________.____

Outlet Drop to Water Surface____________.____ **Outlet Drop to Stream Bottom**____________.____ **E. Abutment Height** (Type 7 bridges only)__________________.____

L. Structure Length (Overall length from inlet to outlet)________________.____

INLET

Inlet Shape ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ FORD ☐ UNKNOWN ☐ REMOVED

Inlet Type ☐ PROJECTING ☐ HEADWALL ☐ WINGWALLS ☐ HEADWALL & WINGWALLS ☐ MITERED TO SLOPE ☐ OTHER ☐ NONE

Inlet Grade (Pick one) ☐ AT STREAM GRADE ☐ INLET DROP ☐ PERCHED ☐ CLOGGED/COLLAPSED/SUBMERGED ☐ UNKNOWN

Inlet Dimensions **A. Width**__________.____ **B. Height**__________.____ **C. Substrate/Water Width**__________.____ **D. Water Depth**__________.____

ADDITIONAL CONDITIONS

Slope % (Optional)__________ **Slope Confidence** ☐ HIGH ☐ LOW | **Internal Structures** ☐ NONE ☐ BAFFLES/WEIRS ☐ SUPPORTS ☐ OTHER__________

Structure Substrate Matches Stream ☐ NONE ☐ COMPARABLE ☐ CONTRASTING ☐ NOT APPROPRIATE ☐ UNKNOWN

Structure Substrate Type (Pick one) ☐ NONE ☐ SILT ☐ SAND ☐ GRAVEL ☐ COBBLE ☐ BOULDER ☐ BEDROCK ☐ UNKNOWN

Structure Substrate Coverage ☐ NONE ☐ 25% ☐ 50% ☐ 75% ☐ 100% ☐ UNKNOWN

Physical Barriers (Pick all that apply) ☐ NONE ☐ DEBRIS/SEDIMENT/ROCK ☐ DEFORMATION ☐ FREE FALL ☐ FENCING ☐ DRY ☐ OTHER

Severity (Choose carefully based on barrier type(s) above) ☐ NONE ☐ MINOR ☐ MODERATE ☐ SEVERE

Water Depth Matches Stream ☐ YES ☐ NO-SHALLOWER ☐ NO-DEEPER ☐ UNKNOWN ☐ DRY

Water Velocity Matches Stream ☐ YES ☐ NO-FASTER ☐ NO-SLOWER ☐ UNKNOWN ☐ DRY

Dry Passage through Structure? ☐ YES ☐ NO ☐ UNKNOWN **Height above Dry Passage**______________

Comments

STRUCTURE 6

Structure Material ☐ METAL ☐ CONCRETE ☐ PLASTIC ☐ WOOD ☐ ROCK/STONE ☐ FIBERGLASS ☐ COMBINATION

OUTLET

Outlet Shape ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ FORD ☐ UNKNOWN ☐ REMOVED **Outlet Armoring** ☐ NONE ☐ NOT EXTENSIVE ☐ EXTENSIVE

Outlet Grade (Pick one) ☐ AT STREAM GRADE ☐ FREE FALL ☐ CASCADE ☐ FREE FALL ONTO CASCADE ☐ CLOGGED/COLLAPSED/SUBMERGED ☐ UNKNOWN

Outlet Dimensions **A. Width**_________.____ **B. Height**_________.____ **C. Substrate/Water Width**_________.____ **D. Water Depth**_________.____

Outlet Drop to Water Surface_________.____ **Outlet Drop to Stream Bottom**_________.____ **E. Abutment Height** (Type 7 bridges only)_________.____

L. Structure Length (Overall length from inlet to outlet)_________.____

INLET

Inlet Shape ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ FORD ☐ UNKNOWN ☐ REMOVED

Inlet Type ☐ PROJECTING ☐ HEADWALL ☐ WINGWALLS ☐ HEADWALL & WINGWALLS ☐ MITERED TO SLOPE ☐ OTHER ☐ NONE

Inlet Grade (Pick one) ☐ AT STREAM GRADE ☐ INLET DROP ☐ PERCHED ☐ CLOGGED/COLLAPSED/SUBMERGED ☐ UNKNOWN

Inlet Dimensions **A. Width**_________.____ **B. Height**_________.____ **C. Substrate/Water Width**_________.____ **D. Water Depth**_________.____

ADDITIONAL CONDITIONS

Slope % (Optional)________ **Slope Confidence** ☐ HIGH ☐ LOW | **Internal Structures** ☐ NONE ☐ BAFFLES/WEIRS ☐ SUPPORTS ☐ OTHER________

Structure Substrate Matches Stream ☐ NONE ☐ COMPARABLE ☐ CONTRASTING ☐ NOT APPROPRIATE ☐ UNKNOWN

Structure Substrate Type (Pick one) ☐ NONE ☐ SILT ☐ SAND ☐ GRAVEL ☐ COBBLE ☐ BOULDER ☐ BEDROCK ☐ UNKNOWN

Structure Substrate Coverage ☐ NONE ☐ 25% ☐ 50% ☐ 75% ☐ 100% ☐ UNKNOWN

Physical Barriers (Pick all that apply) ☐ NONE ☐ DEBRIS/SEDIMENT/ROCK ☐ DEFORMATION ☐ FREE FALL ☐ FENCING ☐ DRY ☐ OTHER

Severity (Choose carefully based on barrier type(s) above) ☐ NONE ☐ MINOR ☐ MODERATE ☐ SEVERE

Water Depth Matches Stream ☐ YES ☐ NO-SHALLOWER ☐ NO-DEEPER ☐ UNKNOWN ☐ DRY

Water Velocity Matches Stream ☐ YES ☐ NO-FASTER ☐ NO-SLOWER ☐ UNKNOWN ☐ DRY

Dry Passage through Structure? ☐ YES ☐ NO ☐ UNKNOWN **Height above Dry Passage**_________

Comments

STRUCTURE 7

Structure Material ☐ METAL ☐ CONCRETE ☐ PLASTIC ☐ WOOD ☐ ROCK/STONE ☐ FIBERGLASS ☐ COMBINATION

OUTLET

Outlet Shape ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ FORD ☐ UNKNOWN ☐ REMOVED **Outlet Armoring** ☐ NONE ☐ NOT EXTENSIVE ☐ EXTENSIVE

Outlet Grade (Pick one) ☐ AT STREAM GRADE ☐ FREE FALL ☐ CASCADE ☐ FREE FALL ONTO CASCADE ☐ CLOGGED/COLLAPSED/SUBMERGED ☐ UNKNOWN

Outlet Dimensions **A. Width**_________.____ **B. Height**_________.____ **C. Substrate/Water Width**_________.____ **D. Water Depth**_________.____

Outlet Drop to Water Surface_________.____ **Outlet Drop to Stream Bottom**_________.____ **E. Abutment Height** (Type 7 bridges only)_________.____

L. Structure Length (Overall length from inlet to outlet)_________.____

INLET

Inlet Shape ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ FORD ☐ UNKNOWN ☐ REMOVED

Inlet Type ☐ PROJECTING ☐ HEADWALL ☐ WINGWALLS ☐ HEADWALL & WINGWALLS ☐ MITERED TO SLOPE ☐ OTHER ☐ NONE

Inlet Grade (Pick one) ☐ AT STREAM GRADE ☐ INLET DROP ☐ PERCHED ☐ CLOGGED/COLLAPSED/SUBMERGED ☐ UNKNOWN

Inlet Dimensions **A. Width**_________.____ **B. Height**_________.____ **C. Substrate/Water Width**_________.____ **D. Water Depth**_________.____

ADDITIONAL CONDITIONS

Slope % (Optional)________ **Slope Confidence** ☐ HIGH ☐ LOW | **Internal Structures** ☐ NONE ☐ BAFFLES/WEIRS ☐ SUPPORTS ☐ OTHER________

Structure Substrate Matches Stream ☐ NONE ☐ COMPARABLE ☐ CONTRASTING ☐ NOT APPROPRIATE ☐ UNKNOWN

Structure Substrate Type (Pick one) ☐ NONE ☐ SILT ☐ SAND ☐ GRAVEL ☐ COBBLE ☐ BOULDER ☐ BEDROCK ☐ UNKNOWN

Structure Substrate Coverage ☐ NONE ☐ 25% ☐ 50% ☐ 75% ☐ 100% ☐ UNKNOWN

Physical Barriers (Pick all that apply) ☐ NONE ☐ DEBRIS/SEDIMENT/ROCK ☐ DEFORMATION ☐ FREE FALL ☐ FENCING ☐ DRY ☐ OTHER

Severity (Choose carefully based on barrier type(s) above) ☐ NONE ☐ MINOR ☐ MODERATE ☐ SEVERE

Water Depth Matches Stream ☐ YES ☐ NO-SHALLOWER ☐ NO-DEEPER ☐ UNKNOWN ☐ DRY

Water Velocity Matches Stream ☐ YES ☐ NO-FASTER ☐ NO-SLOWER ☐ UNKNOWN ☐ DRY

Dry Passage through Structure? ☐ YES ☐ NO ☐ UNKNOWN **Height above Dry Passage**_________

Comments

Structure Shape & Dimensions

1) Select the Structure Shape number from the diagrams below and record it on the form for Inlet and Outlet Shape.

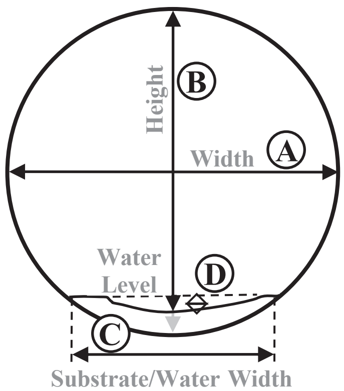
2) Record on the form in the approriate blanks dimensions **A**, **B**, **C** and **D** as shown in the diagrams;
C captures the width of water or substrate, whichever is wider; for dry culverts without substrate, C = 0.
D is the depth of water -- be sure to measure inside the structure; for dry culverts, D = 0.

3) Record Structure Length (**L**). (Record abutment height (**E**) only for Type 7 Structures.)

4) For multiple culverts, also record the Inlet and Outlet shape and dimensions for each additional culvert.

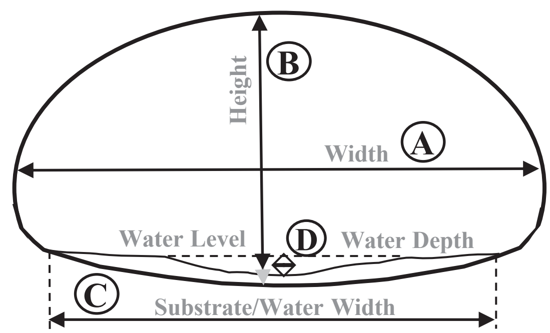
NOTE: Culverts 1, 2 & 4 may or may not have substrate in them, so height measurements (B) are taken from the level of the "stream bed", whether that bed is composed of substrate or just the inside bottom surface of a culvert (grey arrows below show measuring to bottom, black arrows show measuring to substrate).

1



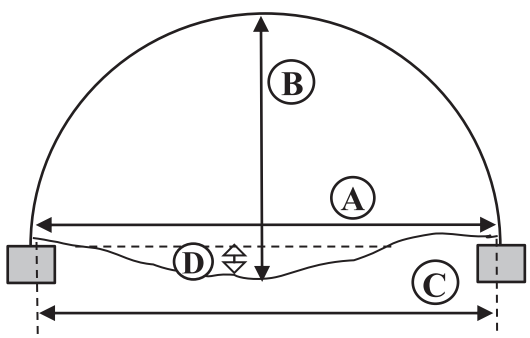
Round Culvert

2



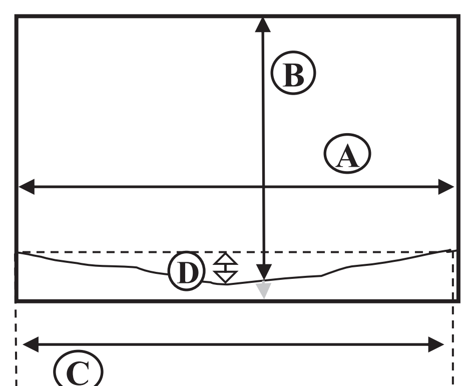
Pipe Arch/Elliptical Culvert

3



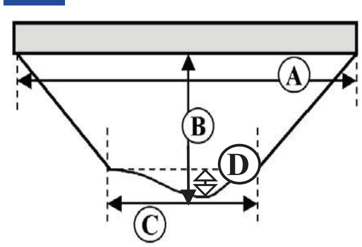
Open Bottom Arch Bridge/Culvert

4



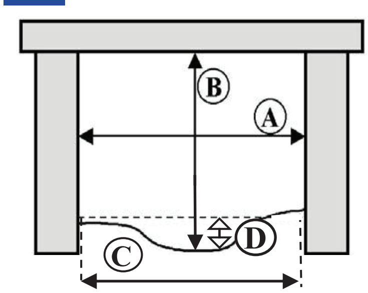
Box Culvert

5



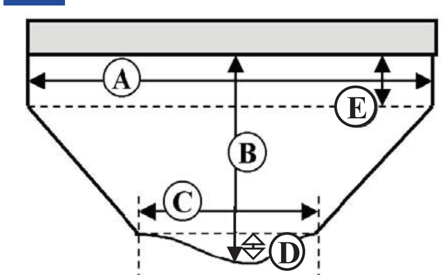
Bridge with Side Slopes

6



Box/Bridge with Abutments

7



Bridge with Abutments and Side Slopes

APPENDIX B

See following page

TYPICAL ENVIRONMENTAL PERMITS AND APPROVALS				
	Permit/Review*	**Permit Purpose**	**When Required**	**Approximate Time to Issue****
Federal	Section 404 Self Verification Notification *USACE	Protection of federal wetlands	< 5,000 sf of wetland impact	> 1 month
	Section 404 Pre-Construction Notification *USACE	Protection of federal wetlands	> 5,000 sf of wetland impact, but less than 1 acre	7 months
	Section 7 and Essential Fish Habitat (EFH) Consultation Letter *USFWS/DMF/NMFS	Protect federal rare species and EFH	Within federal/designated rare species habitat	1.5 months
	Coastal Zone Management (CZM) Consistency Review *CZM	Protect coastal/marine resources	When MEPA ENF review is required	1.5 months
	Coast Guard Waiver/Permit *US Coast Guard	Protect interstate navigation	For viers with commerical navigation or some tidal waterays	waiver: 1 month permit: 10-12 months
	FEMA Floodplain Letter of Map Revision/Conditional Letter of Map Revision *FEMA	Update related floodplain maps	When changing hydrualic opening of a bridge	> 6 months
State Agency/Board	Project Notification Form (PNF) *MA Historical Commission	Protect historic/archaeological resources	All projects	1 month
	MA Endangered Species Act Review *MA Natural Heritage and Endangered Species Program	Protect rare species and their habitats	Within Priority Habitat of Rare Species	1-3 months
	Section 401 Water Quality Certification *MassDEP	Protect federal wetland resources	Impacts federal wetlands (not required if impact < 5,000 sf)	3-4 months
	Chapter 91 License/Permit *MassDEP	Protect public interest in MA tidelands and waterways	Within tidelands, non-tidal rivers, great ponds	4-10 months
	Environmental Notification Form (ENF) *EEA's MEPA Office	Review project's environmental impacts and development of measures to avoid, minimize, and mitigate environmental impacts	Project exceeds certain review thresholds	1.5 months
	Chapter 85 Bridge Review *MassDOT	Ensure bridges are designed properly	For bridge spans greater than 10'	1-3 months
	Dam Safety Permit *MassDCR	Protect against dam failure	When project will result in water level changes that affect safety conditions	1 month
Local Agency/Board	MA Wetlands Protection Act Order of Conditions *Local Conservation Commission; also review by MassDEP	Protect state wetland resources; can include local wetland bylaw reviews	Impacts or within 100' of state wetlands	2 months

*Permit Granting Authority
**time to issue is based on standard projects without much public controversy; does not include time to prepare application materials

APPENDIX C

See following page

FUNDING OPPORTUNITIES AND RESOURCES			
	Funding Opportunity *organization	**About**	**Website**
State	**Culvert Replacment Municipal Assistance Grant Program (CRMA) *DER**	For MA municipalities looking to replace an undersized, perched, and/or degraded culvert locaed within an area of high ecological value. These new crossings are required to meet the goals of the MA Stream Crossing Standards. These standards incorporate improved structural and environmental design standards and flood resiliency criteria to provide fish passage, habitat continuity, and resilience to large storms. For FY2021, $806,880 were dispersed between individual culvert replacement projects.	https://www.mass.gov/how-to/culvert-replacement-municipal-assistance-grant-program
	MVP Action Grants *EEA	Offers financial resources to municipalities to seek and advance priority climate adaptation actions to address a variety of climate change impacts (i.e. inland flooding).	https://www.mass.gov/service-details/mvp-action-grant-eligibility-criteria
	Municipal Small Bridge Program *MassDOT	A 5-year program that assists cities and towns to replace or repair bridges with spans between 10' and 20'. Municipalities may qualify for up to $500,000 per year. These structures are not eligible for federal aid funding.	https://www.mass.gov/municipal-small-bridge-program
	Hazard Mitigation Grant Program (HGMP) *FEMA; Administered by MEMA	Provides funds to states, territories, tribal governments, and other entities after a disaster to reduce/eliminate future risk to life and property from natural hazard events. This funding reduces the need for the reliance on taxpayer-funded federal assitance for disaster recovery while mitigating risk to lives and property. A couple project examples include culvert improvement and infrastructure protection. Funds are only available after a major disaster declaration has been made.	https://mass.gov/service-details/hazard-mitigation-grant-program-hgmp
	Pre-Disaster Mitigation Grant Program (PDM) *FEMA; Adminstered by MEMA	Provides funds to states, territories, tribal governments, and other entities for hazard mitigation planning and mitigation projects prior to a disaster. An annual allocation subject to Congressional appropriation.	https://www.mass.gov/service-details/pdm-fma-grants
	Flood Mitigation Assistance Grant program (FMA) *FEMA; Adminstered by MEMA	Provides funds to assist state agencies and local governments with implementing measures to reduce or elimate long-term risk of flood damage to property insured under the National Flood Insurance Program. An annual allocation subject to Congressional appropriation.	
	MassWorks Infrastructure Program *EOHED	A competitive grant program that provides a large, flexible funding source of capital funds to municipalities and other public entities for infrastructure projects that support and accelerate housing production, spur private development, and create jobs throughout the state.	https://www.mass.gov/service-details/massworks-infrastructure-grants
	Community Compact Best Practices Program *Division of Local Services	A voluntary, mutual agreement between the Baker-Polito Administration and individual municipalites in the state. In a Compact, a community agrees to implement at least one 'best practice' that they select from a variety of areas. These 'best practices' are reviewed between the state and the municipality to ensure those chosen are unique to the municipality and reflect needs of improvement. The Compact also highlights the state's commitments on behalf of all communities.	https://www.mass.gov/how-to/apply-for-the-best-practice-program
Federal	**NOAA Habitat Restoration Projects *NOAA Fisheries, Habitat Conservation**	Supports restoration projects that use a habitat-based approach to (1) rebuild productive and sustainable fisheries, (2) help recover and conserve protected resources, (3) promote healthy ecosystems, (4) provide community and economic benefits.	https://www.fisheries.noaa.gov/grant/coastal-and-marine-habitat-restorationgrants
	NOAA Coastal Resilience Grants *NOAA Fisheries, Habitat Conservation	Intended to fund projects that build reslience to conserve and restore sustainable ecosystem processes, as well as reduce vulnerability of coastal communities from climate change impacts and extreme weather events.	https://www.fisheries.noaa.gov/grant/noaa-coastal-resilience-grants
	National Fish Passage Program *US Fish and Wildlife Service	A voluntary program to provide financial/technical assistance to reconnect habitats by removing barriers. This program partners with state and federal agencies, non-governmental organizations, universities, and trives to complete projects that benefit both species and communities.	https://www.fws.gov/fisheries/fish-passage/fish-passage-projects-atwork. Html
	New England Forest and Rivers Fund *National Fish and Wildlife Foundation	A fund that is for restroing and sustaining healthy forests and rivers that provide habitat for diverse populations of native bird and freshwater fish populations in New England.	https://www.nfwf.org/newengland/Pages/home.aspx

APPENDIX D

See following page

FUNDING OPPORTUNITIES AND RESOURCES			
	Resources *organization	**About**	**Website**
	General Culvert-Related Resources *MassDER	Includes resources to help connect communities with technical assistance, training, tools, approaches, and grant opportunities	https://www.mass.gov/river-restoration-culvert-replacements
	Culvert Replacement Technical Assistance *MassDER	DER helps communities replace poorly designed culverts that can be barriers for fish and wildlife passage and pose risk to the public. Regulartory standards for replacements include the Stream Crossing Standards. DER works with towns to help them replace culverts	https://www.mass.gov/service-details/replace-a-culvert
	Sample RFP and Scope of Work for Site Assessment for Culvert Replacement *MassDER	an example of an RFP for a potential culvert replacement project	https://www.mass.gov/doc/sample-request-for-proposal-for-site-assessment-for-culvert-replacement/downloadx https://www.mass.gov/doc/sample-scope-of-work-for-site-assessment-for-culvert-replacement/download
	Circuit Rider Program *MassDEP	Provides support to Conservation Commissions on wetland issues, in addition to culvert permitting	https://www.mass.gov/guides/massdeps-wetlands-circuit-rider-program
	Regional Technical Staff *MassDEP	Provides technical support to applicants	https://www.mass.gov/guides/massdeps-wetlands-circuit-rider-program

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    a. https://nca2018.globalchange.gov/
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