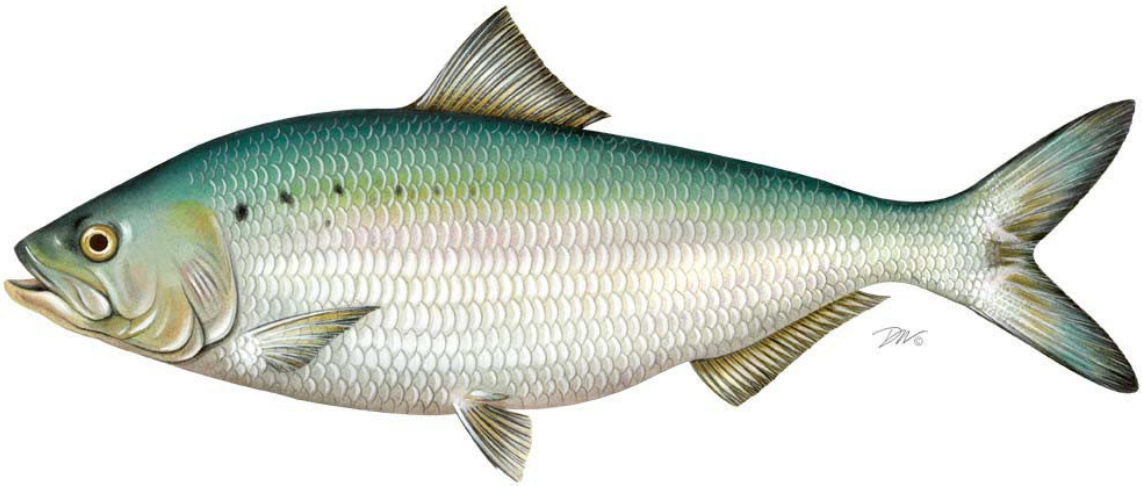
American Shad Habitat Plan for the Connecticut River



Prepared by:

Connecticut River Atlantic Salmon Commission (Connecticut Department of Energy and Environmental Protection, Massachusetts Division of Fisheries and Wildlife, Massachusetts Division of Marine Fisheries, New Hampshire Fish and Game Department, Vermont Department of Fish and Wildlife, U. S. Fish and Wildlife Service and National Oceanic and Atmospheric Administration Fisheries Service)

Submitted to the Atlantic States Marine Fisheries Commission as a requirement of Amendment3 to the Interstate Management Plan for Shad and River Herring

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1 INTRODUCTION

The Atlantic States Marine Fisheries Commission's (ASMFC) Amendment 3 to the American Shad and River Herring Fishery Management Plan (FMP) requires all states to submit a Habitat Plan for shad stocks in their jurisdiction. This document is an update to the first plan submitted and approved in 2014 for the Connecticut River basin. The ASMFC requested a collaborative effort on larger, multi-jurisdictional river plans such as the Connecticut River. Two federal agencies and the four basin member state agencies contributed the Plan. The Connecticut Department of Energy and Environmental Protection (CTDEEP) submitted a statewide plan, including the Connecticut portion of the Connecticut River, to accompany the CTDEEP Sustainable Fishing Management Plan for American Shad (CTDEEP, 2017). The CTDEEP, State of Connecticut American Shad Habitat Plan was approved by the ASMFC in 2021 (CTDEEP, 2021). The Connecticut River's American Shad population is under active restoration through the multi-agency Connecticut River Atlantic Salmon Commission (CRASC), signed into federal law in 1983 with complimentary State legislation (Gephard & McMenemy, 2004). The CRASC and its predecessor organization has served as the lead in obtaining both upstream and downstream passage measures at main stem dams and in coordinating state and federal agencies, commercial river users, and other partners on management topics for this species. The CRASC Technical Committee, under the policy guidance of the Commission, maintains Shad Studies and Fish Passage subcommittees that actively work on topics including shad habitat and access to habitat. The CRASC approved an updated version of the Connecticut River American Shad Management Plan in 2017 replacing the 1994 Management Plan. The 2017 Management Plan utilized a habitat-based approach to define minimum population targets for returns to the river and for the extensive segmented habitat reaches caused by dams in the main stem and tributaries. In 2020, CRASC Commissioners approved the Addendum "Fish Passage Performance" as part of that 2017 Management Plan and included criteria for adult and juvenile shad passage performance that will be defined later in this document (CRASC, 2020). The Federal Energy Regulatory Commission (FERC) approved both documents as a Comprehensive Management Plan[1]. This plan reflects that fish passage is an essential component of any habitat considerations for the restoration and management of the Connecticut River American Shad population.

2 HABITAT ASSESSMENT

The historic upstream extent of the species range on the main stem is Bellow Falls, Vermont, at rkm 280, with three main stem dams located within this range (Table 1 and Figure 1). For this assessment, we have considered habitat in the context of the main stem and tributary barriers that have fragmented, eliminated, or reduced access and altered habitat conditions throughout the basin. Surveys for shad eggs and larvae and spawning behavior have been conducted in the main stem within the state of Connecticut (Marcy, 1976) and from Holyoke Dam (rkm 139) to the Turners Falls Dam (rkm 198), Massachusetts. Marcy (1976) identified American shad spawning in the lower main stem river at river kilometer (rkm) 26 to the most upstream study site at rkm 87, Enfield, Connecticut, with major spawning areas identified as Windsor Locks (rkm 78), Wilson (rkm 74) and Rocky Hill (rkm 51). University of Massachusetts research has shown a relatively wide distribution of documented spawning primarily from egg and fish behavior surveys between the Holyoke Dam, Massachusetts (rkm 139) and the Turners Falls Dam, Massachusetts (rkm 198)

[1] FERC's List of Comprehensive Plans July 2020 can be accessed at https://www.ferc.gov/sites/default/files/2020-07/ListofComprehensivePlans.pdf

(Gilmore, 1975; Watson, 1970; Layzer, 1974; Kuzmeskus, 1977). Shad spawning habitat is located to varying degrees upstream of dam impoundments on both the main stem and identified tributaries and are subject to shifting (over space and time) with changing river discharge (Greene, et al., 2009). The University of Massachusetts conducted studies in the late 1960s and 1970s that showed shad spawning starting at rkm 140, just upstream of Holyoke Dam, to rkm 192, at 22 sampled sites (Kuzmeskus, 1977). Most of the preferred spawning habitat in this main stem reach begins upstream of the Holyoke Dam's impoundment, beginning approximately at rkm 180 and extending upstream to the Turners Falls Dam (rkm 198). Given the lack of consistency in geographically limited habitat assessments, we are currently unable to quantify habitat designations at a fine scale.

Table 1. Main stem dams on the Connecticut River from rkm 0 upriver to the historic upstream extent of American shad range, Bellow Falls, Vermont, at rkm 280.

River Km	Barrier	Designated extent of upstream impoundment/habitat break (rkm)[A]	Purpose	Status
110	Enfield Dam (historic site), Enfield CT	0	Barge canal use	no longer present
139	Holyoke Dam, Holyoke, MA	177	Hydroelectric power	Active, with fishways
198	Turners Falls Dam, Montague, MA	226	Hydroelectric power	Active, with fishways
228	Vernon Dam, Vernon, VT	273	Hydroelectric power	Active, with fishways
280	Bellows Falls Dam, Bellows Falls, VT	-	Hydroelectric power	Active, with fishways

[A] reported impoundment distance may vary slightly, designations attempt to consider transition in habitat features in these dynamic area

As part of the FERC relicensing process for the Turners Falls Dam/Project, Northfield Mountain Pumped Storage Facility, Vernon Dam/Project, and Bellows Falls Dam/Project that started in 2012, several studies specific to American Shad spawning and habitat, in relation to hydropower project operations, were proposed by the agencies and completed by the respective companies. In December 2020, both FirstLight Power (FLP) and Great River Hydropower (GRH) filed Amended Final License Applications (AFLA's). As part of the study phase of relicensing, FirstLight Power Study Report 3.3.6, examined shad spawning, spawning habitat and egg deposition in the areas of the NMPS and Turners Falls Project (FLP, 2016). The study area covered from the Vernon Dam tailwater to the Route 116 Bridge, Sunderland, MA. Their study (using splash counts) reconfirmed findings of spawning and habitat use/types described by earlier university studies, downstream of Turners Falls Dam. Survey work also identified shad spawning activity downstream of Vernon Dam several kilometers. The impoundment of the Turners Falls Dam extends very close to the Vernon Dam (1-2 kilometers) depending on operations and river discharge among the hydroelectric projects (Vernon, NMPS, Turners Falls).

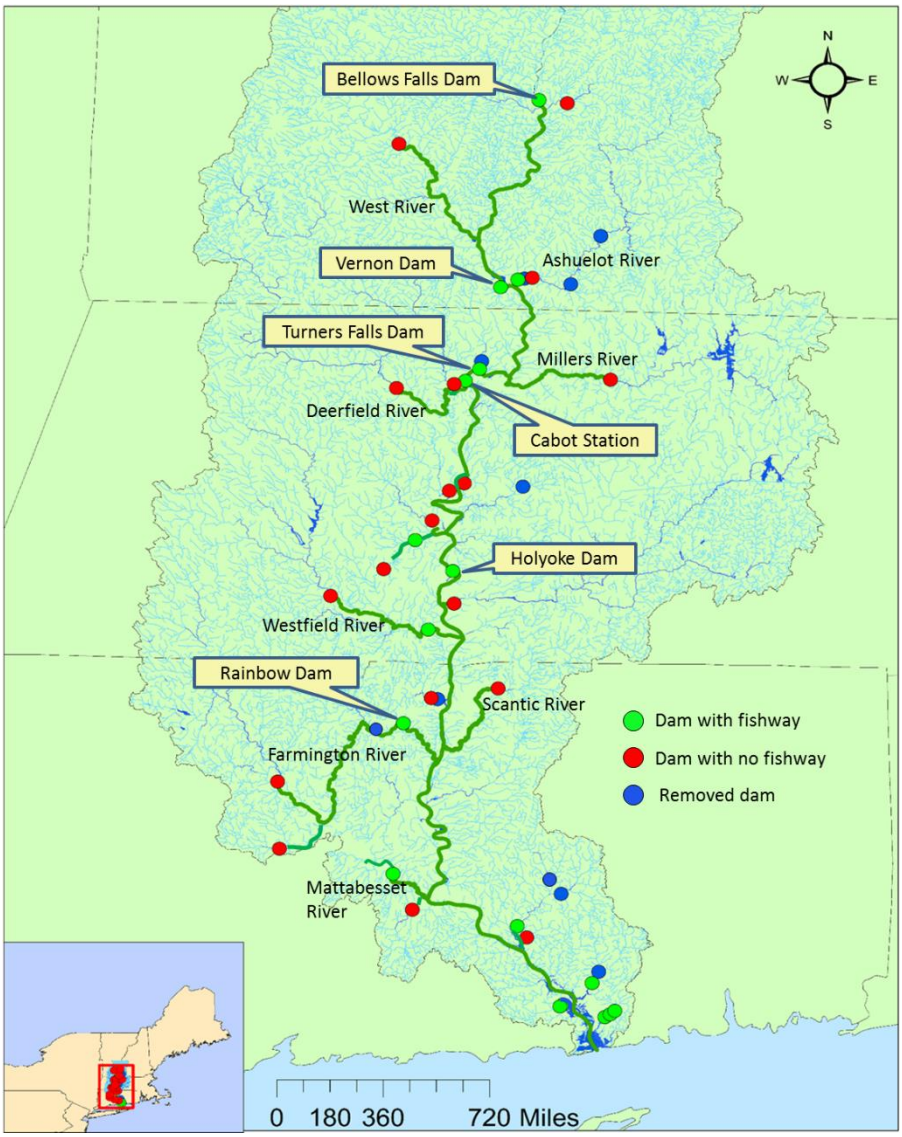

Figure 1. The current range of American shad (green line) in the Connecticut River basin.

A similar study to examine American Shad spawning activity in relation to project operations was completed between Vernon Dam and Bellows Falls Dam. The Study 21 "American Shad Telemetry Study" Final Report (2017) by TransCanada Hydro (sold to GRH same year) describes adult shad movements up to Bellows Falls Dam, ichthyoplankton net surveys for eggs, stage of development and back-calculated area of spawning origin (Normandeau, 2017). Results identifies shad spawning occurring in the riverine habitat downstream of Bellows Falls Dam as well as within the Vernon Dam impoundments and immediately downstream of Vernon Dam (surveyed to 2 km downstream). The report states that tracking of radio tagged shad and ichthyoplankton sampling identified spawning occurred most frequently over gravel-cobble substrates. Available spawning habitat was modeled based on cited criteria under a range of operational conditions. The report notes that habitat areas closest to the dams (Bellows and Vernon), are subject to the greatest variations in habitat (i.e., discharge, flow velocity, and substrate) when modeling between current minimum required flow and the maximum generation capacity. Thus, variations in sub daily

hydropower operations (frequency, timing, magnitude, and duration) are a concern to the agencies for persistent spawning habitat of American Shad.

Annual monitoring of juvenile shad has occurred upstream of Vernon Dam, in the lower impoundment and immediately below Vernon Dam (2 km) by the owners of Vermont Yankee Nuclear Power Station for 15 years, concluding in 2012, with its closure. Beginning in 2017, the Massachusetts Division of Fisheries and Wildlife and the U. S. Fish and Wildlife Service, have conducted a juvenile alosine production survey from the Bellows Falls Dam to the Holyoke Dam (Mattocks, 2019). That study has shown juvenile shad present in all sampled habitat types from August through November annually, using a random stratified cell approach and boat electrofishing gear. Comparisons among river segments from this study have also shown density dependent effects for juveniles sampled in the Turners to Holyoke segment when compared with fish data from both the Bellows to Vernon segment and Vernon to Turners Falls segment (Mattocks, 2019). Insufficient upstream fish passage measures at the Turners Falls Project reduce spawner access to upstream habitat, resulting in stockpiling of production in the Holyoke Pool and underutilized juvenile habitat/production up to the Bellows Falls Dam. The FERC relicensing process will be used to address these upstream passage issues as well as downstream passage concerns in addition to habitat concerns (daily and sub daily peaking operations). The CTDEEP also has maintained a long-term juvenile alosine production survey in the mainstem river from below Holyoke Dam, MA to Essex CT. The CTDEEP survey provides a valuable long-term data set that is used in the Sustainable Fishery Management Plan for Shad (CTDEEP, 2017).

Table 2. Connecticut River estimated spawning and rearing habitat for American Shad by main stem river segment (dam location) in relation to estimated adult shad production or return potential, and <u>minimum</u> annual target fish passage number by barrier. Production is fish/hectare of multiple age classes in a year (203 f/ha in mainstem and 111 f/ha in tributaries).

Reach	Ha	Adjust-ment	Ha	% of total	Adult Shad Return or Production	Project	Minimum target
Main stem Mouth to Holyoke	5,677	0.85	**4,825**	**54.8**	**979,498**		
tributaries (5)	*424*		*424*	*4.8*	*47,064*		
Main stem Holyoke to Turners Falls	1,369		**1,369**	**15.5**	**277,881**	**Holyoke Fish Lift passage**	**687,088**
tributaries (2)	*109*		*109*	*1.2*	*12,099*		
Main stem Turners to Vernon	762		**762**	**8.7**	**154,691**	**Turners Falls Ladder passage**	**397,108**
Tributaries [A] (1)	*139*		*139*	*1.6*	*15,429*		
Main stem Vernon to Bellows Falls	1,042		**1,042**	**11.8**	**211,559**	**Vernon Ladder passage**	**226,988**
tributary (1)	*139*		*139*	*1.6*	15,429		
Totals	**9,661**		**8,809**	**100.0**	**1,713,651**		

[A] Millers River habitat area undefined

Historic and, in some cases, current American shad distribution include three tributaries in the State of Connecticut, five in the State of Massachusetts, one in the State of New Hampshire, and

one in the State of Vermont (Table 3). Habitat information is based on the best information available which often is based on a limited qualitative assessment. It is important to note that it is difficult to categorize what type of habitats may have existed under current dam impoundments.

Table 3. The estimated spawning and rearing habitat for American Shad, by tributary in relation to estimated minimum annual adult shad production or return potential for tributaries (111fish/ha).

Tributary	Total rkm	Area (estimated) ha	Adult Shad Return or Production
Mattabesset, CT	36.3	54.5	6,044
Farmington, CT [A]	72.7	221.0	24,528
Scantic, CT	22.4	31.4	3,481
Westfield, MA	29.4	117.6	13,054
Chicopee, MA[B]		T.B.D.	
Manhan, MA	23.0	23.0	2,553
Deerfield, MA	21.5	86.0	9,546
Millers, MA[C]		T.B.D.	
Ashuelot, NH	60.0	139.0	15,429
West, VT	31.0	139.5	15,485
Total			90,119

[A] – The Pequabuck rkm and habitat area is included with the mainstem Farmington

[B] - First dam is ~1 rkm from confluence with numerous subsequent dams

[C] – Relatively high gradient tributary, more data required

3 HABITAT ACCESSIBILITY

Adult shad have varied degrees of access to main stem habitat to the historic extent of their range up to Bellow Falls Dam (VT) using a fish lift system at the Holyoke Dam (MA), three fish ladders at Turners Falls Dam (MA) where successful passage requires use of two fishways, and the Vernon Dam fish ladder (VT). Upstream fish passage efficiency remains a major concern and has been demonstrated to vary widely among these main stem facilities, with the Turners Falls fishway complex determined to be most problematic for upstream shad passage (Appendix 1). Annual shad passage counts at the second and final required ladder at Turners Falls Project have averaged 10% of the number of shad passed at the previous downstream Holyoke Dam, since some 2010 passage improvements at Turners Falls. Alternatively, the Vernon Dam fish ladder has annually passed 58% (annual average) of the shad counted passing from Turners Falls Project since 2012 fish ladder improvements, excluding the 2020 outlier season due to an entrance gate issue identified in 2021 (Appendix 1). The previously noted FERC relicensing process for Turners Falls has with company agreement, included plans to install a new upstream fish passage facility as noted in their Amended Final License Application (AFLA) submitted to FERC in December 2020 with other proposed passage and protection measures (FirstLight Hydro LLC, 2020; Northfield Mountain LLC, 2020). GRH has also submitted an Amended Final License Application with FERC (December 2020) that provides estimated funds to improve fish passage efficiencies without going into specific detail (Great River Hydro, LLC, 2020). GRH also has proposed (in consultation with the agencies and other stakeholders) operational changes that will create "more stable impoundment water surface elevations…reduce the magnitude and frequency of sub-daily operational changes in discharge from each project, by increasing the amount of time that the Projects are operated in an inflow equal outflow mode" (Great River Hydro, LLC, 2020). The proposed shift in operations will benefit American Shad habitat for all life stages and life history (spawning and migrations). Both AFLAs are presently under agency review. The federal fishery

agencies are also working on fishway prescriptions and habitat recommendations as part of this FERC process and Federal Power Act authorities.

Table 4. Identified American shad tributaries of the Connecticut River basin with first and second dam locations and status of passage.

Tributary	Distance to 1st upstream dam (rkm)	First Dam	Passage provided by	2nd Dam (rkm)	Status	3rd Barrier (rkm) and notes
Mattabesset	11	StanChem	Denil Ladder	Kensington (36)	Alaskan Steepass	Natural waterfall (38)
Farmington [A]	13	Rainbow	Vertical slot	Lower Collinsville (60)	Plans for removal	Upper Collinsville (62), Denil ladder construction 2021
Scantic	21	Somersville	None, not planned	-	-	-
Westfield	7	West Springfield	Denil Ladder	Woronoco (30)	Upstream extent of habitat	-
Chicopee	2	Dwight	None	Chicopee (5)	Nothing planned at this time	-
Manhan	5	Manhan	Denil Ladder	Unnamed (18)	Upstream extent of habitat	-
Deerfield	21	Great River Hydro Dam #2	Upstream extent of habitat	-	-	-
Millers	14	Erving Paper	Partial breach	New Home (22)	Nothing planned at this time	-
Ashuelot	3	Fiske Mill	Fish lift	Lower Roberts (5)	Future U/S passage plan is based on passage trigger at Fiske	-
West	31	Townshend (ACOE)	Upstream extent of habitat	-	-	-

[A] Final barrier is Hogback Dam at rkm 72. The Pequabuck River is a tributary to the Farmington with 17 ha of habitat.

The 2020 American Shad Benchmark Stock Assessment and Peer Review Report provides a comprehensive review of the many issues with fish passage for adult and juvenile shad on both upstream and downstream passage measures (ASMFC, 2020). The Report also contains a modeling analyses to quantify losses of both habitat and adult production from dams that strongly support the need to have substantial improvements in the "performance" of fishways related to percentage rate of passage success, time to pass (delay issues), and survival from passage. These passage metrics must also be considered in their cumulative effects given fragmentations of habitat

by dams in shad rivers like the Connecticut River basin. The need and benefits of having improved, achievable passage performance criteria is well supported and necessary with improvements in fish behavior research and fish passage engineering (USFWS, 2019).

Access to tributary habitat in the Connecticut River basin is often limited due to the presence of dam(s) that often are located less than 20 km from the confluence with the main stem river (Table 4).

Distances of unobstructed access to the first barrier and type of available passage are noted with status of the next barrier, in Table 4. However, as is the case on the main stem, fish passage efficiency is poorly understood on tributary dam fishways. The first dam on the Farmington River has the Rainbow Fishway, in operation since 1976, which is known to not effectively pass shad upstream. This State-owned facility is planned for a replacement in the future with some noted concerns for downstream passage effectiveness. This dam and power station are nonjurisdictional with FERC, restricting agency options on passage and protections. The Westfield River (MA) is the next major tributary with substantial habitat access provided by a Denil fishway at the West Springfield Dam. This fishway has not been evaluated, but shad passage efficiency is expected to be suitable based on the best professional judgement of agency biologists. Other substantial, but not studied tributaries that may provide shad spawning and nursery habitat include the lower Deerfield River (MA) up to its first dam (Dam 32), a distance of 21 rkm and the Millers River (MA), which like the Deerfield quickly transitions into higher gradient reaches and larger substrate types, but also includes more reaches of run habitat between riffles than the Deerfield River. Appendix 2 provides data on barrier locations, habitat, passage types and related data, specific to the Connecticut River basin that is under continued development by the Technical Committee for all American Shad river systems.

4 THREAT ASSESSMENT

4.1 Threat: Barriers to Migration Upstream and Downstream

4.1.1 Recommended Action:

The 2020 American Shad benchmark Stock Assessment and Peer Review Report provides a comprehensive review of the many issues associated fish passage for adult and juvenile shad on both upstream and downstream passage measures and includes the following quotes (ASMFC, 2020):

> *River basin management plans are increasingly placing upstream and downstream passage impacts, needs, and recommendations in the context of cumulative dam/hydropower effects and requiring passage performance measures that are quantitatively defined rather than the open-ended passage terms of "safe, effective, and timely".*
>
> "*Commerce and Interior have not included any specific performance standards that would be used to test the effectiveness of the fish passage facilities…Without specific performance standards to analyze, there is no basis for assessing the benefits of effectiveness testing for fish passage and determining whether effectiveness testing would or would not provide benefits to Alosines...*" (FERC, 2018)

The Plan's Recommended Actions relative to this threat are consistent with the objectives listed in the CRASC's Connecticut River American Shad Management Plan (2020) which includes the following fish passage management objectives:

1. Establish safe, timely, and effective upstream and downstream fish passage for returning adults, post spawn adults, and juveniles [Completed refer to Addendum]; and
2. Establish upstream passage performance measures, addressing fishway attraction, entry, internal passage efficiency and delay at these three stages, as suitable information is available, to support other objectives of this Plan [Completed refer to Addendum]; and
3. Establish downstream performance measures, for adult and juvenile life stages that maximizes survival for through-project passage and that address downstream bypass route attraction, entry, passage efficiency, and delay, as suitable information is available to support objectives of this Plan [Completed refer to Addendum].

The 2020 CRASC Plan Addendum on Fish Passage Performance includes the following Criteria or Objectives for both adult (upstream and downstream) and juvenile (downstream) American Shad for hydroelectric projects in the Connecticut River basin:

1. Upstream adult passage minimum efficiency rate is **75%**, based on the number of shad that approach within 1 kilometer of a project area[A] and/or passage barrier. Passage efficiency is [(# passed/# arrived)*100];
2. Upstream adult passage time-to-pass (1 kilometer threshold) is **48 hours or less** based on fish that are passed (requires achieving Objective #1);
3. Downstream adult and juvenile project passage minimum efficiency and survival rates are each **95%**, based on the number of shad that approach within 1 kilometer of a project area[A] and/or passage barrier and the number that are determined alive post passage (not less than 48 hours evaluation). Passage efficiency is [(# passed/# arrived)*100] and passage survival is [(# alive downstream of project/# passed)*100].
4. Downstream adult and juvenile time-to-pass is **24 hours or less,** for those fish entering the project area[A].

[A] – Project area shall be defined as comprising the river within 1 km of the up- and downstream extent of a hydropower facility and its footprint components. Where a powerhouse is separated from a dam, e.g., by a power canal, this will also include any bypassed reach of the river. The applied definition for 1 km threshold, includes situations whereby a bypassed river reach exists (with regulated/altered flows) from the development and use of a power canal system, by a hydropower operator. In such cases, the location of the dam proper may be several kilometers upstream of the terminus of the power canal system. For upstream passage, the terminus of the power canal and any associated hydropower facility will be the approach basis for the 1 km project area, not the dam. Alternately, for downstream passage, the dam and gatehouse will serve as the basis for the 1 km project approach area, not the generation facilities in the power canal.

Fishways should be evaluated for upstream passage performance (number available relative to passed and time-to-pass) and enumeration of passed fish should occur annually. Downstream passage performance should be evaluated at both main stem and tributary projects/fishways for both adults and juveniles. Study plans may include radio and PIT tags to determine rate of attraction to near field, retention in the entry area, fishway entry/fall backs, and successful passage to exit area in relation to a range of operational conditions and other factors relevant to study

goal/objectives (possible survival and injury rates etc.). Available information suggests delays in both upstream and downstream passage of adult shad are occurring and should be examined and as issues are noted, measures should be implemented and/or developed to achieve CRASC passage performance criteria. Cumulative effects from passage efficiency, delay, and through project mortality are of particular concern given the number of hydroprojects in shad habitat and achieving the goals and objectives of the Plan. Ideally, pre-season, in-season and post season fishway inspections by federal Fish Passage Engineers would occur to increase the ability to identify any issues and ensure operations are following design criteria, to prevent negative impacts that can be avoided in the relatively brief passage season.

4.1.2 Fish passage/habitat access mainstem Connecticut River (MA, NH, VT)

Fish passage performance criteria from the CRASC American Shad Management Plan have been previously described. American Shad have access in the main stem Connecticut River to the historic upstream extent of their range, Bellows Falls, Vermont, using fishways of varied design and operation and efficiencies (Table 1, Figure 1, Appendix 1). Upstream passage for shad includes a fish lift system at Holyoke Dam, upgraded in 2005, as part of that dam's FERC relicensing process. Based on both historic unpublished studies on shad movement, the Holyoke fish lift system (1976-present) passed between 40 to 60% of the adult shad that entered the river mouth in the spring. Additional modifications to that facility completed in 2016, to improve up and downstream passage efficiency/protections, may have affected upstream fish passage rates (percentage passing and time to pass). A mark-recapture study using fish tagged at the mouth should be developed to answer questions on the proportion of shad passage at Holyoke in relation to the population entering the river and factors of influence on passage rates.

Upstream Passage Measures

Turners Falls Dam, Massachusetts - Upstream shad passage at Turners Falls Dam has been problematic since the opening of its three fishways in 1980. Fish are required to enter and use at least two fishway ladders at this project to bypass this barrier system. Fishway designs were based on the best available information at that time. The Cabot Station (powerhouse), at the end of a 3.4 km power canal off the Turners Falls Dam, is the primary location of shad attraction on their upstream migration and has a modified "Ice Harbor" design ladder. Fish that successfully pass that ladder must then proceed up the power canal to the Gatehouse, which contains the Gatehouse Fish Ladder (vertical slot design), that has two entrances from the canal. Fish may also migrate up the "bypassed reach" that parallels the power canal, to the base of the dam and use the "Spillway Ladder" (modified Ice Harbor design) that directs fish at its "exit" end to the entrance of the Gatehouse Ladder. Typically, spill at the dam is less than 1,000 cfs, with river flow directed to the power canal for power station use (up to 17,000 cfs). As part of the FERC relicensing process the facility owners have proposed to build a new fish lift facility at the base of the dam that would then direct fish into the Gatehouse Ladder. The discharge level in the bypassed reach, is proposed for seasonal flow increases as described in the FirstLight Power AFLA that would be tied to Shortnose Sturgeon spawning and early life stage needs in the bypass reach with recognition of fish passage needs for shad. The federal agencies are working on fish passage prescriptions (Federal Power Act; Section 18) and fish habitat recommendations (10J) for this project area currently.

Vernon Dam, Vermont/New Hampshire - Upstream passage at Vernon Dam is made possible through a fish ladder that is a modified Ice Harbor design in its lower section and serpentine vertical slot design in its upper section. This ladder became operational in 1981. Like other

fishways, there have been modifications and adjustments made to address areas of concern. Following several years of low passage counts for shad, in 2011 a design feature/setting was identified as an issue by a USFWS Fish Passage Engineer. Corrective measures were completed with a marked increase in shad passage counts annually noted since 2012 (Appendix 1).

The CRASC Management Plan (2017) and its Fish Passage Performance Plan (2020) define downstream passage performance criteria for adults and juvenile shad that access habitat upstream of hydropower facilities. Cumulative effects from the multiple dams/projects in the basin may be impeding upstream habitat reach goals and objectives. The State of Connecticut Marine Fisheries Division has documented a long-term decline in the proportion of repeat spawners in the shad stock and modeling results (CRASC 2020) suggest poor downstream passage may be driving that trend.

Downstream Passage Measures

Holyoke Dam, Massachusetts - Numerous and varied downstream passage and protection measures have been explored and implemented at the Holyoke Dam to protect fish using the historic upstream habitats. Currently, the Holyoke Dam operates a Bascule Gate with a specially designed "Alden Weir" to facilitate downstream passage of spent American Shad moving towards the power stations intake/forebay to the proximally located gate. This gate is operated for downstream passage of fish from April through July, with dates or operation specified in a CRASC Downstream Passage Notification Letter, issued by the Connecticut River Coordinator. The Holyoke Dam, owned and operated by Holyoke Gas and Electric, completed substantial downstream passage improvements at the Hadley Falls Station in 2015, effective for 2016. A reduced space, full depth bar rack with 2.0 inch clear spacing was installed in front of the station intakes. A novel design downstream bypass with surface and mid-depth entrances and transfer system were placed into this rack. These bypasses direct fish to the downstream spill release from the nearby Alden Weir, in the project's adjacent Bascule Gate. A pre-existing downstream bypass structure, this weir's water release was hydraulically adjusted to direct water/fish at the base of the dam apron, up into the air and into a newly constructed plunge pool that was designed to meet USFWS Fish Passage Criteria. The "jump" reduces landing velocity into the pool and prevents disruption of the attraction flow/jet to the spillway fishlift entrance that passes underneath this jump. An angled retaining wall, near that fish lift entrance, that had interacted with a portion of the weir's spill was also removed.

A second route for downstream shad passage at Holyoke includes the power canal, which has a gatehouse located at its upstream end, adjacent to the dam structure. Shad that are directed or move into the canal will swim and/or drift to a full depth angled weir that covers the entire canal approximately 1 km downstream. The weir bar spacing is designed for juvenile fish guidance as well. At the downstream corner of this acutely angled weir is the entrance to the downstream fish passage pipe. The pipe conveys fish into the tailrace of the Hadley Falls Station, where the pipe discharges directly into deep water from a height of several meters.

Turners Falls Dam - At the Turners Falls Dam/Project, adult and juvenile shad may pass using the following routes; 1) spill at the dam, 2) Station 1 through turbines (power station off the main power canal), 3) Cabot Station through turbines, 4) Cabot Station surface fish bypass/partial depth reduced rack spacing, and 5) Canal emergency spill gates. Downstream fish passage studies for both juveniles and adult shad have been completed for FERC relicensing. The agencies will be seeking the installation and operation of necessary measures to achieve CRASC downstream fish

passage performance criteria for the project for adults and juveniles. These measures will likely include 1) plunge pool at the dam for spilled fish, 2) fish exclusion rack on side of power canal to Station 1, 3) full depth exclusion rack for turbines at Cabot, with downstream bypass passage entrances, 4) upgrades to existing surface bypass, sluiceway, and its associated structures.

Northfield Mountain Pumped Storage Facility, Massachusetts - The Northfield Mountain Pumped Storage Facility (NMPS) is also owned by Firstlight Power, they have also completed FERC studies examining entrainment of early life stages, adult shad upstream and downstream movements, and operational models on project area influences of flow during pumping and generation over a wide range of river discharge values. The company has proposed a full depth exclusion net seasonally installed to prevent juvenile (outmigrant size) entrainment following the CRASC downstream passage dates for juvenile shad protection (August 1 through November 15).

Vernon Dam - At Vernon Dam adult and juvenile shad may pass using the following routes; 1) spill at the dam or trash sluice, 2) through the stations turbines, 3) guidance from a partial depth and partial length louver which directs fish into the primary fish bypass pipe with a secondary, smaller bypass pipe on the Vermont near-shore side. GRH also completed downstream passage studies on both adult and juvenile shad as part of the relicensing process. The owner/operators have not proposed any specific plans for additional downstream passage measures but included dollar estimates in their AFLA (Great River Hydro, LLC, 2020). The agencies will seek the installation and operation of necessary measures to achieve CRASC downstream fish passage performance criteria for the project for adults and juveniles.

4.1.2.1 Agencies with regulatory authority:

The Connecticut River Policy Committee and its State and Federal agency members (predecessor of CRASC) had completed agreements with main stem hydropower operators that led to the installation and or operation of fish passage facilities to facilitate upstream passage on the main stem dams identified. The individual States have their independent authorities related to diadromous fish passage and management and the U. S. Fish and Wildlife Service and National Marine Fisheries Service have fishway prescription authority through the Federal Power Act, used in connection with FERC. The CRASC operates a Fish Passage Subcommittee, under its Technical Committee, which has been a forum to coordinate inter-agency staff, research, and activities with the power companies in both official and unofficial capacities, in a regular and ongoing process. The CRASC issues a schedule of Upstream Passage Operation Dates through the Connecticut River Coordinator, annually in March that specifies species, lifestage, dates and hours of operations.

4.1.2.2 Goal/Target:

The CRASC Management Plan (2020) includes goals and objectives that are quantified in terms of the entire population as well as within the river basin's many segmented habitat reaches. Adult population targets are described as minimum values, based on run data and accessible habitat for the target reference year (1992) described in that plan. Upstream passage efficiency (proportion of arrivals to passed and time to pass) performance criteria have been developed and are part of the Management Plan Addendum approved in 2020. Downstream passage measures must also address Addendum defined passage survival rates for both adult and juvenile shad as well as time-to-pass through project (i.e., delay). Standardized pre-season fishway inspections should be conducted by USFWS Fish Passage Engineers. This work has been focused on main stem facilities given staff limitations and includes examining and addressing site specific concerns with the owner/operators. Habitats that are accessed using fishways must also provide downstream passage measures that

are also defined in the plan, particularly to address cumulative effects of these projects and achieve goals and objectives.

4.1.2.3 Progress:

FERC relicensing is ongoing for Turners Falls Project, Northfield Mountain Pumped Storage Facility, Vernon Project, and Bellows Falls Project. The update to the CRASC Management Plan in 2017 and the Fish Passage Performance Addendum (2020) were important management steps to better define agency goals and objectives considered achievable and necessary in the ongoing effort to restore this population in its historic range as well as providing minimum escapement targets and stock structure metrics. The Management Plan and its Addendum are approved Comprehensive Management Plans by FERC.

In December 2020, both owners of five main stem hydroelectric projects submitted their Amended Final License Applications to FERC. At this time, FERC is in the process of considering the status of those submissions, including a June 2021 additional information submission that was required for FirstLight, in an internal review process.

Vernon Dam - At Vernon Dam, GRH has been working with the state and federal agencies on ongoing studies and improvements to that facility's fish ladder. In the fall of 2019, GRH installed a series of in-ladder modifications, designed by a USFWS Fish Passage Engineer. Relicensing study results of tagged shad within the ladder suggested a potential problem with two corner pools and the modification were made to reduce turbulence. The company continues to work on addressing potential areas of improvement for that fishway. In June of 2020 and 2021, very low river discharge levels led to occurrences of extremely low tailwater elevations at this facility that at times impacted the ladder entrance gates ability to maintain desired flow conditions. In September 2021 GRH contacted the agencies to report their identification of the issue affecting the entrance gate setting and measures to resolve that for the 2022 upstream fish passage season.

Holyoke Dam - Improvements for downstream passage were completed in 2015 at Holyoke Dam and the Hadley Falls Power Station. The fish passage modifications that will benefit American Shad include a full depth reduced space trash rack (2.0 inch clear spacing) that will help exclude adult shad from entrainment into the station's two turbines and a new surface and midwater downstream bypass entrances in that rack system. The bypasses discharge into the modified bascule gate discharge on the dam (also provides downstream passage) that was improved by the removal of a "wing" structure for the spillway ladder entrance near the edge of the dam apron. In addition, on the dam apron, the "bypass water" flow was structurally modified with a lip that projects the flow over the spillway fish entrance jet, into a constructed release pool with required depth, velocity, and area (all designs meet USFWS Fish Passage Criteria). The spillway entrance was also modified from an upper water column gate, to full depth, to facilitate sturgeon entry and passage. These measures were all in place and operating for the 2016 fish passage season.

Ongoing meetings with HGE at the Holyoke Project have resulted in adjusting operations, including effective in 2020 a new agency prescribed threshold daily count values to trigger and conclude earlier daily lift openings for peak run timing. The agencies also agreed to reduced lift operation frequency, also based on daily passage data, for the first two weeks of July.

4.1.2.4 Timeline:

The FERC relicensing process has reached a late-stage development in the process started in 2012 for the noted mainstem projects. The December 2020 AFLA submissions' by First Light Power and GRH, are in review by FERC with additional information required from Firstlight submitted

in June 2021. The issuance of a Ready for Environmental Analyses by FERC would start the time windows for fish passage prescription and habitat recommendation submissions by USFWS and NOAA and State and other intervener recommendations.

4.1.3 Fish passage/habitat access Mattabesset River (CT)

The first barrier on the Mattabesset River, StanChem Dam has a Denil ladder. The next upstream barrier, Kensington Dam, had an Alaskan Steepass ladder installed in 2019. At this time, the State believes no additional fish passage measures for shad is needed upstream of Kensington Dam which provides 2km of habitat to the base of falls (Table 3).

4.1.3.1 Agencies with regulatory authority:

The State of Connecticut has legal authorities regarding dams and fish passage at this small non-hydropower dam.

4.1.3.2 Goal/Target:

Achieve goals and objectives defined in the CRASC 2017 American Shad Plan and the defined passage performance in the 2020 Addendum. An annual run of 6,000 American Shad is the minimum population target for this tributary (Table 3).

4.1.3.3 Progress:

Access to all historic habitat has been achieved.

4.1.3.4 Timeline:

No additional habitat work is planned at this time.

4.1.4 Fish passage/habitat access Farmington River (CT)

Currently upstream and downstream passage at the Rainbow Dam are management issues at this FERC non-jurisdictional dam/project (Table 3). The Rainbow Fish Ladder is a vertical slot designed and owned by the State of Connecticut. The fish ladder opened in 1976 and is planned for replacement by the State of Connecticut. There are concerns for downstream protection of outmigrating adults and juveniles given the current design (trash rack depth/clear spacing) and smaller turbine sizes of the power station. The Winchell Smith Dam, next upstream structure, is considered a possible barrier to upstream movement of shad at lower flow levels. The Lower Collinsville Dam is owned by the State and is planned for removal, no target date available. The Upper Collinsville Dam has a FERC license and planned construction for a Denil Fish Ladder in 2021. The Pequabuck River is a tributary of the Farmington River and the existing Bristol Brass Dam is the upper extent of what the State of Connecticut considers shad habitat.

4.1.4.1 Agencies with regulatory authority:

The Rainbow Dam is not a FERC licensed jurisdictional dam and the fish ladder was installed by the State of Connecticut using its own funds through an agreement with the owners. The State of Connecticut has developed design plans to replace the vertical slot fishway. The State does not have construction funds currently for a new upstream fishway.

4.1.4.2 Goal/Target:

Achieve goals and objectives defined in the CRASC 2017 American Shad Plan and the defined passage performance in the 2020 Addendum. An annual minimum run of 24,500 shad is the target for this tributary. A goal is to install a new upstream fishway at the Rainbow Dam and discontinue the use of the ladder for shad passage. Downstream passage protections for adults and juveniles have also been identified a concern. Explore options for the removal for the degraded Winchell Smith Dam that is believed to impede upstream movement in lower flow conditions. Removal of

the lower Collinsville Dam will provide shad with access to the next upstream dam, Upper Collinsville that is in the process of upstream and downstream passage construction (completion fall 2021).

4.1.4.3 Progress:

Design plans for a Rainbow Dam fish lift are completed but the CTDEEP has additional information in review on best options and other related concerns (e.g., downstream passage measures). The Winchell Smith Dam will be monitored as it deteriorates, and it will be determined if removal or a fishway is necessary. Engineered plans to remove the Lower Collinsville Dam are in progress. The Upper Collinsville fish ladder is expected to be completed by late 2021.

4.1.4.4 Timeline:

Given the construction cost of the Rainbow Fish Lift system, it is unclear how long it will take to fund. The design for the Lower Collinsville Dam removal is underway but there is no firm timeline on when the dam will be removed.

4.1.5 Fish passage/habitat access Scantic River (CT)

The previous first barrier on the Scantic River, Springborn Dam was removed in 2017 by state and federal agencies. Currently, accessible shad habitat extends upstream to the Somersville Dam, an additional 4km of habitat. There are no fish passage or removal plans at this time for the Somersville Dam which is believed to be the upstream extent of shad habitat by the State (Table 3).

4.1.5.1 Agencies with regulatory authority:

The State of Connecticut has legal authorities regarding dams and fish passage at this small non-hydropower dam.

4.1.5.2 Goal/Target:

Following the removal of the Springborn Dam in 2017, the plan for the next dam remains under future consideration. An annual minimum run of 3,400 shad is the target for this tributary.

4.1.5.3 Progress:

The first upstream barrier on the Scantic River, Springborn Dam was removed by state and federal agencies in 2017, opening an additional 5 kilometers of river habitat to fishes including American Shad. Assessment of the habitat upstream of the current first mainstem barrier, Somersville Dam needs occur in addition to determining what species are currently utilizing downstream habitat.

4.1.5.4 Timeline:

Not applicable at this time.

4.1.6 Fish passage/habitat access Westfield River (MA)

All historic shad habitat is accessible with passage at the West Springfield Dam from a Denil Ladder and downstream passage measures also in place (Table 3). The next barrier on this tributary is the Woronoco Dam which is at the historic upstream extent of shad habitat.

4.1.6.1 Agencies with regulatory authority:

The Commonwealth of Massachusetts has legal authorities regarding dams and fish passage and the U. S. Fish and Wildlife Service and National Marine Fisheries Service have authority through the Federal Power Act and through FERC for licensed hydropower dam/projects. Both West Springfield and Woronoco Dam/projects are licensed by FERC.

4.1.6.2 Goal/Target:
Achieve goals and objectives defined in the CRASC 2017 American Shad Plan and the defined passage performance in the 2020 Addendum. An annual minimum run of 13,100 shad is the target for this tributary.

4.1.6.3 Progress:
There are no identified needs for other passage at this time.

4.1.6.4 Timeline:
Not applicable at this time.

4.1.7 Fish passage/habitat access Chicopee River (MA)
Accessible habitat in this tributary is restricted to approximately 2 km from its confluence with the Connecticut River. There is a high density of closely placed hydropower dams that proceed upstream from that point. The Dwight Street Dam is the first upstream barrier with a powerhouse located downstream of the dam approximately 1.0 km.

4.1.7.1 Agencies with regulatory authority
The Commonwealth of Massachusetts has legal authorities regarding dams and fish passage and the U. S. Fish and Wildlife Service and National Marine Fisheries Service have authority through the Federal Power Act and through FERC for licensed hydropower dam/projects.

4.1.7.2 Goal/Target:
There have been unexecuted plans to stock pre-spawn shad, transferred from Holyoke Fish Lift, into the impoundments of the upstream dams with follow up sampling to determine if there is juvenile production. This tributary system requires more study by the agencies considering the complexity of closely placed dams in succession.

4.1.7.3 Progress:
No pre-spawn stocking of shad or herring has occurred to date. It is possible that these stockings, with evaluation for production, may occur in the near future. Regularly occurring spring adult river herring population assessment have consistently documented high relative abundances (adult shad) in the lowermost accessible reach that is surveyed with boat electrofishing in May and June annually.

4.1.7.4 Timeline:
Not defined at this time, given other ongoing priorities.

4.1.8 Fish passage/habitat access Manhan River (MA)
A Denil fish ladder was installed at the first dam on the Manhan (Town of Easthampton) in 2014 that is located 5 miles from its mouth located in the "Oxbow" (Table 4). The ladder provides fish access to habitat up to 18 kilometers upstream where an unnamed dam occurs on its main branch. There is limited habitat for shad in the lower reaches of this system due to its small size (width and depths). This tributary has a total of 23 river kilometers with an estimated 23.0 hectares of habitat. All shad habitat is now accessible.

4.1.8.1 Agencies with regulatory authority
The Commonwealth of Massachusetts has legal authorities regarding dams and fish passage. As the Manhan Dam is non-hydro power, a cooperative approach was developed with the Town that owns the dam to operate and maintain the fish ladder.

4.1.8.2 Goal/Target:
Achieve goals and objectives defined in the CRASC 2017 American Shad Plan and the defined passage performance in the 2020 Addendum. An annual minimum run of 2,553 shad is the target for this tributary.

4.1.8.3 Progress:
No adult shad have been documented passing this fishway based on video monitoring to date. Both adult Blueback Herring and American Shad have been trucked and released by the USFWS in several years into habitat upstream of the dam.

4.1.8.4 Timeline:
Not applicable at this time.

4.1.9 Fish passage/habitat access Deerfield River (MA)
The lower Deerfield River contains an estimated 86 hectares of shad habitat upstream to the first dam, located at rkm 21.5 (Table 3). From its confluence with the Connecticut River, this tributary gains elevation rapidly moving upstream after the first dam, habitat becomes unsuitable for shad and a series of hydropower dams begin in relatively close sequence. All shad habitat is considered accessible.

4.1.9.1 Agencies with regulatory authority
The Commonwealth of Massachusetts has legal authorities regarding dams and fish passage and the U. S. Fish and Wildlife Service and National Marine Fisheries Service have authority through the Federal Power Act and through FERC for licensed hydropower dam/projects.

4.1.9.2 Goal/Target:
Achieve goals and objectives defined in the CRASC 2017 American Shad Plan and the defined passage performance in the 2020 Addendum. An annual minimum run of 9,546 shad is the target for this tributary.

4.1.9.3 Progress:
There are no identified needs for passage at this time.

4.1.9.4 Timeline:
Not applicable at this time.

4.1.10 Fish passage/habitat access Millers River (MA)
The Millers River is a large tributary system that includes a relatively rapid, increase in elevation that creates a high percentage of riffle and run habitat over rock substrate from its confluence with the Connecticut River. There are interspersed stretches of slower flat water but the quantity of suitable shad spawning, and nursery habitat is not known and requires additional study. However, adult shad tagging studies that have been conducted as part of FERC relicensing studies, as well as a USGS Conte Lab tagging study in 2011, would support the statement that this tributary was not utilized by shad based on those tagging study results. The first dam is located at rkm 14 and is partially breached with the second barrier (hydropower dam) located in at rkm 22 (Table 4).

4.1.10.1 Agencies with regulatory authority

The Commonwealth of Massachusetts has legal authorities regarding dams and fish passage and the U. S. Fish and Wildlife Service and National Marine Fisheries Service have authority through the Federal Power Act and through FERC for licensed hydropower dam/projects.

4.1.10.2 Goal/Target:

There is no estimated annual adult production run size at this time.

4.1.10.3 Progress:

There are no identified needs for shad fish passage at this time.

4.1.10.4 Timeline:

Not applicable at this time.

4.1.11 Fish passage/habitat access Ashuelot River (NH)

In 2012, the Fiske Mill Dam, the first barrier 3 km from confluence with the Connecticut River, installed a fish lift. The agencies and FERC have contacted the owner operator with concerns over fishway operation, monitoring and evaluation that remain unresolved. This project is currently in the FERC relicensing process that was initiated in January 2021. The McGoldrick Dam, which had been the next upstream dam (rkm 4), was completely removed in 2001. As shad passage at Fiske Mill Dam becomes documented, upstream passage options to pass fish upstream of both Lower Roberts (rkm 5) and Ashuelot Paper (rkm 5.5) hydropower dams will be developed. Once fish can pass these additional two dams, most targeted spawning, and nursery habitat (90%) will be completely accessible as two additional unmaintained dams have been completely removed from identified shad habitat in 2002 (Town of Winchester) and 2010 (Swanzey Woolen Mill).

4.1.11.1 Agencies with regulatory authority:

The State of New Hampshire has legal authorities regarding dams and fish passage and the U. S. Fish and Wildlife Service and National Marine Fisheries Service have authority through the Federal Power Act and through FERC for the identified dams.

4.1.11.2 Goal/Target:

Achieve goals and objectives defined in the CRASC 2017 American Shad Plan and the defined passage performance in the 2020 Addendum. An annual minimum run of 15,429 shad is the target for this tributary.

4.1.11.3 Progress:

Annual stockings of approximately 430 pre-spawn shad have been conducted by state and federal fishery agencies from 1998 through 2019. Upstream passage options for the remaining dams will be explored as adult fish are documented passing the Fiske Mill Dam. The Fiske Mill Project is in relicensing process with FERC, initiated in 2021. Both Federal agencies (USFWS and NOAA), NHFG and NH DES submitted study request letters in March of 2021 as part of that process.

4.1.11.4 Timeline:

The FERC process for Fiske Mill began in 2021. State and federal agencies expect to address what are considered passage issues and seek to determine what fish may occur below the dam. Upstream passage measures for shad around the second and third dams on the lower Ashuelot will be implemented as returning adult shad are documented at the Fiske Mill Dam fish lift.

4.1.12 Fish passage/habitat access West River (VT)

The West River is primarily a high gradient, large substrate system in the Green Mountains. Its confluence with the Connecticut River has been inundated by the Vernon Dam creating an area known as Retreat Meadows. This shallow protected off mainstem area is approximately 65 ha in size and is known to be used by juvenile shad. The first upstream barrier on the river is Townshend Flood Control Dam, of the Army Corp of Engineers at rkm 31. The extent to which adult shad migrate up and utilize this lower reach is unknown. There is no shad habitat upstream of this barrier.

4.1.12.1 Agencies with regulatory authority:

The State of Vermont has legal authorities regarding dams and fish passage and the U. S. Fish and Wildlife Service and National Marine Fisheries Service work as needed on fish passage and protection issues at USACOE Projects. There are no plans for this Dam relative to shad.

4.1.12.2 Goal/Target:

All shad habitat, estimated as 139.5 ha, is accessible in this tributary. An annual minimum run of 15,485 shad is the target for this tributary.

4.1.12.3 Progress:

There are no identified needs for shad fish passage at this time.

4.1.12.4 Timeline:

Not applicable.

4.2 Threat: Hydropower Dam and Hydropower Facility Impoundment and Discharge Fluctuations and Operations

4.2.1 Recommended Action:

The operation of hydropower facilities includes peaking operations (sub-daily) at all noted power facilities, with the single exception of the Holyoke Dam/Hadley Falls Project (modified run-of-river), which can result in substantial alterations to river discharge (timing, frequency, magnitude, duration) downstream of the facilities as well as upstream (e.g., impounding periods and the operation of NMPS). These situations may impact persistent shad habitat, quantity, and quality at a sub-hourly time scale and a daily basis. An inventory and assessment of all hydropower facilities that are not required to operate as "run-of-the-river" should be identified and evaluated for the extent and types of impacts that may affect shad habitat. This should occur on both the mainstem river and identified tributaries. The FERC relicensing process for the five identified mainstem hydropower projects included studies to determine shad spawning locations, habitat features, and operational effects on these spawning activity (Normandeau, 2017) (FLP, 2016). Changes in the quantity of habitat for species including shad based on model information for shad spawning and juveniles were also examined under dual flow (peaking operations) for a range of paired flows for Bellows Falls and Vernon projects. Study results suggest occurrences of wide- ranging sub-daily changes in flows result in changes to shad habitat (specifically project minimum discharge conditions) with modeled high peaking (based on dual flow analyses). These model results were complicated at Vernon Dam by additional downstream hydropower operations of NMPS and/or Turners Falls Project operations that were outside the scope of the study (Normandeau , 2019).

4.2.2 Agencies with regulatory authority:

The States have legal authorities regarding dams and hydropower operation through FERC, Water Quality Certification (401) and Coastal Zone Management Act, as applies. The U. S. Fish and

Wildlife Service and National Marine Fisheries Service have authority through the Federal Power Act. Fish and Wildlife Coordination Act. and the Endangered Species Act, for designated species such as Dwarf Wedge Mussel, Puritan Tiger Beetle and Shortnose Sturgeon in the Connecticut River. Both PTB and SNS have been shown to be affected by flow re-regulation and help support the position that wide ranging, rapid flow fluctuations, at a sub-daily level are conditions that may affect species habitat use and behavior at important times in life history.

4.2.3 Goal/Target:

The State and Federal agencies will seek to develop and implement measures to reduce or mitigate any documented impacts of water use (e.g., sub daily peaking generation) on shad spawning and nursery habitat based upon available information. A natural flow regime, or increased inflow equal to outflow, to the extent possible, is preferred to better represent river conditions the species evolved with.

4.2.4 Progress:

The FERC relicensing process resulted in planned studies to examine project operation discharge effects on identified shad spawning habitat and behavior below Turners Falls Dam, in the Turners Falls impoundment, below the Vernon Dam, in the Vernon Dam impoundment, and below the Bellows Falls Dam. Those studies have been submitted with State and Federal agency comment letters. Great River Hydro initiated project operations discussion with the agencies in 2020 that led to the proposed operational schedule GRH submitted in their AFLA, that reduces peaking operations in the spring through the fall with increased frequency of inflow equals outflow at projects. The agencies believe the reduction in flow re-regulation, as proposed, will be a significant improvement from the existing peaking operations at the Wilder, Bellows Falls, and Vernon facilities that will benefit American Shad and their habitat use (e.g., migration, spawning, nursery).

4.2.5 Timeline:

The FERC has received the "requested additional information" that was asked of FirstLight Power, partly on GRH's proposed operational schedule that calls for less flow re-regulation (except in winter months) in June 2021. The agencies, companies and other parties are awaiting FERC's review for completeness of the submission. Should FERC determine they now have all necessary information to proceed (from FLP and GRH) they will issue a ready for environmental analyses which will trigger the agencies time window to submit their passage and protection measures along with habitat recommendations.

4.3 Threat: Water Withdrawal

4.3.1 Recommended Action:

An inventory and assessment of all permitted water withdrawals from the mainstem and targeted tributary shad habitat should be conducted using state agency permit data. At this time, there are water withdrawals for cooling water intake structures permitted by appropriate state and or federal agencies from the mainstem river. A partial list of mainstem water diversion permits includes from upstream to downstream: West Springfield Generation Station, MA (fossil fuels); Algonquin Power, Windsor, CT (natural gas); South Meadow Plant, Hartford, CT (fossil), GenConn, Middletown, CT (natural gas/fossil), and others. Information on Water Diversion Permits can be found on individual agency websites. In addition, the NMPS facility in Northfield, MA has a pumping capacity, to its storage reservoir, of up to 15,000 cubic feet per second, and is regulated by the FERC. Pumping duration is a function of the storage reservoir's water level and number of pumps used to refill which may vary on a variety of operational factors. The FLP Pre-Application

Document to FERC (2021) states "*In the summer and winter seasons, the NMPS typically peaks twice a day – in the morning and late afternoon. During other months, commonly called shoulder months, the NMPS may be peaked one to two times a day, pending electrical demand and/or price*." The potential pumping capacity of that plant at full operational capacity, is greater than the mean monthly river discharge for eight months of the year (refer to USGS 01170500 Montague Gage data).

Water withdrawals also occur in tributaries and should also be reviewed for potential impacts to habitat. Details of the type and extent of water withdrawal and subsequent discharge for these plants and others that remain to be collectively examined should be reviewed for potential impacts to American Shad habitat and potential population impacts. Considering climate change and associated changes in precipitation (i.e., timing, magnitude) water withdrawals should be examined, and or managed more closely.

Measures to either prevent or significantly reduce entrainment of eggs, early life stages and juveniles should be considered for commercial river water users.

4.3.2 Agencies with regulatory authority:

Regulatory authority for the withdrawal of water is under State authorities and/or legislation and in some instances the Environmental Protection Agency. In the case of the NMPS facility, licensed through FERC, both the Massachusetts and the federal resources agencies have specific authorities. Massachusetts DEP also has authorities related to water quality and plant operations.

4.3.3 Goal/Target:

The State and Federal agencies will seek to develop and implement measures to reduce documented impacts of water withdrawals on early life stages and outmigrants (e.g., entrainment and/or impingement) through available regulatory or other mechanisms.

4.3.4 Progress:

The Vermont Yankee Nuclear Power Station (Vernon, VT) and Mount Tom Coal Power Station (Holyoke, MA) were closed in 2014. Inventory of water withdrawals remains a management task by the fishery agencies relative to American shad and river herring habitat.

4.3.5 Timeline:

Monitoring of permit reports, permitting and other regulatory oversight by the states and federal agencies as applicable is ongoing.

4.4 Threat: Thermal Discharge

4.4.1 Recommended Action:

An inventory and assessment of all permitted thermal discharges from the mainstem and targeted tributary shad habitat should be conducted using state agency permit data as well as data from the Environmental Protection Agency (EPA) which has responsibility for the National Pollutant Discharge Elimination System (NPDES) and/or its delegation to approved State agencies, to varying levels. Permitted water withdrawals and discharge for cooling water intake structures occur on the mainstem river, from upstream to downstream, West Springfield Generation Station, MA (fossil); Algonquin Power, Windsor, CT (natural gas); South Meadow Plant, Hartford, CT (fossil); GenConn, Middletown, CT (natural gas/fossil); and others.

4.4.2 Agencies with regulatory authority:

NPDES authority has been delegated by the EPA to the states of Connecticut and Vermont. Whereas, the Commonwealth of Massachusetts and the State of New Hampshire have not been delegated authority and work with the EPA to issue NPDES permits.

4.4.3 Goal/Target:

Goals and targets vary among regulatory agencies. A NPDES permit will generally specify an acceptable level of a pollutant or pollutant parameter in a discharge (e.g., water temperature). The permittee may choose which technologies to use to achieve that level. Some permits, however, do contain certain generic 'best management practices'. NPDES permits make sure that a state's mandatory standards for clean water and the federal minimums are being met.

4.4.4 Progress:

Industrial, municipal, and other facilities must obtain permits if their discharges go directly to surface waters since passage of this law in 1972. An inventory of NPDES permitted thermal discharges, remains to be considered as a management task by the fishery agencies relative to American shad and river herring habitat in this basin. The EPA maintains a national website of NPDES permits (https://www.epa.gov/npdes-permits).

4.4.4.1 Timeline:

The Clean Water Act limits the length of NPDES permits to five years. NPDES permits can be renewed (reissued) at any time after the permit holder applies. In addition, NPDES permits can be administratively extended if the facility reapplies more than 180 days before the permit expires, and EPA or the state regulatory agency, which ever issued the original permit, agrees to extend the permit.

4.5 Threat: Water Quality

4.5.1 Recommended Action:

State and Federal agencies should regularly assess water quality monitoring data to ensure water quality does not become impaired and to support recommendations on proposed activities that may affect water quality. Significant water treatment improvement projects are under way for the City of Hartford, CT (https://www.thecleanwaterproject.com/) and Springfield, MA (https://waterandsewer.org/wp-content/uploads/2020/02/IntegratedWastewaterPlan.pdf), with the intent of better handling high pulse rain events that in the past required the dumping of untreated waste water from road run-off (combined sewer overflow). This work can also address related threats from Climate Change due to expected expected increased high intensity, shorter duration rain events. Other strategies to improve water quality and enhance climate change resiliency include maintaining forested riparian zones and stream banks, improving stormwater treatments, and installing compatible stream crossing infrastructure such as appropriately sized culverts.

Physical, chemical, and biological monitoring of water quality should be adequately supported, primarily through existing State agency authorities, by designated agencies, to ensure sufficient temporal and spatial coverage, sampling design, and sampling intensity. Classification standards and data among the four basin states should be coordinated and shared along with necessary monitoring measures. Communication between professional fishery agency staff and water quality staff should continue to be strengthened.

4.5.2 Agencies with regulatory authority:

The Clean Water Act of 1972 is the foundation for surface water quality protection in the United States. Sections of this Act provide direction on standards to the states. The states of Vermont, New Hampshire, Massachusetts, and Connecticut all maintain surface water monitoring programs.

4.5.3 Goal/Target:

Varies by authorizing agency and standards cannot be weaker than federal identified designations. The State of New Hampshire designates the mainstem as Class B. The State of Vermont classifies the mainstem as Class B and as coldwater fish habitat. The Commonwealth of Massachusetts designates the mainstem as Class B and as warmwater fishery habitat. The State of Connecticut also classifies the mainstem and tributaries as Class B. Standards associated with these designations are available on respective state agency web sites.

4.5.4 Progress:

Water quality on the mainstem and tributaries are monitored directly by respective state agencies, federal agencies (e.g., U. S. Geological Survey) non-profit watershed groups, power companies and others. State agency water quality monitoring web sites include: Connecticut https://portal.ct.gov/DEEP/Water/Inland-Water-Monitoring/River-and-Stream-Water-Quality-Monitoring, for Massachusetts https://www.mass.gov/guides/water-quality-monitoring, for New Hampshire https://www.des.nh.gov/water/rivers-and-lakes/river-and-lake-monitoring, and for Vermont https://dec.vermont.gov/watershed/map/monitor#River%20Programs.

4.5.5 Timeline:

State agency monitoring for standard assessments is ongoing as are other programs including USGS gauge stations with water quality instrumentation.

4.6 Threat: Land Use

4.6.1 Recommended Action:

State, Federal, and local governments should continue to support existing protective measures to address poor land use practices that may affect shad habitat either directly or indirectly. These measures may occur at multiple levels of government as noted. Riparian zone vegetation protection and bank protection are examples of concerns that insufficient land use (e.g., agriculture, residential, commercial uses) regulation or enforcement may result in degraded habitat and impact water quality. In some jurisdiction local Conservation Commissions can enact or expand buffer or "no-disturb zones" adjacent to riverbanks and other wetland resources (e.g., Commonwealth of Massachusetts River Protection Act (1996) and Wetland Protection Act (2014)). States should work in collaboration to develop and support consistent regulations and enforcement measures.

4.6.2 Agencies with regulatory authority:

Land use regulatory authority may reside at the local, state and/or federal government level.

4.6.3 Goal/Target:

The codification of rules and adequate enforcement to provide riparian vegetation protection and bank protection/stability and address other potential negatively impacting land use activities will help protect aquatic habitats.

4.6.4 Progress:

Status of existing state and local government rules are not summarized here. Examples of measures that have improved protections for land in Massachusetts include local Conservation Commissions

and DEP use of the Rivers Protection Act and Wetlands Protection Act to protect riparian and wetland habitats. Act 250, is Vermont's land use and development law, enacted in 1970.

4.6.5 Timeline:
Ongoing.

4.7 Threat: Climate Change

4.7.1 Recommended Action:
State and Federal agencies should identify data of value in the detection and monitoring for climate change effects on shad habitat and associated shad population dynamics or other responses (e.g., run timing) and whether those changes can successfully be adapted to by those populations. Sources of data (fishway counts, tagging studies) should be evaluated for ongoing value and whether any modifications may be necessary. Data that would be of value in this effort and are not being regularly collected (e.g., tagging studies) should be identified and developed by the State and Federal agencies as determined necessary. In freshwater, the timing, frequency, and magnitude of river discharge should be evaluated at regular intervals (spring run-off, droughts, pulse events) and related to fishery data including, but not limited to, fishway operational schedules, fish movement and behavior data, spawning success, habitats, and juvenile recruitment and outmigration. In the near-shore and marine environment, monitoring, and studies to assess shifts in conditions and habitats (e.g., water temperatures, currents, food sources, predators) should occur at regular intervals. The ASMFC 2020 American Shad Benchmark Stock Assessment and Peer Review provides modeling analyses that shows reduced growth rates and maximum size with increase sea surface temperatures (ASMFC, 2020). Additional work to understand climate change effects in freshwater and estuarine habitats on life history events and/or population level effects should also be examined.

Efforts to improve climate change resiliency should be pursued. Strategies should be developed and implemented to reduce stressors associated with climate change including drought, floods and increasing temperatures. Disaster management, urban planning, and river restoration are some strategies that can help mitigate the impacts of climate change.

4.7.2 Agencies with regulatory authority:
Regulatory authorities for climate change are not clearly in place currently. However, both State and Federal resources agencies have recognized the need to incorporate the reality of climate change as physical scientists work to develop future scenarios on effects (e.g., temperature regimes, river discharge, rainfall, snowpack) that may to varying degrees, affect species occurrence, population viability, and habitat quantity and quality.

4.7.3 Goal/Target:
It will be desirable to understand any trends in population metrics or other parameters, and any linked climate change drivers that may affect population structure, distribution, abundance, and viability. The resource agencies will seek to improve climate change resiliency and reduce other anthropogenic impacts that may exacerbate these impacts. Ultimately the agencies will seek to ensure the full restoration and long-term sustainability of this population given it is not at the extreme end of its distribution range.

4.7.4 Progress:
New or updated federal resource plans are required to include climate change.

4.7.5 Timeline:
Ongoing.

4.8 Threat: Invasive Species

4.8.1 Recommended Action:
Invasive aquatic plant species are increasing in occurrences and expanding their range within the Connecticut River basin, impacting native aquatic plant species and habitats (https://portal.ct.gov/DEEP/Fishing/General-Information/Aquatic-Invasive-Species). Eurasian water milfoil, water chestnut and most recent hydrilla have been expanding in the mainstem as well as in tributary and coves, primarily in Connecticut and Massachusetts. State agencies have been working to monitor the locations and extent of these invasive plants and work with partners on mitigation measures including pulling of plants before they go to seed. This highly labor-intensive approach includes federal agency assistance and NGOs. Boat launches in all basin states have signage explaining the issues with these invasive plant introductions, establishment, and expansion. Launches are also sometime staffed by agency representatives or volunteers that also interact to help ensure "clean, drain, dry" measures are used when trailering boats. Other invasive organisms not yet present (documented) of potential concern include range expansions of Asian mussel species (e.g., Zebra Mussel) and other organisms that have demonstrated detrimental impacts when introduced in other aquatic systems (e.g., Blue Catfish, Snakehead).

4.8.2 Agencies with regulatory authority:
State agencies have developed statutes that forbid the importation of the previously list plants and many other non-natives, with associated fines. Similarly, there are regulations requiring boaters' clean trailers or be subject to fines. Importation bans for certain identified species occur at the Federal and State level.

4.8.3 Goal/Target:
Measures that can help prevent either the direct or indirect introduction on non-native species should continue to focus on outreach and education. The development and implementation of safe and effective measure to reduce the rate of spread, or other mitigation measures should continue to be explored and evaluated.

4.8.4 Progress:
State agencies have increased efforts on education and outreach with boaters and anglers. Partnerships to manage certain areas (pulling of plants) have been developing. Aquatic Nuisance Species funding at the Federal level has been increasing in recent years due to the extent of this problem. These funds are used primarily by state agencies and have increased monitoring, assessment, and planning activities.

4.8.5 Timeline:
This work is ongoing and steadily expanding.

5 Habitat Restoration Program

Since the submission of the first plan in 2014 the following progress on both dam removals and technical fishway construction has occurred in both Connecticut and Massachusetts (Table 5). There are some other potential projects that are in early stages of development that would benefit American Shad habitat. The removal of the lower Collinsville Dam (Canton) on the Farmington River would restore shad habitat to the upper Collinsville Dam that is in final stages of upstream and downstream passage construction. The lower dam is owned by the state and has removal

design plans in place currently. The agencies and partners will continue work on restoring shad habitat and habitat accessibility, including barrier removal.

Table 5. Descriptions of American Shad habitat access improvements since the first submitted Plan.

State	System	Activity	Outcome
Connecticut	Mattabesset River	Kensington Dam, steepass ladder install	Access to an additional 2 km of habitat
Connecticut	Scantic River	Removal of Springborn Dam	Access to an additional 4 km of habitat
Massachusetts	Manhan River	Completion of Easthampton Dam Denil fish ladder	Access to approximately 18 km of habitat

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APPENDIX 1.

Annual American shad fish passage counts from 1980 through 2020 for the Holyoke Dam (MA), Turners Falls Dam (MA), Vernon Dam (VT), Farmington River (CT) and Westfield River (MA). These data are influenced by changing environmental conditions (e.g., spill), facility operations, and identification of issues with improvements to fishways (e.g., 2012 at Vernon Ladder).

Year	Holyoke Dam	Turners Falls Dam Passed	TF % of Holyoke Total	Vernon Dam Passed	Vernon % of TF Total	Farmington River, Rainbow Dam Passed	Westfield River, W. Springfield Dam Passed
1980	376,066	298	0%			480	
1981	377,124	200	0%	97	49%		
1982	294,842	11	0%	9	82%	737	
1983	528,185	12,705	2%	2,597	20%	1,565	
1984	496,884	4,333	1%	335	8%	2,289	
1985	487,158	3,855	1%	833	22%	1,042	
1986	352,122	17,858	5%	982	5%	1,206	
1987	276,835	18,959	7%	3,459	18%	792	
1988	294,158	15,787	5%	1,370	9%	378	
1989	354,180	9,511	3%	2,953	31%	215	
1990	363,725	27,908	8%	10,894	39%	432	
1991	523,153	54,656	10%	37,197	68%	591	
1992	721,764	60,089	8%	31,155	52%	793	
1993	340,431	10,221	3%	3,652	36%	460	
1994	181,038	3,729	2%	2,681	72%	250	
1995	190,295	18,369	10%	15,771	86%	246	
1996	276,289	16,192	6%	18,844	116%	668	1,413
1997	299,448	9,216	3%	7,384	80%	421	1,012
1998	315,810	10,527	3%	7,289	69%	262	2,292
1999	193,780	6,751	3%	5,097	75%	70	2,668
2000	225,042	2,590	1%	1,548	60%	283	3,558
2001	273,206	1,540	1%	1,744	113%	153	4,720
2002	374,534	2,870	1%	356	12%	110	2,762
2003	286,814		0%	268		76	1,957
2004	191,555	2,192	1%	653	30%	123	913
2005	116,511	1,581	1%	167	11%	8	1,237
2006	154,745	1,810	1%	133	7%	73	1,534
2007	158,807	2,248	1%	65	3%	156	4,497
2008	153,109	4,000	3%	271	7%	89	3,212
2009	160,649	3,813	2%	16	0%	35	1,395
2010	164,439	16,422	10%	290	2%	548	3,449
2011	244,177	16,798	7%	46	0%	267	5,029
2012	490,431	26,727	5%	10,386	39%	174	10,300
2013	392,967	35,293	9%	18,220	52%	84	4,900
2014	370,506	39,914	11%	27,706	69%	536	4,787
2015	412,656	58,079	14%	39,771	68%	316	3,383
2016	385,930	54,069	14%	35,513	66%	141	5,940
2017	537,249	48,727	9%	28,682	59%	615	6,000
2018	275,232	43,146	16%	31,724	74%	341	5,752
2019	314,353	22,575	7%	12,862	57%	276	4,064
2020	362,423	41,252	11%	13,897	34%	510	5,549
Mean	324,113	18,171		9,423		445	3,693
SD	130,732	18,436		12,356		450	2,154
Low	116,511	11		9		8	913
High	721,764	60,089		39,771		2,289	10,300