Vermont Agency of Natural Resources

Study Requests

for

Wilder Hydroelectric Project
FERC No. 1892-026

Bellows Falls Hydroelectric Project
FERC No. 1855-045

Vernon Hydroelectric Project
FERC No. 1904-073

Turners Falls Hydroelectric Project
FERC No. 1889-081

Northfield Mountain Pumped Storage Project
FERC No. 2485-063

March 1, 2013

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Wilder Hydroelectric Project – FERC No. 1892-026

Study Request 1: Shoreline and downstream erosion from water level fluctuation in the impoundment and downstream from peaking operations

Goals and Objectives

The goal of this study is to determine how project operations contribute to the shoreline erosion and riverbank failure within the impoundment and downstream of the Wilder Hydro Project.

The objectives of this study are to:

1. determine how water level fluctuations within the minimum and maximum operating range and discharges from peaking operations at the Wilder hydroelectric project contribute to shoreline erosion;
2. identify and determine the effects of shoreline bank erosion and riverbank failure on other resources (i.e. riparian areas and shoreline wetlands, rare plant and animal populations, water quality, aquatic and terrestrial wildlife habitat, etc.);
3. identify techniques that could be used to mitigate the effects of project operations or other mitigation techniques that could be developed to reduce on riverbank erosion within the impoundment and downstream of the tailrace.

Resource Management Goals

The Connecticut River is considered Class B water by the states of Vermont and New Hampshire. Vermont lists the section of the Connecticut River below the Wilder dam on the Section 303(d) impaired water list due to flow alterations resulting in the destabilization and eroding of shoreline impairing aquatic life and habitat. In Class B waters, Vermont's water quality standards state that water level fluctuation and flow alterations can only occur to the extent that it supports all uses and does not lead to degradation of the water resource or habitat. New Hampshire's surface water quality regulations state that "unless the flows are caused by naturally occurring conditions, surface water quantity shall be maintained at levels adequate to protect existing and designated uses." (Env-Wq 1703.01(d)). The specific New Hampshire water quality criteria for turbidity in Class B waters is not to exceed naturally occurring conditions by more than 10 NTUs (Env-Wq 1703.11).

Public Interest Consideration

The Vermont Agency of Natural Resources and the New Hampshire Department of Environmental Services request this study. The requestors are state natural resource agencies.

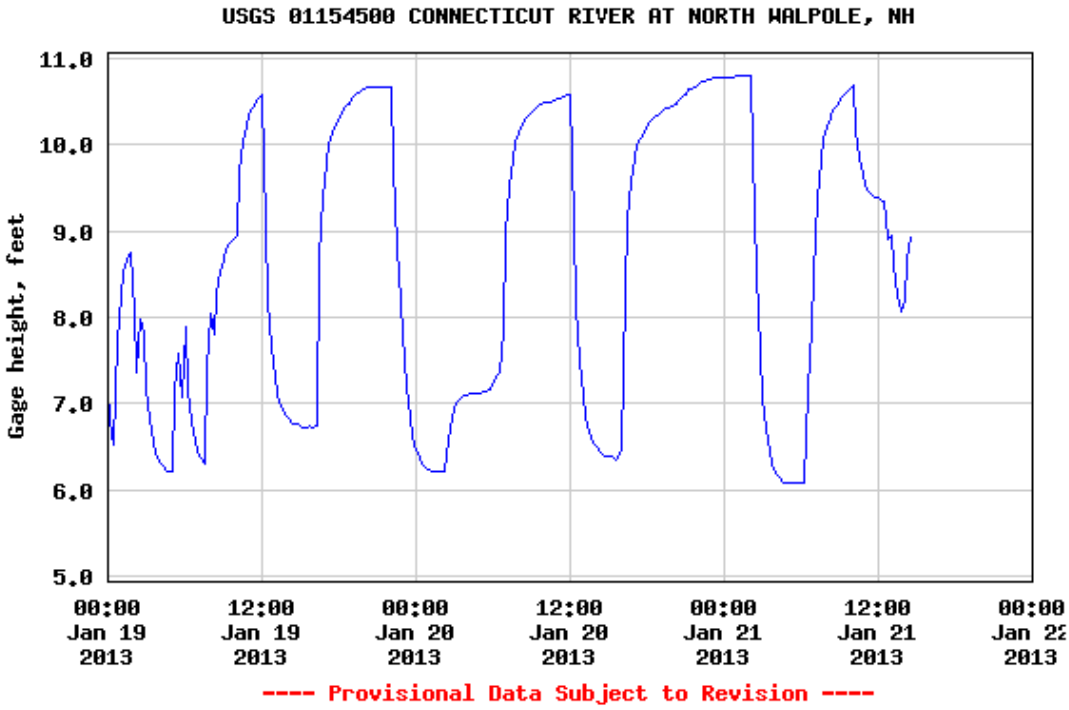
Existing Information

The PAD references several studies pertaining to shoreline erosion within the Connecticut River, including the study by US Army Corp of Engineers (Simion et al. 1979). This study evaluated the shoreline within the Wilder impoundment and identified water level fluctuation and periodic high flow events as causes of shoreline erosion. The PAD also discusses the erosion survey that TransCanada initiated in 2010 to inventory sites where erosion is occurring within the Wilder impoundment (Kleinschmidt 2011). Bank slumping can occur when fluvial erosional forces act on the toe of the bank slope. The PAD did not address how project related operations contribute to shoreline erosion, could be changed to mitigate impacts on shoreline erosion, or discuss the

impacts of shoreline erosion on other resources (i.e. riparian areas and shoreline wetlands, rare plant and animal populations, water quality, aquatic and terrestrial wildlife habitat, etc.).

Repetitive water level fluctuations and flow alterations caused by hydroelectric peaking operations are known to be a major contributor to shoreline erosion (Lawson 1985). Sediment from shoreline erosion and riverbank failure is one of the major contributors negatively affecting water quality and habitat by increasing turbidity and sedimentation, smothering aquatic habitat in the United States. Vermont Surface Water Management Strategy identifies sediment from excessive channel erosion as a stressor on Vermont water and aquatic habitat. Additionally, Vermont lists this section of the Connecticut River on the Vermont Section 303(d) impaired water list due to flow alterations resulting from the destabilization and eroding of shoreline impairing aquatic life and habitat.

An example of the water level fluctuations that occur in Lower Connecticut River due to hydropower generation is shown below.



Project Nexus

Wilder Hydroelectric Project operations currently result in daily water level fluctuation in the impoundment by as much as 2.5 feet, which has the potential to affect shoreline erosion in the impoundment. The project is currently permitted to water level fluctuation in the impoundment by 5 feet. Additionally the project "peaking" operation could contribute to bank erosion downstream of the dam by increasing the shear stress on the bank toe. Furthermore, river profile operations during high flow events minimize overland flow by drawing down the impoundment prior to high flows containing high velocity flows to the river channel, possibly increasing shoreline erosion rate within the impoundment. TransCanada is not proposing any changes to project operations.

Proposed Methodology

Kleinschmidt (2011) conducted a shoreline erosion survey on the Connecticut River, from which we have data on the spatial locations, lengths and heights of such erosion. However, this study did not investigate whether the practice of flow modification is a causative agent to this erosion. Consequently, the Vermont Agency of Natural Resources and the New Hampshire Department of Environmental Services recommend TransCanada further investigate sites on the Connecticut River to evaluate the processes that are active along banks. This investigation should build on the erosion survey that was previously completed by determining the process causing erosion at a site, the extent erosion is negatively affecting other resources (i.e. riparian areas and shoreline wetlands, rare plant and animal populations, water quality, aquatic and terrestrial wildlife habitat, etc.), and determining how erosion could be stabilized or mitigated by changing project operations. This investigation can be completed performing the following tasks.

Task 1: Determine erosion and riverbank failure process at identified sites

Shoreline erosion areas and riverbank failure sites were identified during the Kleinschmidt (2011) survey. A survey similar to Kleinschmidt (2011) should be conducted to document if any additional erosion has occurred, and identify new sites of erosion within the impoundment, given the occurrence of Tropical Storm Irene since the Kleinschmidt survey. For each erosion site, the following erosion process element will be identified by determining soil type and subsoil characteristics (i.e. depth to bedrock, texture, rock content, signs of soil piping), reservoir water levels at the time of observation, water level fluctuation, climatic conditions, ground water seepage, wind-driven waves, boat waves, and recreation. Additional site characteristic to identify and record in the erosion survey will include but not be limited to an estimate of the length and average height of the erosional area, slope of the site, dominant vegetation cover types present, associated vegetation cover types present, an ocular estimate of total plant cover and total cover by plant class (tree, shrub, herbaceous) in surrounding undisturbed areas. Data from each shoreline erosion site will be recorded on a field form and entered into a database. In addition, a photograph or photographs will be taken of each site. Sites should be visited when water levels are lowest.

Erosion processes will be determined by field observations and applying site appropriate geology, geomorphic and hydrological principles. To evaluate the relative influence of water level fluctuations on existing shoreline erosion, a minimum of six select sites (three in the impoundment and three downstream of the dam) will be identified for more detailed measurements and observations. In aid of site selection, comparison of successive aerial photographs will be conducted to identify sites that have experienced visible bank movement. Data from erosion surveys will be examined to identify sites with varying conditions of riparian buffer, vegetation type and bank slope. The sites selected for detailed evaluation will represent different combinations of bank movement, riparian buffer, vegetation type and bank slope. In those bank sites that are selected, rebar pins will be inserted into the banks in a grid at varying heights with each rebar being horizontally level. Initial rebar pin installation will take place when the water level in the impoundment is at its authorized lowest elevation. Each rebar pin will be assigned an individual number and photographed, with the distance from the end of the pin to the bank material measured. A survey will also be conducted of each bank along several

bank transects in the immediate vicinity of each site to accurately document bank shape as well as the location and elevation of each rebar and the water surface elevation at the beginning and end of each site visit. Pressure transducers (one in the air and one in the water) will also be installed at each site to automatically record how water surface elevation at each site varies with time.

Biweekly for a period of one year, each of the six sites will be revisited. During each revisit, the bank and each rebar pin will be photographed and the distance from the end of the pin to the bank material will be measured. Any slumping of a pin will be noted. If a pin is found dislodged or removed during a site visit, a new rebar pin will be reinstalled in the approximate location of the previously existing pin.. In addition, a survey of the bank and rebars will be conducted as described above. Surveys will be conducted in the same manner and will use the same benchmark each site visit. Data from pressure transducers will be downloaded and analyzed each site visit to ensure they are working properly. When this dataset is related to the flow record from existing stream gauges in the river segment, this evaluation will allow for a determination as to whether the erosion is Project related, and if so, how Project operations may be impacting the sites.

Task 2: Determining the effects of erosion on other resources

The effects of shoreline erosion and riverbank failure on other resources should be determined. This will required coordination between studies to determine the effects of erosion on riparian areas and shoreline wetlands, rare plant and animal populations, water quality, aquatic and terrestrial wildlife habitat, and recreation. Erosion sites identified as having an impact on resources will be assess to determine if project operations are causing erosion and a mitigation plan to protect the resource of interest should be developed.

Task 3: Development of a Shoreline Management Plan

The information that is collected during the study should be used to develop a Shoreline Management Plan for the impoundment. If results from the erosion evaluation suggest that Project operations are impacting erosion within the impoundment, further evaluation should be undertaken to determine if there is a feasible way to reduce impacts. This feasibility analysis will be based on field observations and knowledge of current erosion control and slope failure stabilization methods that may be suitable for sites. The analysis will provide a preliminary list of potential control measures necessary to reduce erosion at these sites. Detailed analyses for final design and construction of erosion and slope stabilization control measures will not be part of the study. As part of this process, the landowner should be identified for each of the erosion sites and future mitigation and stabilization techniques should be presented.

The study area for the shoreline erosion study should extend from the upstream end of the impoundment above the Wilder Dam to the beginning of the Bellows Falls impoundment. Water level fluctuations caused by the Project may affect not only the impoundment but also the downstream river reaches below the dam.

Level of Effort and Cost

The cost and effort of this study will be moderate, but is important to document the potential impact project operations on shoreline erosion and riverbank failure, and to determine how this may impact other resources.

Literature Cited

Kleinschmidt (Kleinschmidt Associates, Inc.). 2011. Lower Connecticut River Shoreline Survey Report – 2010: Bellows Falls Project (FERC No. 1855), Wilder Project (FERC No. 1892), Vernon Project (FERC No. 1904). Draft Report March 2011. Prepared for TransCanada Hydro Northeast Inc., Westborough, MA.

Lawson, D.E., 1985, Erosion of northern reservoir shores: An analysis and application of pertinent literature: US Army Corps of Engineers Cold Regions Research and Engineering Laboratory Monograph 85-1, 198 p.

Simons, D.B., Andrews, J.W., Li, R.M., and Alawady, M.A. 1979. Connecticut River Streambank Erosion Study Massachusetts, New Hampshire, and Vermont. Prepared for USACE, New England Division.

Bellows Falls Hydroelectric Project – FERC No. 1855-045

Study Request 1: Shoreline and downstream erosion from water level fluctuation in the impoundment and downstream from peaking operations

Goals and Objectives

The goal of this study is to determine how project operations contribute to the shoreline erosion and riverbank failure within the impoundment and downstream of the Bellows Falls Hydroelectric Project.

The objectives of this study are to:

1. determine how water level fluctuations within the minimum and maximum operating range and discharges from peaking operations at the Wilder hydroelectric project contribute to shoreline erosion;
2. identify and determine the effects of shoreline bank erosion and riverbank failure on other resources (i.e. riparian areas and shoreline wetlands, rare plant and animal populations, water quality, aquatic and terrestrial wildlife habitat, etc.);
3. identify techniques that could be used to mitigate the effects of project operations or other mitigation techniques that could be developed to reduce on riverbank erosion within the impoundment and downstream of the tailrace.

Resource Management Goals

The Connecticut River is considered Class B water by the states of Vermont and New Hampshire. Vermont list the section of the Connecticut River above and below Bellows Falls dam on the Section 303(d) impaired water list due to flow alterations resulting in the destabilization and eroding of shoreline impairing aquatic life and habitat. In Class B waters, Vermont's water quality standards state that water level fluctuation and flow alterations can only occur to the extent that it supports all uses and does not lead to degradation of the water resource or habitat. New Hampshire's surface water quality regulations state that "unless the flows are caused by naturally occurring conditions, surface water quantity shall be maintained at levels adequate to protect existing and designated uses." (Env-Wq 1703.01(d)). The specific New Hampshire water quality criteria for turbidity in Class B waters is not to exceed naturally occurring conditions by more than 10 NTUs (Env-Wq 1703.11).

Public Interest Consideration

The Vermont Agency of Natural Resources and the New Hampshire Department of Environmental Services request this study. The requestors are state natural resource agencies.

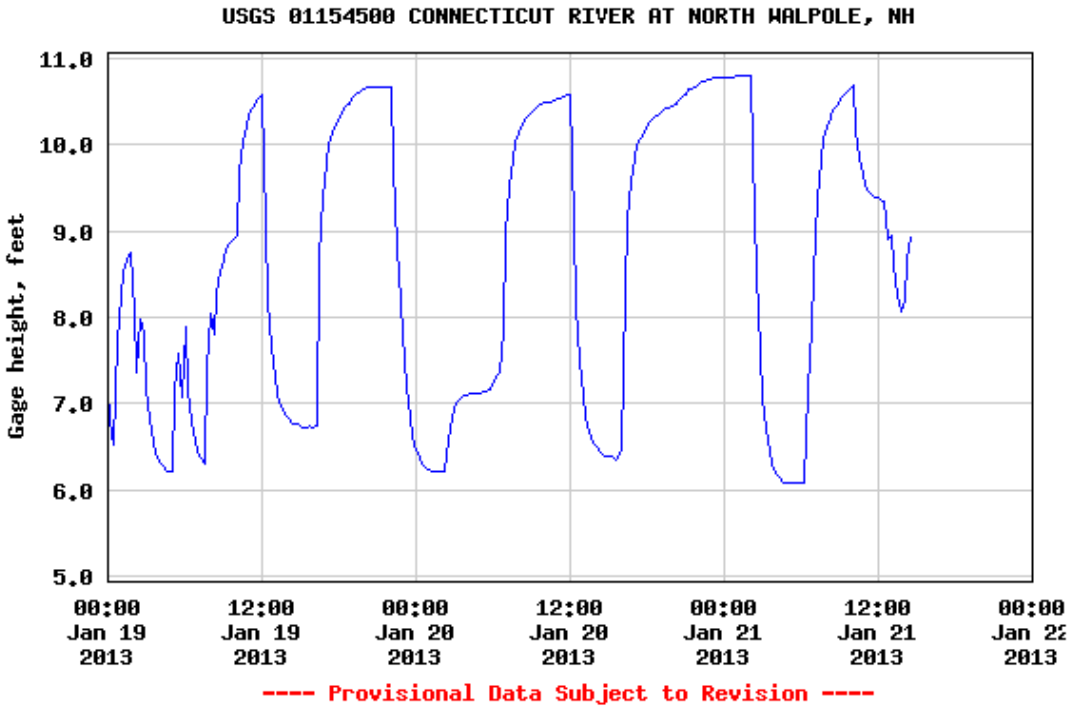
Existing Information

The PAD references several studies pertaining to shoreline erosion within the Connecticut River, including the study by US Army Corp of Engineers (Simion et al. 1979). This study evaluated the shoreline within the Wilder impoundment and identified water level fluctuation and periodic high flow events as causes of shoreline erosion. The PAD also discusses the erosion survey that TransCanada initiated 2010 to inventory sites where erosion is occurring within the Bellows Falls impoundment (Kleinschmidt 2011). Bank slumping can occur when fluvial erosional forces act on the toe of the bank slope. The PAD did not address how project related operations

contribute to shoreline erosion, could be changed to mitigate impacts on shoreline erosion, or discuss the impacts of shoreline erosion on other resources (i.e. riparian areas and shoreline wetlands, rare plant and animal populations, water quality, aquatic and terrestrial wildlife habitat, etc.).

Repetitive water level fluctuations and flow alterations caused by hydroelectric peaking operations are known to be a major contributor to shoreline erosion (Lawson 1985). Sediment from shoreline erosion and riverbank failure is one of the major contributors negatively affecting water quality and habitat by increasing turbidity and sedimentation, smothering aquatic habitat in the United States. Vermont Surface Water Management Strategy identifies sediment from excessive channel erosion as a stressor on Vermont water and aquatic habitat. Additionally, Vermont lists this section of the Connecticut River on the Vermont Section 303(d) impaired water list due to flow alterations resulting from the destabilization and eroding of shoreline impairing aquatic life and habitat.

An example of the water level fluctuations that occur in Lower Connecticut River due to hydropower generation is shown below.



Project Nexus

Bellows Falls Hydroelectric Project operations currently result in daily water level fluctuation in the impoundment by approximately 2 feet, which affects shoreline erosion in the impoundment by increasing the rate of soil piping. The project is currently permitted to water level fluctuation in the impoundment by 3 feet. Additionally the project “peaking” operation could contribute to bank erosion downstream of the dam by increasing the shear stress on the bank toe. Furthermore, river profile operations during high flow events the project impoundment is operated to minimize overland flow by drawing down impoundment prior to high flows containing high velocity flows

to the river channel, possibly increasing shoreline erosion rate within the impoundment. TransCanada is not proposing any changes to project operations.

Proposed Methodology

Kleinschmidt (2011) conducted a shoreline erosion survey on the Connecticut River, from which we have data on the spatial locations, lengths and heights of such erosion. However, this study did not investigate whether the practice of flow modification is a causative agent to this erosion. Consequently, the Vermont Agency of Natural Resources and the New Hampshire Department of Environmental Services recommend TransCanada further investigate sites on the Connecticut River to evaluate the processes that are active along banks. This investigation should build on the erosion survey that was previously completed by determining the process causing erosion at a site, the extent erosion is negatively affecting other resources (i.e. riparian areas and shoreline wetlands, rare plant and animal populations, water quality, aquatic and terrestrial wildlife habitat, etc.), and determining how erosion could be stabilized or mitigated by changing project operations. This investigation can be completed performing the following tasks.

Task 1: Determine erosion and riverbank failure process at identified sites

Shoreline erosion areas and riverbank failure sites were identified during the Kleinschmidt (2011) survey. A survey similar to Kleinschmidt (2011) should be conducted to document if any additional erosion has occurred, and identify new sites of erosion within the impoundment, given the occurrence of Tropical Storm Irene since the Kleinschmidt survey. For each erosion site, the following erosion process element will be identified by determining soil type and subsoil characteristics (i.e. depth to bedrock, texture, rock content, signs of soil piping), reservoir water levels at the time of observation, water level fluctuation, climatic conditions, ground water seepage, wind-driven waves, boat waves, and recreation. Additional site characteristic to identify and record in the erosion survey will include but not be limited to an estimate of the length and average height of the erosional area, slope of the site, dominant vegetation cover types present, associated vegetation cover types present, an ocular estimate of total plant cover and total cover by plant class (tree, shrub, herbaceous) in surrounding undisturbed areas. Data from each shoreline erosion site will be recorded on a field form and entered into a database. In addition, a photograph or photographs will be taken of each site. Sites should be visited when water levels are lowest.

Erosion processes will be determined by field observations and applying site appropriate geology, geomorphic and hydrological principles. To evaluate the relative influence of water level fluctuations on existing shoreline erosion, a minimum of six select sites (three in the impoundment and three downstream of the dam) will be identified for more detailed measurements and observations. In aid of site selection, comparison of successive aerial photographs will be conducted to identify sites that have experienced visible bank movement. Data from erosion surveys will be examined to identify sites with varying conditions of riparian buffer, vegetation type and bank slope. The sites selected for detailed evaluation will represent different combinations of bank movement, riparian buffer, vegetation type and bank slope. In those bank sites that are selected, rebar pins will be inserted into the banks in a grid at varying heights with each rebar being horizontally level. Initial rebar pin installation will take place when the water level in the impoundment is at its authorized lowest elevation. Each rebar pin

will be assigned an individual number and photographed, with the distance from the end of the pin to the bank material measured. A survey will also be conducted of each bank along several bank transects in the immediate vicinity of each site to accurately document bank shape as well as the location and elevation of each rebar and the water surface elevation at the beginning and end of each site visit. Pressure transducers (one in the air and one in the water) will also be installed at each site to automatically record how water surface elevation at each site varies with time.

Biweekly for a period of one year, each of the six sites will be revisited. During each revisit, the bank and each rebar pin will be photographed and the distance from the end of the pin to the bank material will be measured. Any slumping of a pin will be noted. If a pin is found dislodged or removed during a site visit, a new rebar pin will be reinstalled in the approximate location of the previously existing pin.. In addition, a survey of the bank and rebars will be conducted as described above. Surveys will be conducted in the same manner and will use the same benchmark each site visit. Data from pressure transducers will be downloaded and analyzed each site visit to ensure they are working properly. When this dataset is related to the flow record from existing stream gauges in the river segment, this evaluation will allow for a determination as to whether the erosion is Project related, and if so, how Project operations may be impacting the sites.

Task 2: Determining the effects of erosion on other resources

The effects of shoreline erosion and riverbank failure on other resources should be determined. This will required coordination between studies to determine the effects of erosion on riparian areas and shoreline wetlands, rare plant and animal populations, water quality, aquatic and terrestrial wildlife habitat, and recreation. Erosion sites identified as having an impact on resources will be assess to determine if project operations are causing erosion and a mitigation plan to protect the resource of interest should be developed.

Task 3: Development of a Shoreline Management Plan

The information that is collected during the study should be used to develop a Shoreline Management Plan for the impoundment. If results from the erosion evaluation suggest that Project operations are impacting erosion within the impoundment, further evaluation should be undertaken to determine if there is a feasible way to reduce impacts. This feasibility analysis will be based on field observations and knowledge of current erosion control and slope failure stabilization methods that may be suitable for sites. The analysis will provide a preliminary list of potential control measures necessary to reduce erosion at these sites. Detailed analyses for final design and construction of erosion and slope stabilization control measures will not be part of the study. As part of this process, the landowner should be identified for each of the erosion sites and future mitigation and stabilization techniques should be presented.

The study area for the shoreline erosion study should extend from the upstream end of the impoundment above the Bellows Falls Dam to the beginning of the Vernon impoundment. Water level fluctuations caused by the Project may affect not only the impoundment but also the downstream river reaches below the dam.

Level of Effort and Cost

The cost and effort of this study will be moderate, but is important to document the potential impact project operations on shoreline erosion and riverbank failure, and to determine how this may impact other resources.

Literature Cited

Kleinschmidt (Kleinschmidt Associates, Inc.). 2011. Lower Connecticut River Shoreline Survey Report – 2010: Bellows Falls Project (FERC No. 1855), Wilder Project (FERC No. 1892), Vernon Project (FERC No. 1904). Draft Report March 2011. Prepared for TransCanada Hydro Northeast Inc., Westborough, MA.

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Vernon Hydroelectric Project – FERC No. 1904-073

Study Request 1: Shoreline and downstream erosion from water level fluctuation in the impoundment and downstream from peaking operations

Goals and Objectives

The goal of this study is to determine how project operations contribute to the shoreline erosion and riverbank failure within the impoundment and downstream of the Vernon Hydroelectric Project.

The objectives of this study are to:

1. determine how water level fluctuations within the minimum and maximum operating range and discharges from peaking operations at the Wilder hydroelectric project contribute to shoreline erosion;
2. identify and determine the effects of shoreline bank erosion and riverbank failure on other resources (i.e. riparian areas and shoreline wetlands, rare plant and animal populations, water quality, aquatic and terrestrial wildlife habitat, etc.);
3. identify techniques that could be used to mitigate the effects of project operations or other mitigation techniques that could be developed to reduce on riverbank erosion within the impoundment and downstream of the tailrace.

Resource Management Goals

The Connecticut River is considered Class B water by the states of Vermont and New Hampshire. Vermont lists the section of the Connecticut River above and below Vernon dam on the Section 303(d) impaired water list due to flow alterations resulting in the destabilization and eroding of shoreline impairing aquatic life and habitat. In Class B waters, Vermont's water quality standards state that water level fluctuation and flow alterations can only occur to the extent that it supports all uses and does not lead to degradation of the water resource or habitat. New Hampshire's surface water quality regulations state that "unless the flows are caused by naturally occurring conditions, surface water quantity shall be maintained at levels adequate to protect existing and designated uses." (Env-Wq 1703.01(d)). The specific New Hampshire water quality criteria for turbidity in Class B waters is not to exceed naturally occurring conditions by more than 10 NTUs (Env-Wq 1703.11).

Public Interest Consideration

The Vermont Agency of Natural Resources and the New Hampshire Department of Environmental Services request this study. The requestors are state natural resource agencies.

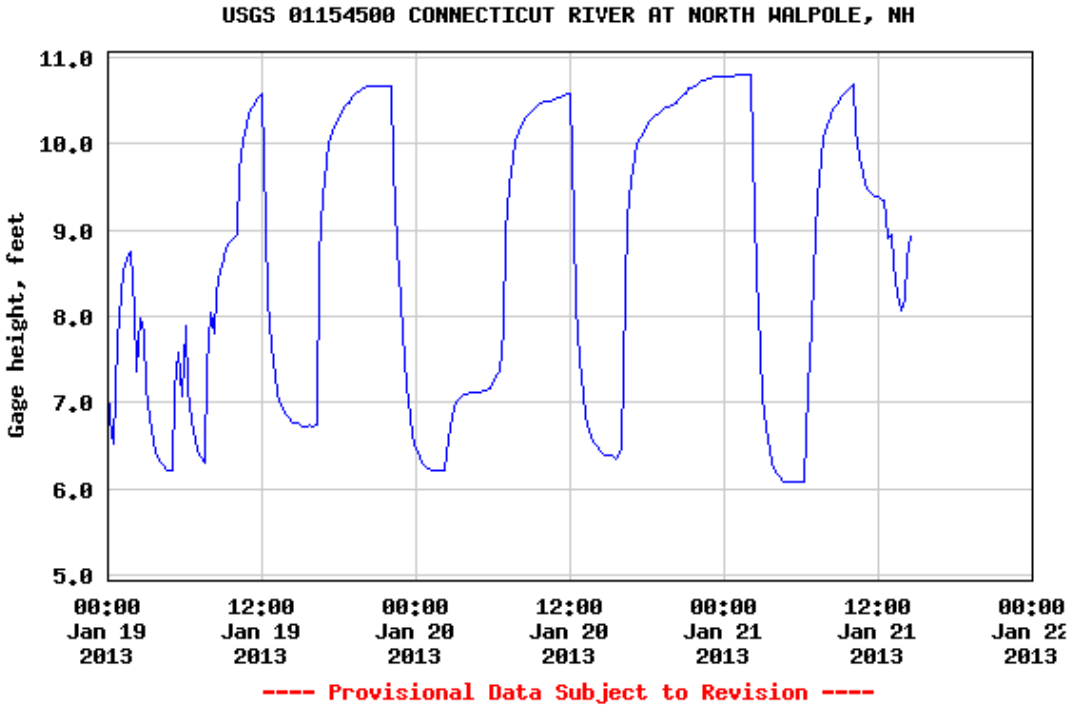
Existing Information

The PAD references several studies pertaining to shoreline erosion within the Connecticut River, including the study by US Army Corp of Engineers (Simion et al. 1979). This study evaluated the shoreline within the Wilder impoundment and identified water level fluctuation and periodic high flow events as causes of shoreline erosion. The PAD also discusses the erosion survey that TransCanada initiated 2010 to inventory sites where erosion is occurring within the Vernon impoundment (Kleinschmidt 2011). Bank slumping can occur when fluvial erosional forces act on the toe of the bank slope. The PAD did not address how project related operations contribute

to shoreline erosion, could be changed to mitigate impacts on shoreline erosion, or discuss the impacts of shoreline erosion on other resources (i.e. riparian areas and shoreline wetlands, rare plant and animal populations, water quality, aquatic and terrestrial wildlife habitat, etc.).

Repetitive water level fluctuations and flow alterations caused by hydroelectric peaking operations are known to be a major contributor to shoreline erosion (Lawson 1985). Sediment from shoreline erosion and riverbank failure is one of the major contributors negatively affecting water quality and habitat by increasing turbidity and sedimentation, smothering aquatic habitat in the United States. Vermont Surface Water Management Strategy identifies sediment from excessive channel erosion as a stressor on Vermont water and aquatic habitat. Additionally, Vermont lists this section of the Connecticut River on the Vermont Section 303(d) impaired water list due to flow alterations resulting from the destabilization and eroding of shoreline impairing aquatic life and habitat.

An example of the water level fluctuations that occur in Lower Connecticut River due to hydropower generation is shown below.



Project Nexus

Vernon Hydroelectric Project operations currently result in daily water level fluctuation in the impoundment by approximately 2 feet, which affects shoreline erosion in the impoundment by increasing the rate of soil piping. The project is currently permitted to water level fluctuation in the impoundment by 8 feet. Additionally the project “peaking” operation could contribute to bank erosion downstream of the dam by increasing the shear stress on the bank toe. TransCanada is not proposing any changes to project operations.

Proposed Methodology

Kleinschmidt (2011) conducted a shoreline erosion survey on the Connecticut River, from which we have data on the spatial locations, lengths and heights of such erosion. However, this study did not investigate whether the practice of flow modification is a causative agent to this erosion. Consequently, the Vermont Agency of Natural Resources and the New Hampshire Department of Environmental Services recommend TransCanada further investigate sites on the Connecticut River to evaluate the processes that are active along banks. This investigation should build on the erosion survey that was previously completed by determining the process causing erosion at a site, the extent erosion is negatively affecting other resources (i.e. riparian areas and shoreline wetlands, rare plant and animal populations, water quality, aquatic and terrestrial wildlife habitat, etc.), and determining how erosion could be stabilized or mitigated by changing project operations. This investigation can be completed performing the following tasks.

Task 1: Determine erosion and riverbank failure process at identified sites

Shoreline erosion areas and riverbank failure sites were identified during the Kleinschmidt (2011) survey. A survey similar to Kleinschmidt (2011) should be conducted to document if any additional erosion has occurred, and identify new sites of erosion within the impoundment, given the occurrence of Tropical Storm Irene since the Kleinschmidt survey. For each erosion site, the following erosion process element will be identified by determining soil type and subsoil characteristics (i.e. depth to bedrock, texture, rock content, signs of soil piping), reservoir water levels at the time of observation, water level fluctuation, climatic conditions, ground water seepage, wind-driven waves, boat waves, and recreation. Additional site characteristic to identify and record in the erosion survey will include but not be limited to an estimate of the length and average height of the erosional area, slope of the site, dominant vegetation cover types present, associated vegetation cover types present, an ocular estimate of total plant cover and total cover by plant class (tree, shrub, herbaceous) in surrounding undisturbed areas. Data from each shoreline erosion site will be recorded on a field form and entered into a database. In addition, a photograph or photographs will be taken of each site. Sites. should be visited when water levels are lowest.

Erosion processes will be determined by field observations and applying site appropriate geology, geomorphic and hydrological principles. To evaluate the relative influence of water level fluctuations on existing shoreline erosion, a minimum of six select sites (three in the impoundment and three downstream of the dam) will be identified for more detailed measurements and observations. In aid of site selection, comparison of successive aerial photographs will be conducted to identify sites that have experienced visible bank movement. Data from erosion surveys will be examined to identify sites with varying conditions of riparian buffer, vegetation type and bank slope. The sites selected for detailed evaluation will represent different combinations of bank movement, riparian buffer, vegetation type and bank slope. In those bank sites that are selected, rebar pins will be inserted into the banks in a grid at varying heights with each rebar being horizontally level. Initial rebar pin installation will take place when the water level in the impoundment is at its authorized lowest elevation. Each rebar pin will be assigned an individual number and photographed, with the distance from the end of the pin to the bank material measured. A survey will also be conducted of each bank along several bank transects in the immediate vicinity of each site to accurately document bank shape as well

as the location and elevation of each rebar and the water surface elevation at the beginning and end of each site visit. Pressure transducers (one in the air and one in the water) will also be installed at each site to automatically record how water surface elevation at each site varies with time.

Biweekly for a period of one year, each of the six sites will be revisited. During each revisit, the bank and each rebar pin will be photographed and the distance from the end of the pin to the bank material will be measured. Any slumping of a pin will be noted. If a pin is found dislodged or removed during a site visit, a new rebar pin will be reinstalled in the approximate location of the previously existing pin.. In addition, a survey of the bank and rebars will be conducted as described above. Surveys will be conducted in the same manner and will use the same benchmark each site visit. Data from pressure transducers will be downloaded and analyzed each site visit to ensure they are working properly. When this dataset is related to the flow record from existing stream gauges in the river segment, this evaluation will allow for a determination as to whether the erosion is Project related, and if so, how Project operations may be impacting the sites.

Task 2: Determining the effects of erosion on other resources

The effects of shoreline erosion and riverbank failure on other resources should be determined. This will required coordination between studies to determine the effects of erosion on riparian areas and shoreline wetlands, rare plant and animal populations, water quality, aquatic and terrestrial wildlife habitat, and recreation. Erosion sites identified as having an impact on resources will be assess to determine if project operations are causing erosion and a mitigation plan to protect the resource of interest should be developed.

Task 3: Development of a Shoreline Management Plan

The information that is collected during the study should be used to develop a Shoreline Management Plan for the impoundment. If results from the erosion evaluation suggest that Project operations are impacting erosion within the impoundment, further evaluation should be undertaken to determine if there is a feasible way to reduce impacts. This feasibility analysis will be based on field observations and knowledge of current erosion control and slope failure stabilization methods that may be suitable for sites. The analysis will provide a preliminary list of potential control measures necessary to reduce erosion at these sites. Detailed analyses for final design and construction of erosion and slope stabilization control measures will not be part of the study. As part of this process, the landowner should be identified for each of the erosion sites and future mitigation and stabilization techniques should be presented.

The study area for the shoreline erosion study should extend from the upstream end of the impoundment above the Vernon Dam to the beginning of the Turner Falls impoundment. Water level fluctuations caused by the Project may affect not only the impoundment but also the downstream river reaches below the dam.

Level of Effort and Cost

The cost and effort of this study will be moderate, but is important to document the potential impact project operations on shoreline erosion and riverbank failure, and to determine how this may impact other resources.

Literature Cited

Kleinschmidt (Kleinschmidt Associates, Inc.). 2011. Lower Connecticut River Shoreline Survey Report – 2010: Bellows Falls Project (FERC No. 1855), Wilder Project (FERC No. 1892), Vernon Project (FERC No. 1904). Draft Report March 2011. Prepared for TransCanada Hydro Northeast Inc., Westborough, MA.

Lawson, D.E., 1985, Erosion of northern reservoir shores: An analysis and application of pertinent literature: US Army Corps of Engineers Cold Regions Research and Engineering Laboratory Monograph 85-1, 198 p.

Simons, D.B., Andrews, J.W., Li, R.M., and Alawady, M.A. 1979. Connecticut River Streambank Erosion Study Massachusetts, New Hampshire, and Vermont. Prepared for USACE, New England Division.

Turners Falls Hydroelectric Project – FERC No. 1889-081
Northfield Mountain Pumped Storage Project – FERC No. 2485-063

Study Request 1: Shoreline and downstream erosion from water level fluctuation in the impoundment and downstream from peaking operations

Goals and Objectives
The goal of this study is to determine how project operations contribute to the shoreline erosion and riverbank failure within the impoundment and downstream of the Turner Falls/Northfield Mountain projects.

The objectives of this study are to:

1. determine how water level fluctuations within the minimum and maximum operating range and discharges from peaking operations at the Turner Falls/Northfield Pump Station hydroelectric project contribute to shoreline erosion;
2. identify and determine the effects of shoreline bank erosion and riverbank failure on other resources (i.e. riparian areas and shoreline wetlands, rare plant and animal populations, water quality, aquatic and terrestrial wildlife habitat, etc.);
3. identify techniques that could be used to mitigate the effects of project operations or other mitigation techniques that could be developed to reduce on riverbank erosion within the impoundment and downstream of the tailrace.

Resource Management Goals
The Connecticut River is considered Class B water by the states of Vermont. Vermont lists the section of the Connecticut River below the Wilder dam on the Section 303(d) impaired water list due to flow alterations resulting in the destabilization and eroding of shoreline impairing aquatic life and habitat. In Class B waters, Vermont's water quality standards state that water level fluctuation and flow alterations can only occur to the extent that it supports all uses and does not lead to degradation of the water resource or habitat.

Public Interest Consideration
The requestor is a state natural resource agency.

Existing Information
The PAD makes reference to several studies in section 4.2.4 including the Erosion Control Plan (Simons & Associates, 1999), previous Full River Reconnaissance studies (1998, 2001 – maps but no report generated, 2004, and 2008), Field Geology Services' 2007 fluvial geomorphic investigation of the Turners Fall headpond, and 2012 investigations by Simons & Associates.

Field Geology Services' 2007 investigation provided several good recommendations for future work in section 9.3 of his report which, if implemented, could provide for: a) an improved understanding of the causes of erosion; b) more accurate monitoring of erosion; and c) more successful bank stabilization efforts. This document is a good point of reference. The Simons & Associates' (2012) documents are qualitative and based on several unstated assumptions that may not be valid. Full River Reconnaissance efforts have been undertaken using varying methodologies, making for difficult comparisons from one report to the other.

We believe that these existing studies do have data that can be useful if certain new analyses are undertaken. These analyses of existing data would help fill in our gaps of understanding of bank erosion in the Turners Fall headpond. We are also asking for some additional field collected data. With the existing information, it should be possible to better display what changes have occurred to streambanks over time. Current Geographic Information System (GIS) software allows for various types of data to be assembled into a map and into a database such that change over time analysis can be conducted fairly easily. The change over time analysis is a critical analysis that is needed, and was already started under Field (2007).

Photos that have been taken at or near the same location but at different times exist. For example, the last three Full River Reconnaissance efforts have included continuous videotaping of the river banks with locational information. With these data, "snapshots" of the bank at various locations could be extracted and compared over time. Field (2007) photo locations could be re-shot as well. This existing information should be presented such that it is easy to discern where the photo was taken and what changes have occurred over time. A comparison of the bank every 100 ft could be compared over the years.
Historic aerial photography for the Turners Fall headpond should be gathered and analyzed. Examples of good photographic datasets include the Field 2007 appendices and 1929 aerials. The location of the shoreline over time should be noted such that it is easy to discern where bank retreat has been most severe and where the river has been relatively stable since the earliest aerial photograph was taken.

Very little turbidity data for the Turner's Falls headpond, the bypass reach or stretches of the Connecticut River downstream of the Turner's Fall project exist. Thus far, implementation of the *Northfield Mountain Pumped Storage Project Sediment Management Plan* (revised February 15, 2012) has yielded few results, and many technological difficulties (see *2012 Sediment Management Plan – 2012 Summary of Annual Monitoring* dated November 30, 2012). Suspended sediment monitoring equipment is installed at the Route 10 Bridge upstream of the project and inside the powerhouse, theoretically taking readings representative of pumping and discharging through the turbines. An analysis of how turbidity might change relative to rapidly changing headpond levels would be very useful information.

Project Nexus

The construction of the NMPS project was contingent upon the Turner's Falls project raising the dam crest elevation by 5.9 feet which has extended the headpond into Vermont and New Hampshire. The NMPS project operations rely on the Turner's Falls headpond as the source of water to be pumped and to be discharged into. The importance of this river reach to the NMPS operation is made clear by Firstlight's reference to this portion of the river as the "lower reservoir." Daily pumping and discharging changes the ponded elevation of the Connecticut River which in turn leads to bank material that repeatedly becomes saturated and then dewatered. Weakened bank material can then become eroded and the fine grain material from the banks can enter the water column and be transported in suspension in the river and eventually settle onto bed material. The raising of the Turner's Falls headpond also made recreational boating more popular, including the introduction of large, high-horsepower powerboats that were not previously present. Because of the fluctuating water levels, boat wakes impact the shoreline to a much greater extent than would occur if levels were more constant, thus exacerbating both the

effects of the wakes and the fluctuating levels. The requested study will help inform the Agency when contemplating mitigation measures and or operational modifications.

Proposed Methodology

This investigation should build on the erosion survey that was previously completed by determining the process causing erosion at a site, the extent erosion is negatively affecting other resources (i.e. riparian areas and shoreline wetlands, rare plant and animal populations, water quality, aquatic and terrestrial wildlife habitat, etc.), and determining how erosion could be stabilized or mitigated by changing project operations. This investigation can be completed performing the following tasks.

Task 1: Determine erosion and riverbank failure process at identified sites

Shoreline erosion areas and riverbank failure sites were identified during the previous surveys. A survey should be conducted to document if any additional erosion has occurred, and identify new sites of erosion within the impoundment. For each erosion site, the following erosion process element will be identified by determining soil type and subsoil characteristics (i.e. depth to bedrock, texture, rock content, signs of soil piping), reservoir water levels at the time of observation, water level fluctuation, climatic conditions, ground water seepage, wind-driven waves, boat waves, and recreation. Additional site characteristic to identify and record in the erosion survey will include but not be limited to an estimate of the length and average height of the erosional area, slope of the site, dominant vegetation cover types present, associated vegetation cover types present, an ocular estimate of total plant cover and total cover by plant class (tree, shrub, herbaceous) in surrounding undisturbed areas. Data from each shoreline erosion site will be recorded on a field form and entered into a database. In addition, a photograph or photographs will be taken of each site. Sites should be visited when water levels are lowest.

Erosion processes will be determined by field observations and applying site appropriate geology, geomorphic and hydrological principles. To evaluate the relative influence of water level fluctuations on existing shoreline erosion, a minimum of six select sites (three in the impoundment and three downstream of the dam) will be identified for more detailed measurements and observations. In aid of site selection, comparison of successive aerial photographs will be conducted to identify sites that have experienced visible bank movement. Data from erosion surveys will be examined to identify sites with varying conditions of riparian buffer, vegetation type and bank slope. The sites selected for detailed evaluation will represent different combinations of bank movement, riparian buffer, vegetation type and bank slope. In those bank sites that are selected, rebar pins will be inserted into the banks in a grid at varying heights with each rebar being horizontally level. Initial rebar pin installation will take place when the water level in the impoundment is at its authorized lowest elevation. Each rebar pin will be assigned an individual number and photographed, with the distance from the end of the pin to the bank material measured. A survey will also be conducted of each bank along several bank transects in the immediate vicinity of each site to accurately document bank shape as well as the location and elevation of each rebar and the water surface elevation at the beginning and end of each site visit. Pressure transducers (one in the air and one in the water) will also be

installed at each site to automatically record how water surface elevation at each site varies with time.

Biweekly for a period of one year, each of the six sites will be revisited. During each revisit, the bank and each rebar pin will be photographed and the distance from the end of the pin to the bank material will be measured. Any slumping of a pin will be noted. If a pin is found dislodged or removed during a site visit, a new rebar pin will be reinstalled in the approximate location of the previously existing pin. In addition, a survey of the bank and rebars will be conducted as described above. Surveys will be conducted in the same manner and will use the same benchmark each site visit. Data from pressure transducers will be downloaded and analyzed each site visit to ensure they are working properly. When this dataset is related to the flow record from existing stream gauges in the river segment, this evaluation will allow for a determination as to whether the erosion is Project related, and if so, how Project operations may be impacting the sites.

Task 2: Determining the effects of erosion on other resources

The effects of shoreline erosion and riverbank failure on other resources should be determined. This will required coordination between studies to determine the effects of erosion on riparian areas and shoreline wetlands, rare plant and animal populations, water quality, aquatic and terrestrial wildlife habitat, and recreation. Erosion sites identified as having an impact on resources will be assess to determine if project operations are causing erosion and a mitigation plan to protect the resource of interest should be developed.

Task 3: Development of a Shoreline Management Plan

The information that is collected during the study should be used to develop a Shoreline Management Plan for the impoundment. If results from the erosion evaluation suggest that Project operations are impacting erosion within the impoundment, further evaluation should be undertaken to determine if there is a feasible way to reduce impacts. This feasibility analysis will be based on field observations and knowledge of current erosion control and slope failure stabilization methods that may be suitable for sites. The analysis will provide a preliminary list of potential control measures necessary to reduce erosion at these sites. Detailed analyses for final design and construction of erosion and slope stabilization control measures will not be part of the study. As part of this process, the landowner should be identified for each of the erosion sites and future mitigation and stabilization techniques should be presented.

Level of Effort and Cost

The cost and effort of this study will be moderate, but is important to document the potential impact project operations on shoreline erosion and riverbank failure, and to determine how this may impact other resources.

Literature Cited

Lawson, D.E., 1985, Erosion of northern reservoir shores: An analysis and application of pertinent literature: US Army Corps of Engineers Cold Regions Research and Engineering Laboratory Monograph 85-1, 198 p.

Simons, D.B., Andrews, J.W., Li, R.M., and Alawady, M.A. 1979. Connecticut River Streambank Erosion Study Massachusetts, New Hampshire, and Vermont. Prepared for USACE, New England Division.

Wilder Hydroelectric Project – FERC No. 1892-026

Study Request 2: Water quality monitoring within the project impoundment and tailrace

Goals and Objectives

The goal of this study is to determine if the operational impacts of the Wilder Hydroelectric Project are causing or contributing to violations of New Hampshire and/or Vermont state water quality standards.

The objective of this study will be to collect water temperature, dissolved oxygen, specific conductance, pH, nutrients, and chlorophyll-a data at multiple locations in the project area. This monitoring effort will consist of both instantaneous measurements and continuous data collected via multi-parameter dataloggers. Data should be collected under normal operating conditions and ambient conditions that include periods of low flow and higher water temperatures. Weekly profiles and grab samples should reflect various flow conditions. The water quality data will be compared to both Vermont and New Hampshire water quality standards to determine if the project is causing or contributing to water quality standard violations.

Resource Management Goals

The Connecticut River is classified by the state of Vermont as Class B cold water fish habitat. Vermont Water Quality Standards state that Class B waters should be managed to achieve and maintain a level of quality that fully supports aquatic biota and habitat. Vermont lists the section of the Connecticut River below the Wilder dam on the Section 303(d) impaired water list due to flow alterations aquatic life and habitat.

All sections of the Connecticut River related to the project are classified by New Hampshire as Class B. It should be noted that although the classification name is the same as Vermont's, New Hampshire surface water criteria for Class B waters, are in some cases, different from Vermont's.

New Hampshire surface water quality standards (Env-Wq 1703.01) state that the surface water quality criteria for all surface waters shall be restored to meet the water quality criteria for their designated classification, including existing and designated uses, and to maintain the chemical, physical, and biological integrity of surface water.

Public Interest Consideration

The Vermont Agency of Natural Resources and the New Hampshire Department of Environmental Services are requesting this study. The requestors are state natural resource agencies.

Existing Information

The PAD contains information on water quality monitoring that was completed between June 20, 2012 and September 11, 2012 in the tailrace and just upstream of the dam. The data indicated that Vermont Water Quality Standards for dissolved oxygen were not met during a seven day period in August. The PAD does not provide information on the water quality throughout the impoundment or how water quality is affected by project operations. The PAD does indicate that

in general temperature, specific conductance, and pH did increase from upstream to downstream while dissolved oxygen decreased, reflecting the impacts of the impoundment.

Project Nexus

The project impounds 45 miles of river that would otherwise be free flowing. It currently operates in a peaking mode, with allowable impoundment fluctuations of up to 5 feet, with proposals to continue as such. The below-project flow requirement is equal to 0.20 csm (675 cfs). Water quality can be affected by the operating mode of a hydropower project. The PAD provides limited information on how project operations affect water quality within the project impoundment and tailrace.

Operations of the project must conform to Vermont and New Hampshire water quality standards. The Vermont Agency of Natural Resources and the New Hampshire Department of Environmental Services request a study that will provide the data needed to determine if the Connecticut River in the vicinity of the Wilder Hydroelectric Project is or is not attaining the water quality standards of both states.

Proposed Methodology

The methodology for this study should be similar to TransCanada's water quality monitoring in 2012 including weekly vertical profiles within the impoundment, weekly water quality samples of nutrients and chlorophyll-a for laboratory analysis and the deployment of multi-parameter continuous dataloggers at multiple locations within the impoundment and tailrace. An additional site should be monitored in the free flowing section of the river above the impoundment to serve as a "reference site". At each designated datalogger monitoring location at least 10 days of data should be collected at 15 minute increments during a period of low flow ($\leq$3 x 7Q10) and high temperatures (preferably over 23 degrees C) between June 1 and September 30. Dataloggers deployed in the impoundment should be set at the bottom of the epilimnion (if stratified) or at 25% depth if not stratified. A vertical dissolved oxygen and water temperature profile should be conducted at the time of deployment of dataloggers in the impounded section to determine if river is stratified and thus the appropriate depth for deployment. Water quality results should be graphically compared to both state water quality standards and project operations, including the generation status, impoundment elevation, and discharge.

If low flow conditions are not met the first year of the study, a second year of data may be necessary.

It is preferable that the water quality monitoring for all three projects be coordinated so that sampling can occur at each location within each project during the same period of time and under the same operational, flow, and environmental conditions.

Level of Effort and Cost

The cost and effort of this study will be moderate, but is important to document the potential impact operations have on water quality and determine if they meet Vermont and New Hampshire water quality standards.

Bellow Falls Hydroelectric Project – FERC No. 1855-045

Study Request 2: Water quality monitoring within the project impoundment, bypass, and tailrace

Goals and Objectives

The goal of this study is to determine if the operational impacts of the Bellows Falls Hydroelectric Project are causing or contributing to violations of New Hampshire and/or Vermont state water quality standards.

The objective of this study will be to collect water temperature, dissolved oxygen, specific conductance, pH, nutrients, and chlorophyll-a data at multiple locations in the project area. This monitoring effort will consist of both instantaneous measurements and continuous data collected via multi-parameter dataloggers. Data should be collected under normal operating conditions and ambient conditions that include periods of low flow and higher water temperatures. Weekly profiles and grab samples should reflect various flow conditions. The water quality data will be compared to both Vermont and New Hampshire water quality standards to determine if the project is causing or contributing to water quality standard violations.

Resource Management Goals

The Connecticut River is classified by the state of Vermont as Class B cold water fish habitat. Vermont Water Quality Standards state that Class B waters should be managed to achieve and maintain a level of quality that fully supports aquatic biota and habitat. Vermont list the section of the Connecticut River above and below Bellows Falls dam on the Section 303(d) impaired water list due to flow alterations impairing aquatic life and habitat.

All sections of the Connecticut River related to the project are classified by New Hampshire as Class B. It should be noted that although the classification name is the same as Vermont's, New Hampshire surface water criteria for Class B waters, are in some cases, different from Vermont's.

New Hampshire surface water quality standards (Env-Wq 1703.01) state that the surface water quality criteria for all surface waters shall be restored to meet the water quality criteria for their designated classification, including existing and designated uses, and to maintain the chemical, physical, and biological integrity of surface water.

Public Interest Consideration

The Vermont Agency of Natural Resources and the New Hampshire Department of Environmental Services are requesting this study. The requestors are state natural resource agencies.

Existing Information

The PAD contains information on water quality monitoring that was completed between June 20, 2012 and September 12, 2012 in the tailrace, bypass reach and just upstream of the dam. Additionally, weekly water column profiles were collected at three locations within the impoundment. The data indicated that Vermont and New Hampshire water quality standards for dissolved oxygen were not met in the bypass reach and in the impoundment. Furthermore, pH

readings collected in water profile measurements indicated that in two different locations during two separate events in the impoundment did not meet Vermont and New Hampshire water quality standards. The PAD does not provide information on the continuous water quality throughout the impoundment or how water quality is affected by project operations. The PAD indicates that in general temperature, specific conductance, and pH did increase from upstream to downstream while dissolved oxygen decreased, reflecting the impacts of the impoundment.

Project Nexus

The project impounds 26 miles of river that would otherwise be free flowing. It currently operates in a peaking mode, with allowable impoundment fluctuations of up to 3 feet, with proposals to continue as such. The below-project flow requirement is equal to 0.20 csm (1083 cfs). Water quality can be affected by the operating mode of a hydropower project. The PAD provides limited information on how project operations affect water quality within the project impoundment, bypass reach and tailrace.

Operations of the project must conform to Vermont and New Hampshire water quality standards. The Vermont Agency of Natural Resources and the New Hampshire Department of Environmental Services request a study that will provide the data needed to determine if the Connecticut River in the vicinity of the Wilder Hydroelectric Project is or is not attaining the water quality standards of both states.

Proposed Methodology

The methodology for this study should be similar to TransCanada's water quality monitoring in 2012 including weekly vertical profiles within the impoundment, weekly water quality samples of nutrients and chlorophyll-a for laboratory analysis and the deployment of multi-parameter continuous dataloggers at multiple locations within the impoundment, the bypass reach, and tailrace. An additional site should be monitored in the 17 mile free flowing section of the river above the impoundment to serve as a "reference site". At each designated datalogger monitoring location at least 10 days of data should be collected at 15 minute increments during a period of low flow ($\leq$3 x 7Q10) and high temperatures (preferably over 23 degrees C) between June 1 and September 30. Dataloggers deployed in the impoundment should be set at the bottom of the epilimnion (if stratified) or at 25% depth if not stratified. A vertical dissolved oxygen and water temperature profile should be conducted at the time of deployment of dataloggers in the impounded section to determine if river is stratified and thus the appropriate depth for deployment. Water quality results should be graphically compared to both state water quality standards and project operations, including the generation status, impoundment elevation, and discharge.

If low flow conditions are not met the first year of the study, a second year of data may be necessary.

It is preferable that the water quality monitoring for all three projects be coordinated so that sampling can occur at each location within each project during the same period of time and under the same operational, flow, and environmental conditions.

Level of Effort and Cost

The cost and effort of this study will be moderate, but is important to document the potential impact operations have on water quality and determine if they meet Vermont and New Hampshire water quality standards.

Vernon Hydroelectric Project – FERC No. 1904-073

Study Request 2: Water quality monitoring within the project impoundment and tailrace

Goals and Objectives

The goal of this study is to determine if the operational impacts of at the Vernon Hydroelectric Project are causing or contributing to violations of New Hampshire and/or Vermont state water quality standards.

The objective of this study will be to collect water temperature, dissolved oxygen, specific conductance, pH, nutrients, and chlorophyll-a data at multiple locations in the project area. This monitoring effort will consist of both instantaneous measurements and continuous data collected via multi-parameter dataloggers. Data should be collected under normal operating conditions and ambient conditions that include periods of low flow and higher water temperatures. Weekly profiles and grab samples should reflect various flow conditions. The water quality data will be compared to both Vermont and New Hampshire water quality standards to determine if the project is causing or contributing to water quality standard violations.

Resource Management Goals

The Connecticut River is classified by the state of Vermont as Class B cold water fish habitat. Vermont Water Quality Standards state that Class B waters should be managed to achieve and maintain a level of quality that fully supports aquatic biota and habitat. Vermont lists the section of the Connecticut River above and below Vernon dam on the Section 303(d) impaired water list due to flow alterations impairing aquatic life and habitat.

All sections of the Connecticut River related to the project are classified by New Hampshire as Class B. It should be noted that although the classification name is the same as Vermont's, New Hampshire surface water criteria for Class B waters, are in some cases, different from Vermont's.

New Hampshire surface water quality standards (Env-Wq 1703.01) state that the surface water quality criteria for all surface waters shall be restored to meet the water quality criteria for their designated classification, including existing and designated uses, and to maintain the chemical, physical, and biological integrity of surface water.

Public Interest Consideration

The Vermont Agency of Natural Resources and the New Hampshire Department of Environmental Services are requesting this study. The requestors are state natural resource agencies.

Existing Information

The PAD contains information on water quality monitoring that was completed between June 20, 2012 and September 11, 2012 in the tailrace and just upstream of the dam. Temperature data indicated that it reached levels that would be critical threshold for salmonids, and above the natural regime for the river. The PAD does not provide information on the water quality throughout the impoundment or how water quality is affected by project operations. The PAD does indicates that in general temperature, specific conductance, and pH did increase from

upstream to downstream while dissolved oxygen decreased, reflecting the impacts of the impoundment on increase travel time in the river.

Project Nexus

The project impounds 26 miles of river that would otherwise be natural free-flowing. It currently operates in a peaking mode, with allowable impoundment fluctuations of up to 8 feet, with proposals to continue as such. The below-project flow requirement is equal to 0.20 csm (1250 cfs). Water quality can be affected by the operating mode of a hydropower project. The PAD provides limited information on how project operations affect water quality within the project impoundment and tailrace.

Operations of the project must conform to Vermont and New Hampshire water quality standards . The Vermont Agency of Natural Resources and the New Hampshire Department of Environmental Services request a study that will provide the data needed to determine if the Connecticut River in the vicinity of the Wilder Hydroelectric Project is or is not attaining the water quality standards of both states.

Proposed Methodology

The methodology for this study should be similar to TransCanada's water quality monitoring in 2012 including weekly vertical profiles within the impoundment, weekly water quality samples of nutrients and chlorophyll-a for laboratory analysis and the deployment of multi-parameter continuous dataloggers at multiple locations within the impoundment and tailrace. An additional site should be monitored in the free flowing section of the river above the impoundment to serve as a "reference site". At each designated datalogger monitoring location at least 10 days of data should be collected at 15 minute increments during a period of low flow ($\leq$3 x 7Q10) and high temperatures (preferably over 23 degrees C) between June 1 and September 30. Dataloggers deployed in the impoundment should be set at the bottom of the epilimnion (if stratified) or at 25% depth if not stratified. A vertical dissolved oxygen and water temperature profile should be conducted at the time of deployment of dataloggers in the impounded section to determine if river is stratified and thus the appropriate depth for deployment. Water quality results should be graphically compared to both state water quality standards and project operations, including the generation status, impoundment elevation, and discharge.

If low flow conditions are not met the first year of the study, a second year of data may be necessary.

It is preferable that the water quality monitoring for all three projects be coordinated so that sampling can occur at each location within each project during the same period of time and under the same operational, flow, and environmental conditions.

Level of Effort and Cost

The cost and effort of this study will be moderate, but is important to document the potential impact project operations have on water quality and determine if they meet Vermont and New Hampshire water quality standards.

Turners Falls Hydroelectric Project – FERC No. 1889-081
Northfield Mountain Pumped Storage Project – FERC No. 2485-063

Study Request 2: Water quality monitoring within the project impoundment and tailrace

Goals and Objectives
The goal of this study is to determine if the operational impacts of at the Turner Falls Project are causing or contributing to violations of New Hampshire and/or Vermont state water quality standards.

The objective of this study will be to collect water temperature, dissolved oxygen, specific conductance, pH, nutrients, and chlorophyll-a data at multiple locations in the project area. This monitoring effort will consist of both instantaneous measurements and continuous data collected via multi-parameter dataloggers. Data should be collected under normal operating conditions and ambient conditions that include periods of low flow and higher water temperatures. Weekly profiles and grab samples should reflect various flow conditions. The water quality data will be compared to both Vermont and New Hampshire water quality standards to determine if the project is causing or contributing to water quality standard violations.

Resource Management Goals
The Connecticut River is classified by the state of Vermont as Class B cold water fish habitat. Vermont Water Quality Standards state that Class B waters should be managed to achieve and maintain a level of quality that fully supports aquatic biota and habitat. Vermont lists the section of the Connecticut River below Vernon dam on the Section 303(d) impaired water list due to flow alterations impairing aquatic life and habitat.

Public Interest Consideration
The requestor is a state natural resource agency.

Existing Information
The PAD provides a summary of existing water quality data. While a number of monitoring efforts have taken place and include sample sites within the project boundary, none of those studies were designed to comprehensively investigate whether all relevant project areas currently meet Class B standards, and no data was collected in the section of the impoundment between Vermont and New Hampshire: The Massachusetts DEP's Connecticut River watershed assessment monitoring occurred in 2003, only had two stations located within the project area (both upstream of the Turners Falls dam) and only collected five to six samples from late April to early October; the Connecticut River Watershed Council's volunteer monitoring program only had one sample site within the project area (at Barton's Cove in the Turners Falls headpond) and while those data are more recent, only three samples were collected in 2007 and only six samples in 2008 (over the course of three to four months each year); and the U.S. Geological Survey's long-term water quality monitoring station located downstream of the Cabot Station tailrace only collects information roughly once per month (and no dissolved oxygen data are provided).

No directed, site-specific surveys have been conducted to determine whether waters within the Project area in Vermont and New Hampshire meet State standards. This information gap needs

to be filled so that resource agencies can evaluate properly the potential impact of project operations on water quality.

Project Nexus

The project creates a 20-mile-long impoundment where there would naturally be a free-flowing river with 5.7 miles between Vermont and New Hampshire. It currently operates in a peaking mode, with allowable headpond fluctuations of up to 9 feet, with proposals to continue as such. Portions of the headpond are nearly 100 feet-deep. There is a 2.7 mile-long reach of river bypassed by the Turners Falls power canal with only a nominal seasonal release required (equal to 0.05 cfsm). The below-project flow requirement is equal to 0.20 cfsm (1,433 cfs). Water quality can be affected by the operating mode of a hydropower project. Impoundments can stratify, resulting in a near-hypoxic hypolimnion. If the project intake draws off of these deep waters then it could cause low dissolved oxygen levels downstream from the project discharge.

The Vermont Agency of Natural Resources requests that the applicant conduct a water quality survey of the impoundment reach within Vermont in order to determine whether state water quality standards are being met under all currently-licensed operating conditions (i.e., during periods of generation and non-generation). Results of the survey would be used, in conjunction with other studies requested herein, to determine an appropriate below-Project flow prescription, bypass reach flow(s), and to recommend an appropriate water level management protocol for the headpond (e.g., limiting impoundment fluctuations to protect water quality).

Operation of upstream hydroelectric projects as well as the Turners Falls Project and Northfield Mountain Project may impact water quality through the use of water for hydropower generation.

Proposed Methodology

The methodology for this study should include weekly vertical profiles within the impoundment, weekly water quality samples of nutrients and chlorophyll-a for laboratory analysis and the deployment of multi-parameter continuous dataloggers at multiple locations within the impoundment. An additional site should be monitored in the free flowing section of the river above the impoundment to serve as a “reference site”. At each designated datalogger monitoring location at least 10 days of data should be collected at 15 minute increments during a period of low flow ($\leq$3 x 7Q10) and high temperatures (preferably over 23 degrees C) between June 1 and September 30. Dataloggers deployed in the impoundment should be set at the bottom of the epilimnion (if stratified) or at 25% depth if not stratified. A vertical dissolved oxygen and water temperature profile should be conducted at the time of deployment of dataloggers in the impounded section to determine if river is stratified and thus the appropriate depth for deployment. Water quality results should be graphically compared to both state water quality standards and project operations, including the generation status, impoundment elevation, and discharge.

If low flow conditions are not met the first year of the study, a second year of data may be necessary.

It is preferable that the water quality monitoring be coordinated with TransCanada so that sampling can occur at each location within each project during the same period of time and under the same operational, flow, and environmental conditions.

Level of Effort and Cost

The cost and effort of this study will be moderate, but is important to document the potential impact project operations have on water quality and determine if they meet Vermont water quality standards.

Wilder Hydroelectric Project – FERC No. 1892-026

Study Request 3: Continuous water temperature monitoring at various locations within the impoundment and tailrace, and downstream Connecticut River

Goals and Objectives

The goal of this study is to determine the potential impacts (both project specific and cumulative) of the Wilder Hydroelectric Project operations on hourly/daily temperature fluctuations and spatial thermal distribution within the Wilder Hydroelectric Project Impoundment and Tailrace**,** and the Connecticut River downstream of the Wilder Dam.

The objectives of this study are to:

1. Obtain continuous temperature data (every 15 minutes) at various locations and depths throughout the project impoundment, tailrace, and downstream Connecticut River using temperature loggers;

2. Analyze data for hourly/daily shifts in temperature regime and thermal distribution (aquatic isotherm maps) associated project specific and cumulative impacts associated with project operations; and

3. Determine if any shifts in hourly temperature regime or thermal distribution are impacting aquatic habitat within the project impoundment and tailrace and lower Connecticut River (e.g., thermal blocks to migration, thermal stress, habitat degradation).

Resource Management Goals

Temperature is an important habitat consideration for many aquatic species including migratory fish and rare, threatened, endangered species. Temperature influences the distribution, behavior, metabolism, growth, reproduction, and survival of fishes (Diana 2004). The Connecticut River is considered a Class B waters cold water fish habitat. Vermont Water Quality Standards state that Class B waters should be managed to achieve and maintain a level of quality that fully supports aquatic biota and habitat. Additionally the Vermont Water Quality Standards states that in Class B cold water fish habitat, the total increase in from any activity or discharge should not result in a temperature increase that exceeds 1.0°F.

Public Interest Consideration

The requestor is a state natural resource agency.

Existing Information

The PAD provides limited information on impacts of project operations (“daily run-of-river”) on temperature in the project impoundment, tailrace or lower Connecticut River. Hourly/daily temperature shifts associated with project operations at Wilder Dam can impact aquatic habitat rendering it unsuitable for some organisms. The information in the PAD does not define the spatial extent of temperatures (aquatic isotherm map) within the impoundment, lower Connecticut River. The PAD mainly indicates that in general, temperature did increase from

upstream to downstream while dissolved oxygen decreased, reflecting the impacts of the impoundment.

Project Nexus

The project impounds 45 miles of river that would otherwise be free flowing. It currently operates in a peaking mode, with allowable impoundment fluctuations of up to 5 feet, with proposals to continue as such. The below-project flow requirement is equal to 0.20 csm (675 cfs). Water temperature can be affected by the operating mode of a hydropower project. The impounded water increases the water surface area of the river reach containing the project. The increased surface acts as a large solar radiation collector and the thermal mass of the impounded water acts a heat sink storing heat from solar radiation. At night the increased surface area may act as convective radiator that releases heat. Together these attributes may contribute to unnatural thermal properties in the project impoundment that may impact natural temperature regime and influence habitat conditions for fish, wildlife and plant resources (temperature tolerance, life cycle timing (e.g., reproduction or migration), and food availability).

The project discharges regulated Connecticut River flows ("daily run-of-river") from the impoundment to the downstream seventeen mile reach of the Connecticut River. The project can sporadically release large volumes of impoundment water that may be of a different temperature than the receiving water downstream of the dam. Unnatural and rapid shifts in temperature regimes in the downstream water can impact fish, wildlife and plant resources and instream habitat. The Agency requests that more recent temperature data is collected in a more intensive, systematic and scientific manner in order to assess project specific and cumulative impacts on fish, wildlife and plant resources at the project. Results from this study may be used to directly inform the evaluation of project effects on related resources, such as a fish and other aquatic species.

Proposed Methodology

Use of temperature loggers to gain information on thermal trends has been a standard technique to look at impacts of water storage associated with hydroelectric projects. We recommend that transects be established in the upper, middle, and lower project impoundment, as well as in the tailrace and downstream project. An additional transect should be established in the free flowing section of river above the impoundment to serve as a "reference site". Inexpensive temperature loggers should be deployed along each transects at a minimum of three locations: at depths of 1 meter subsurface, mid-depth, and 1 meter off the bottom (on buoy lines) where water depths permit. The temperature loggers should be deployed from April 1 – November 15 and be set to record temperature at 15 minute intervals. The temperature loggers should be checked and the data downloaded on the monthly basis. The data from the loggers should then be used to develop hourly/daily aquatic isotherm maps, and temperature change and distribution as a result of project and cumulative impacts should be assessed.

Level of Effort and Cost

The effort and cost of this study is expected to be moderate to high, but the potential project specific and cumulative thermal alteration impacts have never been studied in a comprehensive

manner and their potential impacts to aquatic habitat and fish, wildlife, and resources has not been adequately studied.

Literature Cited

Diana, J.S. 2004. Biology and Ecology of Fishes. 2nd edition. Biological Sciences Press.

Bellows Falls Hydroelectric Project – FERC No. 1855-045

Study Request 3: Continuous water temperature monitoring at various locations within the impoundment and tailrace, and downstream Connecticut River

Goals and Objectives

The goal of this study is to determine the potential impacts (both project specific and cumulative) of the Bellows Falls Hydroelectric Project operations on hourly/daily temperature fluctuations and spatial thermal distribution within the Bellows Falls Hydroelectric Project Impoundment and Tailrace**,** and the Connecticut River downstream of the Bellows Falls Dam.

The objectives of this study are to:

1. Obtain continuous temperature data (every 15 minutes) at various locations and depths throughout the project impoundment, tailrace, and downstream Connecticut River using temperature loggers.

2. Analyze data for hourly/daily shifts in temperature regime and thermal distribution (aquatic isotherm maps) associated project specific and cumulative impacts associated with project operations.

3. Determine if any shifts in hourly temperature regime or thermal distribution are impacting aquatic habitat within the project impoundment and tailrace and lower Connecticut River (e.g., thermal blocks to migration, thermal stress, habitat degradation).

Resource Management Goals

Temperature is an important habitat consideration for many aquatic species including migratory fish and rare, threatened, endangered species. Temperature influences the distribution, behavior, metabolism, growth, reproduction, and survival of fishes (Diana 2004). The Connecticut River is considered a Class B waters cold water fish habitat. Vermont Water Quality Standards state that Class B waters should be managed to achieve and maintain a level of quality that fully supports aquatic biota and habitat. Additionally the Vermont Water Quality Standards states that in Class B cold water fish habitat, the total increase in from any activity or discharge should not result in a temperature increase that exceeds 1.0°F.

Public Interest Consideration

The requestor is a state natural resource agency.

Existing Information

The PAD provides limited information on impacts of project operations (“daily run-of-river”) on temperature in the project impoundment, tailrace or lower Connecticut River. Hourly/daily temperature shifts associated with project operations at Bellows Falls Dam can impact aquatic habitat rendering it unsuitable for some organisms. The information in the PAD does not define the spatial extent of temperatures (aquatic isotherm map) within the impoundment, lower Connecticut River. The PAD mainly indicates that in general, temperature did increase from

upstream to downstream while dissolved oxygen decreased, reflecting the impacts of the impoundment.

Project Nexus

The project impounds 26 miles of river that would otherwise be free flowing. It currently operates in a peaking mode, with allowable impoundment fluctuations of up to 3 feet, with proposals to continue as such. The below-project flow requirement is equal to 0.20 csm (1083 cfs). Water quality can be affected by the operating mode of a hydropower project. The PAD provides limited information on how project operations affect water quality within the project impoundment, bypass reach and tailrace. Water temperature can be affected by the operating mode of a hydropower project. The impounded water increases the water surface area of the river reach containing the project. The increased surface acts as a larger solar radiation collector and the thermal mass of the impounded water acts a heat sink storing heat from solar radiation. At night the increased surface area may act as convective radiator that releases heat. Together these attributes may contribute to unnatural thermal properties in the project impoundment that may impact natural temperature regime and influence habitat conditions for fish, wildlife and plant resources (temperature tolerance, life cycle timing (e.g., reproduction or migration), and food availability).

The project discharges regulated Connecticut River flows ("daily run-of-river") from the impoundment to the downstream seventeen mile reach of the Connecticut River. The project can sporadically release large volumes of impoundment water that may be of a different temperature than the receiving water downstream of the dam. Unnatural and rapid shifts in temperature regimes in the downstream water can impact fish, wildlife and plant resources and instream habitat. The Agency requests that more recent temperature data is collected in a more intensive, systematic and scientific manner in order to assess project specific and cumulative impacts on fish, wildlife and plant resources at the project. Results from this study may be used to directly inform the evaluation of project effects on related resources, such as a fish and other aquatic species.

Proposed Methodology

Use of temperature loggers to gain information on thermal trends has been a standard technique to look at impacts of water storage associated with hydroelectric projects. We recommend that transects be established in the upper, middle, and lower project impoundment, as well as in the tailrace and downstream project. An additional transect should be established in the free flowing section of river above the impoundment to serve as a "reference site". Inexpensive temperature loggers should be deployed along each transects at a minimum of three locations: at depths of 1 meter subsurface, mid-depth, and 1 meter off the bottom (on buoy lines) where water depths permit. The temperature loggers should be deployed from April 1 – November 15 and be set to record temperature at 15 minute intervals. The temperature loggers should be checked and the data downloaded on the monthly basis. The data from the loggers should then be used to develop hourly/daily aquatic isotherm maps, and temperature change and distribution as a result of project and cumulative impacts should be assessed.

Level of Effort and Cost

The effort and cost of this study is expected to be moderate to high, but the potential project specific and cumulative thermal alteration impacts have never been studied in a comprehensive manner and their potential impacts to aquatic habitat and fish, wildlife, and resources has not been adequately studied.

Literature Cited

Diana, J.S. 2004. Biology and Ecology of Fishes. 2nd edition. Biological Sciences Press.

Vernon Hydroelectric Project – FERC No. 1904-073

Study Request 3: Continuous water temperature monitoring at various locations within the impoundment and tailrace, and downstream Connecticut River

Goals and Objectives

The goal of this study is to determine the potential impacts (both project specific and cumulative) of the Vernon Hydroelectric Project operations on hourly/daily temperature fluctuations and spatial thermal distribution within the Vernon Hydroelectric Project Impoundment and Tailrace**,** and the Connecticut River downstream of the Vernon Dam to the Massachusetts line.

The objectives of this study are to:

1. Obtain continuous temperature data (every 15 minutes) at various locations and depths throughout the project impoundment, tailrace, and downstream Connecticut River using temperature loggers.

2. Analyze data for hourly/daily shifts in temperature regime and thermal distribution (aquatic isotherm maps) associated project specific and cumulative impacts associated with project operations.

3. Determine if any shifts in hourly temperature regime or thermal distribution are impacting aquatic habitat within the project impoundment and tailrace and lower Connecticut River (e.g., thermal blocks to migration, thermal stress, habitat degradation).

Resource Management Goals

Temperature is an important habitat consideration for many aquatic species including migratory fish and rare, threatened, endangered species. Temperature influences the distribution, behavior, metabolism, growth, reproduction, and survival of fishes (Diana 2004). The Connecticut River is considered a Class B waters cold water fish habitat. Vermont Water Quality Standards state that Class B waters should be managed to achieve and maintain a level of quality that fully supports aquatic biota and habitat. Additionally the Vermont Water Quality Standards states that in Class B cold water fish habitat, the total increase in from any activity or discharge should not result in a temperature increase that exceeds 1.0°F.

Public Interest Consideration

The requestor is a state natural resource agency.

Existing Information

The PAD provides limited information on impacts of project operations (“daily run-of-river”) on temperature in the project impoundment, tailrace or lower Connecticut River. Hourly/daily temperature shifts associated with project operations at Vernon Dam can impact aquatic habitat rendering it unsuitable for some organisms. The information in the PAD does not define the spatial extent of temperatures (aquatic isotherm map) within the impoundment, lower Connecticut River. The PAD mainly indicates that in general, temperature did increase from

upstream to downstream while dissolved oxygen decreased, reflecting the impacts of the impoundment.

Project Nexus

The project impounds 26 miles of river that would otherwise be natural free-flowing. It currently operates in a peaking mode, with allowable impoundment fluctuations of up to 8 feet, with proposals to continue as such. The below-project flow requirement is equal to 0.20 csm (1250 cfs). Water temperature can be affected by the operating mode of a hydropower project. The impounded water increases the water surface area of the river reach containing the project. The increased surface acts as a larger solar radiation collector and the thermal mass of the impounded water acts a heat sink storing heat from solar radiation. At night the increased surface area may act as convective radiator that releases heat. Together these attributes may contribute to unnatural thermal properties in the project impoundment that may impact natural temperature regime and influence habitat conditions for fish, wildlife and plant resources (temperature tolerance, life cycle timing (e.g., reproduction or migration), and food availability).

The project discharges regulated Connecticut River flows ("daily run-of-river") from the impoundment to the downstream seventeen mile reach of the Connecticut River. The project can sporadically release large volumes of impoundment water that may be of a different temperature than the receiving water downstream of the dam. Unnatural and rapid shifts in temperature regimes in the downstream water can impact fish, wildlife and plant resources and instream habitat. The Agency requests that more recent temperature data is collected in a more intensive, systematic and scientific manner is needed to assess project specific and cumulative impacts on fish, wildlife and plant resources at the project. Results from this study may be used to directly inform the evaluation of project effects on related resources, such as a fish and other aquatic species.

Proposed Methodology

Use of temperature loggers to gain information on thermal trends has been a standard technique to look at impacts of water storage associated with hydroelectric projects. We recommend that transects be established in the upper, middle, and lower project impoundment, as well as in the tailrace and downstream project. An additional transect should be established in the free flowing section of river above the impoundment to serve as a "reference site". Inexpensive temperature loggers should be deployed along each transects at a minimum of three locations: at depths of 1 meter subsurface, mid-depth, and 1 meter off the bottom (on buoy lines) where water depths permit. The temperature loggers should be deployed from April 1 – November 15 and be set to record temperature at 15 minute intervals. The temperature loggers should be checked and the data downloaded on the monthly basis. The data from the loggers should then be used to develop hourly/daily aquatic isotherm maps, and temperature change and distribution as a result of project and cumulative impacts should be assessed.

Level of Effort and Cost

The effort and cost of this study is expected to be moderate to high, but the potential project specific and cumulative thermal alteration impacts have never been studied in a comprehensive

manner and their potential impacts to aquatic habitat and fish, wildlife, and resources has not been adequately studied.

Literature Cited

Diana, J.S. 2004. Biology and Ecology of Fishes. 2nd edition. Biological Sciences Press.

Wilder Hydroelectric Project – FERC No. 1892-026
Bellows Falls Hydroelectric Project – FERC No. 1855-045
Vernon Hydroelectric Project – FERC No. 1904-073

Study Request 4: Model river flows and water levels upstream and downstream from the Wilder, Bellows Falls and Vernon stations and integration of project modeling with downstream project operations

Goals and Objectives

The goal of this study is to develop river flow models that permit the evaluation of the hydrologic changes to the river caused by the physical presence and operation of the Wilder, Bellows Falls, and Vernon Hydroelectric Projects and the interrelationships between the operation of all five hydroelectric projects up for relicensing and river inflows. Specific objectives of this study include:

1. Conduct quantitative hydrologic modeling of the hydrologic influences and interactions that exist between the water surface elevations of the Wilder, Bellows Falls, and Vernon project impoundments and discharges from the Wilder, Bellows Falls, and Vernon projects and the downstream hydroelectric projects including:
    a. Inflows into the Wilder, Bellows Falls, and Vernon impoundments from the Fifteen Mile Falls Project, FERC No. 2007, and other sources;
    b. Existing and potential discharges from the Wilder, Bellows Falls, and Vernon project generating facilities and spill flows, including existing and potential minimum flow and other operational requirements;
    c. Existing and potential water level fluctuation restrictions (maximum and minimum pond levels) of the Wilder, Bellows Falls, and Vernon impoundments, and consequent changes in downstream project discharges; and
    d. Incorporation of the potential effects of climate-altered flows on project operations over the course of the license.
2. Assess how existing and potential operations of the Wilder, Bellows Falls, and Vernon projects affect the operations of the Northfield Mountain and Turners Falls Projects, including:
    a. How Wilder, Bellows Falls, and Vernon flow fluctuations affect pool levels of the Turners Falls impoundment; and
    b. How operations of the Wilder, Bellows Falls, and Vernon projects affect Turners Falls discharges.

Resource Management Goals

The Agency's goals related to aquatic natural resources are to:

1. Protect, enhance, or restore, diverse high quality habitat necessary to sustain healthy aquatic and riparian plant and animal communities.
2. Provide an instream flow regime that meets the life history requirements of resident fish and wildlife (including invertebrates such as freshwater mussels) throughout the area impacted by Project operations.

3. Minimize the potential negative effects of project operation on water quality and aquatic habitat, and mitigate for loss or degradation.

The Connecticut River is considered Class B water by the states of Vermont. Vermont lists the section of the Connecticut River below the Wilder dam to Massachusetts line on the Section 303(d) impaired water list due to flow alterations impairing aquatic life and habitat. In Class B waters, Vermont's water quality standards state that water level fluctuation and flow alterations can only occur to the extent that it supports all uses and does not lead to degradation of the water resource or habitat.

Our study requests are intended to facilitate the collection of information necessary to conduct effects analyses and to develop reasonable and prudent conservation measures, and protection, mitigation, and enhancement measures under the Vermont Water Quality Standards.

Public Interest Consideration
The requestor is a state natural resource agency.

Existing Information
Available information in the PAD does not indicate how project operations have altered the hydrology downstream from each of these facilities, which may affect resident and migratory fish, macroinvertebrates, rare, threatened and endangered species, aquatic plants and other biota and natural processes in the Connecticut River. It is also unclear how operations at one facility affect the operations at another.

Project Nexus
The Wilder, Bellows Falls, and Vernon projects are each currently operated with required minimum flows of 675, 1,083, and 1,250 cfs (or inflows if less) for each facility, respectively, though in practice minimum flows are operated as 700, 1300, and 1600 cfs, respectively. There is presently no required minimum flow for the bypassed reach of the Bellows Falls Project. Each of the projects operates as a daily peaking facility, such that "Generation can vary during the course of any day between the required minimum flow and full capacity if higher flows are available" (p. 2-28, p. 2-29, and p. 2-30 in the Wilder, Bellows Falls and Vernon PADs, respectively). Total hydraulic capacity of each facility is 12,700, 11,010, and 12,634 cfs, respectively. Regular daily fluctuations on the order of 9,000 cfs or greater are commonly recorded at USGS gages 01144500 (Connecticut River at West Lebanon, below Wilder Dam) and 01154500 (Connecticut River at North Walpole, NH, below Bellows Falls Dam). Daily fluctuations in headpond elevation are approximately 2.5' (382' to 384.5' MSL), 1.2' (289.9' to 291.1' MSL), and 1.2' (218.6' to 219.8' MSL) at the Wilder, Bellows Falls, and Vernon impoundments, respectively.

These described changes affect biotic habitat and biota upstream and downstream of each project. Project operations and potential changes to operations to mitigate impacts at each facility are influenced by inflows and operations of upstream projects. Results of river flow analyses will provide necessary information regarding changes that can be made to the Wilder, Bellows Falls, and Vernon Project flow releases and/or water level restrictions, how such

changes may be constrained by inflows and upstream project operations, and how these changes potentially affect downstream resources. This information will then be used to develop flow-related license requirements and/or other mitigation measures.

Proposed Methodology

River hydrology statistics and hourly flow modeling are commonly employed at hydroelectric projects to assess implications of project operations on the river environment.

Level of Effort and Cost

Level of effort and cost of model development are expected to be moderate as much of the baseline modeling has already been completed, but running of various scenarios through the model(s) will be needed throughout the relicensing process to assess the implications of changes to the operations of each project on other projects and other resources. The modeling exercise will also require coordination and cooperation between TransCanada and the downstream licensee to assure that the model inputs and outputs can be accurately related.

We would anticipate that the expected level of effort and anticipated costs will be comparable to that experienced on similar FERC relicensing projects of this size (e.g., Conowingo, FERC No. 405).

Wilder Hydroelectric Project – FERC No. 1892-026
Bellows Falls Hydroelectric Project – FERC No. 1855-045
Vernon Hydroelectric Project – FERC No. 1904-073

Study Request 5: Climate change as it relates to continued operation of the Vernon, Bellows Falls and Wilder projects

Goals and Objectives

The goal of this study is to determine how climate change relates to the continued operation of the Vernon, Bellows Falls, and Wilder projects.

The objectives of this study are:

1. Quantify the amount of thermal loading contributed by each respective impoundment
2. Using climate change prediction models, calculate how much warmer the project impoundments are projected to get in the next 30-50 years.
3. Model the effect of various project modifications on river temperature under current conditions and climate change predictions (e.g., converting to run-of-river, deep-water releases, dam removal, large-scale riparian revegetation, etc.).
4. Using climate change prediction models, determine if the projects actually provide an environmental benefit with respect to mitigating against climate change impacts (warming of air and water temperatures) by producing low greenhouse gas emitting energy.
5. Determine how climate change predictions will impact management of high flow events at the three projects and evaluate if changes to dam structures would mitigate adverse impacts of the existing flood management protocols.

Resource Management Goals

The Agency's goals related to aquatic natural resources are to:

1. Protect, enhance, or restore, diverse high quality habitat necessary to sustain healthy aquatic and riparian plant and animal communities.
2. Provide an instream flow regime that meets the life history requirements of resident fish and wildlife (including invertebrates such as freshwater mussels) throughout the area impacted by Project operations.
3. Minimize the potential negative effects of project operation on water quality and aquatic habitat, and mitigate for loss or degradation.

The Connecticut River is classified by the State of Vermont as Class B cold water fish habitat. Vermont Water Quality Standards state that Class B waters should be managed to achieve and maintain a level of quality that fully supports aquatic biota and habitat. Furthermore, the Vermont Fish and Wildlife Department's mission is "the conservation of all species of fish, wildlife, and plants and their habitats for the people of Vermont" (Kart et al. 2005).

Two of the Department's planning goals are:

1. Conserve, enhance, and restore Vermont's natural communities, habitats, and species and the ecological processes that sustain them.

2. Provide a diversity of fish- and wildlife-based activities and opportunities that allow the safe and ethical viewing, regulated harvesting, and utilization of fish, plant and wildlife resources consistent with the North American model of fish and wildlife conservation.

Specific to climate change, Executive Order 11-05 by the Governor established the Climate Cabinet to provide coordinated leadership in the states effort to adapt to climate change.
The Agency goals as it relates to climate change initiatives are:

1. Improve our understanding on the effects of climate change in Vermont on natural resources and ecosystem services.
2. Identify adaptation strategies that could be used to protect Vermonter's, their property, and the state's natural resources and ecosystem services they provide.

Our study requests are intended to facilitate the collection of information necessary to conduct effects analyses and to develop reasonable and prudent conservation measures, and protection, mitigation, and enhancement measures pursuant to the Agency goals.

Public Interest Consideration

The requester is a resource agency.

Existing Information

The PADs contains no information relative to climate change and how climate change predictions may impact future operation of the hydroelectric plants, nor of how the projects either mitigate for or exacerbate predicted climate change impacts to freshwater ecosystems.

TransCanada's PADs provide a summary of water quality data collected in 2012. Table 1 below is a synthesis of the temperature data collected by TransCanada. It should be noted that the upper and mid-impoundment stations at each project represent the average of temperature readings taken over the entire water column, while the continuous loggers (Lower Cont. and TR) were located near the water surface. These data indicate that from the upstream end of the Wilder headpond to the Vernon tailrace, water temperature increased approximately 6°C.

Table 1. Median water temperature at monitoring stations located within the impoundments and tailraces of the three hydropower projects.

	Median Water Temperature °C			
Project	Upper Imp.	Mid-Imp.	Lower Cont.	TR
Wilder	20.86	21.83	24.08	23.59
BF	22.43	23.67	24.86	24.38
Vernon	23.81	24.49	26.73	26.35

Relative to existing flood management protocols at each station, TransCanada's PADs identify that all three dams utilize stanchion bays (two at Vernon, three at Bellows Falls, and four at Wilder). When inflows to each dam reach certain levels, the stanchion bays are removed, and

cannot be replaced until inflows subside. The depth of these bays and the flows they are removed at are outlined in Table 2, below.

Table 2. Summary of pertinent stanchion bay Information for the Vernon, Bellows Falls, and Wilder projects.

Project	Stanchion Height (feet)	Flow Triggering Complete Stanchion Removal
Wilder	17	145,000 cfs
BF	13	50,000 cfs
Vernon	10	105,000 cfs

The PADs provide no information on the history of stanchion removal at any of the projects (frequency, duration, timing), nor a discussion of how predicted climate change might alter management of the stanchion bays in the future (with respect to the frequency and seasonality of occurrence). There also is no discussion of potential impacts to headpond resources that occurs as a result of stanchion bay removal. These information gaps need to be filled so resource agencies can assess the relative and cumulative impact of project operations with respect to the Agency's management goals and objectives.

Data provided by the National Oceanic and Atmospheric Administration, Climate Data Center, illustrates long-term increasing air temperatures in the Northeast (Figure 1). Long-term, monthly mean water temperature data for the Vernon Dam impoundment, monitored by Vermont Yankee, has shown significant differences over time (ANOVA analyses, $P < 0.05$) that when plotted and further analyzed by linear regression, show a significant increasing trend for the period 1974 – 2011 for the months of January, September, and October (Figure 2). These analyses were performed with data from Vermont Yankee, analyzed by the Massachusetts Department of Environmental Protection.

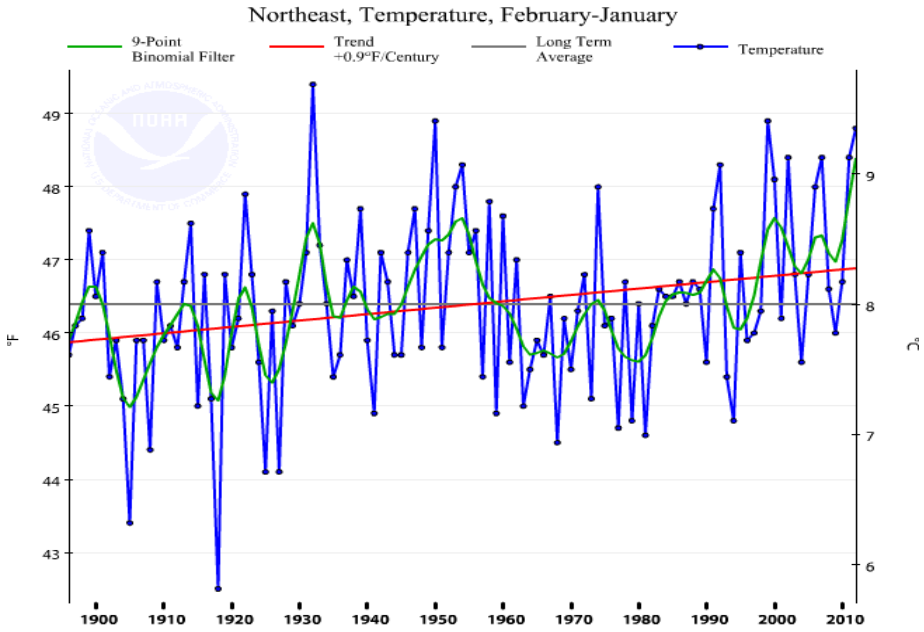


Figure 1. NOAA National Climate Data Center, Northeast 12-month average temperature for the period 1896 through 2012 (October).

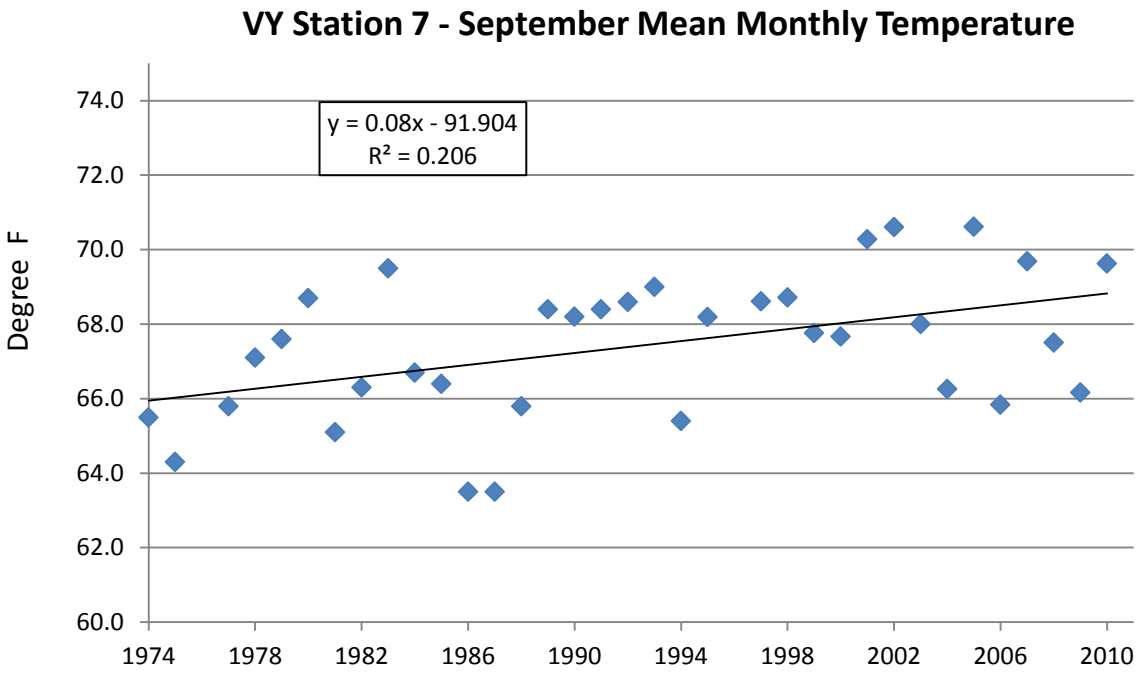


Figure 2. A plot of September's mean temperatures for Vermont Yankees' Station 7 (excludes outlier 1996 data point) for the period 1974 through 2011.

Project Nexus

The three mainstem projects have very long impoundments capable of storing large volumes of water (Table 3, below). These impoundments effectively have converted large portions of the Connecticut River into a series of in-river "lakes." Because water velocities slow in these impounded sections of river, it allows for increased thermal loading and resultant higher water surface temperatures than in free-flowing sections of river.

Table 3. Relevant characteristics of the reservoirs behind the Wilder, Bellows Falls, and Vernon.

Project	Headpond Length (miles)	Gross Storage Volume (acre-ft.)	Average Depth (ft.)	Surface Area (acres)	Flushing Rate (days)
Wilder	45	34,350	11	3,100	3
BF	26	26,900	10	2,804	<2
Vernon	26	40,000	16	2,550	2

Depending on where the hydropower intakes withdraw water, these warmer surface waters may be discharged downstream, raising the temperature of those waters as well (the data in Table 1 above suggest that the projects do draw water from the upper levels of the reservoirs). This effect may be felt for miles downstream. If there are a series of impoundments (like on the Connecticut River), the cumulative impact is an overall warming of the river. Even small run-of-river dams have been shown to elevate downstream water temperature (Lessard and Hayes 2003; Saila et al. 2005). The most recent climate change prediction models specific to the northeast forecast warmer air temperatures, more frequent high precipitation events, more heat waves, and an increase in the incidence of short term droughts (Karl et al. 2009).

Resource concerns related to this project effect include the potential impacts to populations (reductions in abundance, structure, condition) or loss of species not tolerant of increases in temperature and other effects related to physiology such as energetic costs with warmer temperatures (Leggett 2004). As one example, American shad restoration target numbers for fish passage at mainstem dams into upstream historic habitat could be negatively impacted from artificially increased water temperatures. Water temperature has been identified as a factor in the timing (i.e., duration) of this species migration, as well as its role in gonad development and spawning (Glebe and Leggett 1981; Leggett 2004). These factors can be logical reasoned to potentially result in accelerated rates of energy reserve use and a reduced migration window, possibly reducing the ability of fish to reach up-river habitats and further reducing the ability to survive downstream outmigration.

With respect to project operations during high flow events, all TransCanada projects have stanchion bays that are used to manage water during high flow events. Each time these stanchion bays are removed, the headponds are lowered substantially (from 10 to 17 feet, depending on the project) and must remain lowered until inflows subside. Depending on the timing and duration of these deep drawdowns, headpond resources could be negatively impacted.

All of the dams also contain other mechanisms for managing flows, such as Tainter gates, sluice gates, roller gates, skimmer gates and hydraulic flood gates. All of these gates have an advantage over stanchion bays in that they do not require flows to subside significantly before they can be closed to return impoundment levels back to normal. One climate change prediction for the northeast is that we will see more frequent high precipitation events which will result in high flow conditions on rivers. Therefore, it is likely that the stanchion bay removal protocol will have to be employed more frequently in the future.

Proposed Methodology

1. In order to quantify the amount of thermal loading contributed by each respective impoundment, detailed bathymetry will need to be collected. This bathymetry, combined with storage volume, tributary hydrology, and project operations, should be used to calculate the thermal loading of each headpond. The individual and cumulative increase in surface water temperature due to the impoundments should then be used to predict future warming based on climate change models.

2. Analyze different mitigation strategies to understand which have the greatest benefit in terms of building resilience against the impacts of climate change on water temperature. Potential scenarios to analyze include converting the projects to run-of-river, implementing deep-water releases, removing one or more dams, conducting large-scale riparian revegetation, etc.).

3. Input to climate change models the amount of GHG emissions that would be generated if fossil fuel plants were producing the equivalent amount of net energy as the three hydropower projects to determine the impact on air and surface water temperatures.

4. Climate change prediction model output should be assessed to determine if the frequency and timing of high flow events is likely to change in the future. If high flow events that necessitate initiating the stanchion bay removal protocol are predicted to increase in frequency and/or shift in timing, the applicant should evaluate structural and/or operational alternatives that would mitigate adverse impacts of the existing flood management protocols.

Level of Effort and Cost

The level of cost and effort for the thermal loading analysis would be low to moderate. Collecting bathymetry in the three TransCanada headponds would take two staff less than one week to collect (it took the Kansas Biological Survey two days to collect bathymetry at a 3,500 acre lake; Jakubauskas et al. 2011). The remaining work would be desk-based; loading relevant information into an appropriate thermal loading model to compute the estimated thermal loading of each headpond and then comparing this information to surface water data from climate change prediction models.

The high flow flood protocol study is a desktop analysis that should require low cost and effort. Climate change models already exist and that output would be downloaded and analyzed. The remaining analysis requires a review of alternative means of managing flows without the use of stanchion bays.

The applicant did not propose any studies to meet this need in the PAD.

Literature Cited

Glebe, B. D. and W. C. Leggett. 1981. Latitudinal differences in energy allocation and use during the freshwater migration of American shad and their life history consequences. Canadian Journal of Fisheries and Aquatic Sciences 38, 806-820

Jakubauskas, M., J. deNoyelles, E. A. Martinko. 2011. Bathymetric and Sediment Survey of Elk City Reservoir, Montgomery County, Kansas. Applied Science and Technology for Reservoir Assessment (ASTRA) Program, Lawrence, KS. Report No. 2010-01

Karl, T.R., Melillo, J.M., and T.C. Peterson. 2009. Global Climate Change Impacts in the United States. Cambridge University Press.

Leggett, W. C. 2004. The American shad, with special reference to its migration and population dynamics in the Connecticut River. Pages 181-238 in P. M. Jacobson, D. A. Dixon, W.C. Leggett, B.C. Marcy, Jr., and R.R. Massengill, editors. The Connecticut River Ecological Study (1965-1973) revisited: ecology of the lower Connecticut River 1973-2003. American Fisheries Society. Monograph 9, Bethesda, MD.

Lessard, J.L. and D.B. Hayes. 2003. Effects of elevated water temperature on fish and macroinvertebrate communities below small dams. River Research and Applications.

Saila, S.B., Poyer, D., and D. Aube. 2005. Small dams and habitat quality in low order streams. Wood-Pawcatuck Watershed Association. April 29, 2005. 16 pp.

Stier, D. J. and J. H. Crance. 1985. Habitat suitability index models and instream flow suitability curves: American shad. U. S. Fish and Wildlife Service Biological Report No. 82 (10.88), Washington D.C.

Bellows Falls Hydroelectric Project – FERC No. 1855-045

Study Request 6: Bypass flow and habitat

Goals and Objectives

The goal of this study is to determine appropriate bypass flows meet Vermont surface water quality standards and that will protect and enhance the aquatic resources of the Bellows Falls bypass reach.

The objective of the study will be to evaluate the relationship between flow and habitat suitability in the bypass reach and evaluate the impacts of the "barrier dam" in the downstream portion of the bypass reach.

Resource Management Goals

The Connecticut River is considered Class B water by the states of Vermont. Vermont lists the section of the Connecticut River below the Wilder dam on the Section 303(d) impaired water list due to flow alterations impairing aquatic life and habitat. In Class B waters, Vermont's water quality standards state that water level fluctuation and flow alterations can only occur to the extent that it supports all uses and does not lead to degradation of the water resource or habitat.

The Agency's goals related to aquatic natural resources are to:

4. Protect, enhance, or restore, diverse high quality habitat necessary to sustain healthy aquatic and riparian plant and animal communities.
5. Provide an instream flow regime that meets the life history requirements of resident fish and wildlife (including invertebrates such as freshwater mussels) throughout the area impacted by Project operations.
6. Minimize the potential negative effects of project operation on water quality and aquatic habitat, and mitigate for loss or degradation.

Specific to aquatic resources within the Bellows Falls bypass reach, the Agency's goals are:

1. Protect, enhance, or restore, diverse high quality aquatic and riparian habitats for plants, animals, food webs, and communities in the watershed and mitigate for loss or degradation of these habitats.
2. Provide appropriate flows in the bypass reach that meets the life history requirements of resident fish and wildlife, including freshwater mussels and other benthic invertebrates.
3. Minimize current and potential negative project operation effects on water quality and aquatic habitat.

Our study requests are intended to facilitate the collection of information necessary to conduct effects analyses and to develop reasonable and prudent conservation measures, and protection, mitigation, and enhancement measures under the Vermont Water Quality Standards.

Public Interest Consideration

The requester is a resource agency.

Existing Information

The Bellows Falls Project bypasses a 3,500 foot-long section of the Connecticut River. There is a small concreter barrier dam in the lower portion of the bypass reach which was installed to "prevent upstream migrating fish from being attracted by spillway discharge into the reach and later becoming trapped in isolated pools after the spill ends." Presently this bypass reach only receives flow when inflow exceeds the hydraulic capacity of the Bellow Falls station. According to exceedance curves provided in the PAD, on a monthly basis the bypass reach receives flow the following amount of time:

Month	**% time flow > 11,000 cfs**	**Month**	**% Time Flow >11,000 cfs**
Jan.	15	July	10
Feb.	15	August	8
March	50	Sept.	4
April	90	Oct.	20
May	60	Nov.	35
June	20	Dec.	26

No information exists on the adequacy of the existing bypass flow regime to protect water quality and aquatic life. The bypass reach receives flow less than 30% of the time on an annual basis. While TransCanada did conduct a preliminary water quality study in the summer of 2012 that indicated water quality at the bypass reach sample station was not meeting state water quality standards, only a summary of the data are provided in the PAD. It does not indicate where the sonde was located, nor the bypass reach conditions during the study period (e.g., what was the flow into the bypass reach during the study? Was the sonde located in the only wetted area of the bypass reach?). Further, the PAD provides no detailed description of the physical or biological characteristics of the bypass reach.

An empirical study is needed to provide information on the relationship between flow and habitat in the bypass reach for the Agency to use in determining appropriate flows in the bypass reach.

Project Nexus

The Project includes a 3,500-foot-long bypass reach. Absent a mandated discharge at the dam, this habitat would remain dewatered during those times when inflow was within the hydraulic capacity of the units (~70% of the time on an annual basis). The existing license does not require any flow through the bypass reach. The current situation does not sufficiently protect the aquatic resources inhabiting or potentially inhabiting the bypass reach.

The Connecticut River in the project vicinity is dominated by sections that are impounded, backwatered from downstream impoundments or otherwise deep and slow-flowing. In contrast, the Bellows Falls bypass channel is very irregular and diverse, consisting of both coarse substrate of various sizes and in the more downstream segment, jagged, irregular ledge. Given an adequate flow regime, the bypass could provide habitat types that are now rare and therefore of great importance.

Results of the flow study will be used by the Agency to determine an appropriate flow recommendation that will protect and/or enhance the aquatic resources in the bypass reach for the duration of any new license issued by the Commission.

Proposed methodology

The Agency requests a bypass flow study be conducted at the Project. Bypass flow habitat assessments are commonly employed in developing flow release protocols that will reduce impacts or enhance habitat conditions in reaches of river bypassed by hydroelectric projects.

Given the size of the bypass reach (3,500 feet long) and the rareness of the habitat types it contains in this portion of the Connecticut River, we believe a study methodology that utilizes an IFIM approach is appropriate for this site. This same protocol was used during the relicensing of the Housatonic River Project (FERC No. 2576),[1] and has been accepted by the Commission in other licensing proceedings[2].

Given the unique channel formation habitat modeling using standard PHABSIM 1-dimensional modeling may not be sufficient to assess the habitat suitability in the bypass reach but rather 2-dimensional, (2D) modeling may be needed to better characterize flows and velocities in this reach. We recommend that the approach to habitat modeling be determined during the study plan development stage based on consultations between the applicant and the resource agencies.

Level of effort and cost

The expected level of effort and anticipated costs will be comparable to that experienced on similar FERC relicensing projects of this size.

Field work for flow studies can be reasonably extensive but will depend on consultation with the applicant on study methodology and on-site decisions on locations for data collection and the number of collection locations. Post-fieldwork data analysis would be a moderate cost and effort. Field work associated with this study could be done in conjunction with the Instream Flow Study Request. We anticipate that the level of effort and costs will be comparable to that experienced on similar FERC relicensing projects (e.g., the Glendale Project, FERC No. 2801).

[1] Housatonic River Project License Application, Volume 4, Appendix F. Connecticut Light and Power Company, August 1999.

[2] Glendale Project (FERC No. 2801) Final Bypass Reach Aquatic Habitat and Instream Flow Study in Glendale Hydroelectric Project Application for Subsequent License (FERC No. 2801), Volume 2, Appendix B, pages 7-8, October 2007.

Wilder Hydroelectric Project – FERC No. 1892-026
Bellows Falls Hydroelectric Project – FERC No. 1855-045
Vernon Hydroelectric Project – FERC No. 1904-073

Study Request 7: In-stream flow habitat assessment of downstream reaches

Goals and Objectives

The goal of this study is to determine an appropriate flow regime that will protect and enhance the aquatic resources below the Wilder, Bellows Falls, and Vernon projects. Specifically, the objective of this study is to conduct an instream flow habitat study to assess the impacts of the range of proposed project discharges on the wetted area and optimal habitat for key species.

The study should include non-steady flow approaches to assess effects of within-day flow fluctuations due to peaking power operations on target fish species and benthic invertebrate communities. Target species will include but are not limited to: American shad, fallfish, white sucker, yellow perch, smallmouth bass, walleye, and dwarf wedge mussel.

Resource Management Goals

The Connecticut River is considered Class B water by the states of Vermont. Vermont lists the section of the Connecticut River below the Wilder dam on the Section 303(d) impaired water list due to flow alterations impairing aquatic life and habitat. In Class B waters, Vermont's water quality standards state that water level fluctuation and flow alterations can only occur to the extent that it supports all uses and does not lead to degradation of the water resource or habitat.

The Agency's goals related to aquatic natural resources are to:

7. Protect, enhance, or restore, diverse high quality habitat necessary to sustain healthy aquatic and riparian plant and animal communities.
8. Provide an instream flow regime that meets the life history requirements of resident fish and wildlife (including invertebrates such as freshwater mussels) throughout the area impacted by Project operations.
9. Minimize the potential negative effects of project operation on water quality and aquatic habitat, and mitigate for loss or degradation.

Our study requests are intended to facilitate the collection of information necessary to conduct effects analyses and to develop reasonable and prudent conservation measures, and protection, mitigation, and enhancement measures under the Vermont Water Quality Standards.

Public Interest Consideration

The requestor is a state natural resource agency.

Existing Information

The distance from the upstream end of the Wilder impoundment downstream to the Vernon dam is 120 miles. A total of 97 miles (81%) of this segment is impounded. The remaining riverine habitat is within the 17 miles downstream of Wilder dam and the 6 miles downstream of Bellows Falls. At the scoping meetings, First Light also indicated that their project assessment may

provide evidence that the upstream extent of the Turners Falls impoundment may not reach all the way to Vernon Dam. This would suggest that there may be additional riverine habitat for a presently unknown distance below the Vernon project.

The Wilder, Bellows Falls, and Vernon projects are each operated as daily peaking facilities. Total hydraulic capacity of each facility is 12,700, 11,010, and 12,634 cfs, respectively. Each of the PADs for these projects indicate that "Generation can vary during the course of any day between the required minimum flow and full capacity if higher flows are available" (p. 2-28, p. 2-29, and p. 2-30 in the Wilder, Bellows Falls and Vernon PADs, respectively). Regular daily fluctuations on the order of 9,000 cfs or greater are commonly recorded at USGS gages 01144500 (Connecticut River at West Lebanon, below Wilder Dam) and 01154500 (Connecticut River at North Walpole, NH, below Bellows Falls Dam). Required minimum flows are 675, 1,083, and 1,250 cfs (or inflows if less) for each facility, respectively, though in practice minimum flows are operated as 700, 1300, and 1600 cfs, respectively. The PADs for these projects do not indicate how these minimum flow requirements were established or what specific ecological resources they are intended to benefit. The Agency is not aware of any previously conducted studies that have evaluated the adequacy of this minimum flow in protecting aquatic resources in the 23+ miles of riverine habitat below these projects, nor project effects of daily hydropeaking on riverine habitat. Therefore, in order to fill this important information gap, an empirical study is needed to provide information on the relationship between flow and habitat in the Connecticut River downstream of the Wilder, Bellows Falls, and Vernon projects. Results will be used by the Agency to determine an appropriate flow recommendation.

Project Nexus

The Wilder, Bellows Falls, and Vernon projects are currently operated with a minimum flow release that was not based on biological criteria or field study. Further, the projects generate power in a peaking mode resulting in substantial within-day flow fluctuations between the minimum and project capacity. The large and rapid changes in flow releases from peaking hydropower dams are known to cause adverse effects on downstream habitat and biota (Cushman 1985, Blinn et al. 1995, Freeman et al. 2001). There are at least 23 miles of lotic (flowing) habitat below the project's discharge that are impacted by peaking operations from these projects. This section of the Connecticut River contains habitat that supports native riverine species, including the federally endangered dwarf wedge mussel, and could include spawning and rearing habitat for migratory fish such as American shad. While the existing licenses of the Wilder, Bellows Falls, and Vernon projects do require a continuous minimum flow of 675, 1,083, and 1,250 cfs, respectively, we do not believe this flow sufficiently protects the aquatic resources, including endangered species, of these river reaches, especially in the context of the magnitude, frequency, and duration of changes in habitat that likely occur due to hydropeaking operations.

Results of the flow study will be used by the Agency to determine an appropriate flow recommendation that will protect and/or enhance the aquatic resources below the Project.

Proposed Methodology

In-stream flow habitat assessments are commonly employed in developing operational flow regimes that will reduce the impacts or enhance habitat conditions downstream of hydroelectric projects.

The Service requests a flow study be conducted in the following areas: in the approximately 17 miles between the Wilder Dam and the headwaters of the Bellows Falls pool, in the approximately 6 miles between the Bellows Falls Dam and the headwaters of the Vernon pool, and in the approximately 1.5 miles between Vernon Dam and the downstream end of Stebbins Island (or the upstream extent of the Turners Pool as determined by First Light, whichever river length is greater).

Given the length of river reach (23+ miles) impacted by project operations, we believe a study methodology that utilizes an IFIM approach is appropriate for this context. Similar protocols have been used and accepted by FERC in numerous other licensing proceedings.

The study design should involve collecting wetted perimeter, depth, velocity, and substrate data along transects in the deep, straight-channel areas of the specified river reaches mentioned above. Two-dimensional hydraulic modeling should be conducted in the sections of river with more complex features such as islands, braiding, falls, and shallow-water shoals. The measurements should be taken over a range of flows sufficient to model the full extent of the operational flow regime. This information should then be synthesized to quantify habitat suitability (using mutually agreed-upon habitat suitability index (HSI) curves) over a range of flows for target species identified by the fisheries agencies. Data should be collected in such a way that allows a dual-flow analysis and habitat time series or similar approaches that will permit assessment of how quality and location of habitat for target species changes over the range of flows that occur as part of the operational flow regime.

Level of Effort and Cost

Field work for instream flow studies can be reasonably extensive but will depend on consultation with the applicant on study methodology and on-site decisions on locations for data collection and the number of collection locations. Use of laser measurements, GPS, and/or an Acoustic Doppler Current Profiler (ADCP, if available) can improve efficiency and accuracy of field measurements. Post-fieldwork data analysis would be a moderate cost and effort. We anticipate that the level of effort and costs will be comparable to that of other FERC relicensing projects of similar size to these projects.

Literature Cited

Blinn, W., J.P. Shannon, L.E. Stevens, and J.P. Carder. 1995. Consequences of fluctuating discharge for lotic communities. Journal of the North American Benthological Society 14: 233–248.

Cushman, R.M. 1985. Review of ecological effects of rapidly varying flows downstream from hydroelectric facilities. North American Journal of Fisheries Management 5: 330–339.

Freeman, M.C, Z.H. Bowen, K.D. Bovee, and E.R. Irwin. 2001. Flow and habitat effects on juvenile fish abundance in natural and altered flow regimes. Ecological Applications 11: 179–190.

Wilder Hydroelectric Project – FERC No. 1892-026
Bellows Falls Hydroelectric Project – FERC No. 1855-045
Vernon Hydroelectric Project – FERC No. 1904-073

Study Request 8: Project effects on channel morphology and benthic habitat impacts

Goals and Objectives
It is well known that dams interrupt the downstream continuum of sediment supply and transport, which in turn can affect channel morphology and limit the amount of coarse (i.e. gravel/cobble) substrate available for aquatic biota. The Vernon, Bellows Falls and Wilder projects' effects on fluvial processes, channel formation and associated anadromous and riverine fish habitat, as well as aquatic invertebrate habitat, is unclear. This study request aims to provide information on coarse sediment supply and transport as it relates to aquatic benthic habitat (e.g. gravel bars). Results will be used to identify techniques to minimize and/or mitigate impacts to this valuable habitat.

The goal of this study is to understand how the projects affect bedload distribution, particle size and composition as it relates to habitat availability (amount and size of coarse substrate material) for different life-history stages of anadromous (e.g. sea lamprey) and riverine fishes (e.g. walleye), as well as invertebrates (e.g. mussels, tiger beetles).

The study objectives include:

1. Assess the distribution and extent of the existing substrate types, including gravel and cobble bars within the project affected areas.

2. Identify the current conditions of the channel and determine the stability of the present substrate/benthic habitat and identify if flow or sediment measures are necessary to improve the aquatic benthic habitat.

Resource Management Goals
The Connecticut River is classified by the state of Vermont as Class B cold water fish habitat. Vermont Water Quality Standards state that Class B waters should be managed to achieve and maintain a level of quality that fully supports aquatic biota and habitat. Furthermore, the VTFWD's mission is "the conservation of all species of fish, wildlife, and plants and their habitats for the people of Vermont" (Kart et al. 2005).
Two of the Department's planning goals are:

1. Conserve, enhance, and restore Vermont's natural communities, habitats, and species and the ecological processes that sustain them.

2. Provide a diversity of fish- and wildlife-based activities and opportunities that allow the safe and ethical viewing, regulated harvesting, and utilization of fish, plant and wildlife resources consistent with the North American model of fish and wildlife conservation.

Gravel/cobble habitat is utilized by various riverine fish species during different life history stages and seasons, as it provides sites for spawning, feeding, and refuge (Gore and Shields 1995). Many fish species and aquatic invertebrates (e.g., fresh water mussels, snails, worms, and aquatic insects) live on or near gravel habitat, because it provides a source of food and cover (Miller 1988). Gravel bars also play an important role in water quality, hydrology, and morphology of rivers (Lewis 2005).

As identified in Vermont's Wildlife Action plan (Kart et al. 2005), several state listed mussel species are known to utilize gravel-type substrate. Furthermore, sea lamprey (*Petromyzon marinus*) spawning occurs over substrate composed of a mixture of sand, gravel and rubble. The sea lamprey, within the Connecticut River drainage, is one of New Hampshire and Vermont's Species of Greatest Conservation Need (SGCN). The conservation status of sea lamprey in New Hampshire is listed as "vulnerable." One of the threats identified in Vermont's Wildlife Action Plan (Kart et al. 2005) is degraded spawning habitat, which is second to habitat fragmentation. In support of VTFWD's mission, and the Vermont Water Quality Standards, gaining a better understanding of the benthic habitat present in project affected areas how projects operations may be affecting this habitat is important.

Public Interest Consideration

The requestor is a state natural resource agency.

Existing Information

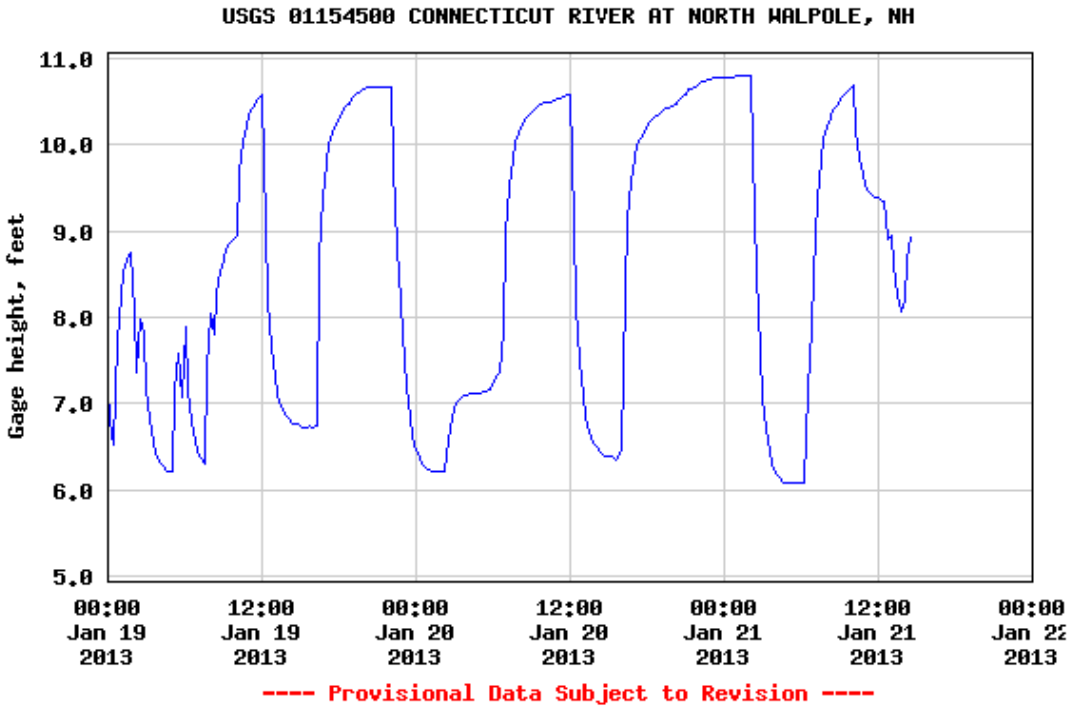
The PAD generally focusses on erosional impacts due to the projects' operations, but lacks specific information on fluvial geomorphic processes and substrate composition as it relates to impacts to aquatic benthic habitat. Recent studies assessing fluvial geomorphic process and substrate composition in Connecticut River tributaries have documented the impacts of regulated flows from dams on substrate composition, and the possible impacts on the mainstem of the river.

Curtis et al. (2010) utilized a combination of historical aerial photographs, mainstem- and tributary-channel pebble counts, and HEC-RAS flow modeling in the West and White River watersheds (tributaries to the Connecticut River). They documented the time series of post-regulation channel narrowing and associated bar growth due to the influx of tributary sediment. In the West River, Svendsen et al. (2009) quantified changes in channel bed morphology as a result of flow regulation. Utilizing bi-monthly cross-section data from the gauging stations they determined the mean water depth and bed elevation for each cross-section measurement during the pre-dam and post-dam periods. In addition, annual peak stream flow data for each station were used to calculate the flood recurrence, and surface grain distributions at sampling sites upstream and downstream of each tributary confluence using Wolman pebble counts. They found that the sediment load from tributaries are impacting the flow-regulated mainstem West River rather than ameliorating conditions, and that these impacts are reflected in the benthic community structure. These results indicate that environmental flows that mimic the natural hydrograph are needed in regulated reaches of river.

Project Nexus

Dams have major impacts on geomorphic processes, ecological function and in turn biotic communities. Changes to substrate composition can significantly affect aquatic life include stability of channel habitats, size distribution and embeddedness of substrate, and decreased habitat diversity and heterogeneity. The projects impound a large portion of the Lower Connecticut River that otherwise would be free flowing and would transport fine sediment downstream leaving larger substrate material (gravel/cobble) exposed to be utilized by aquatic biota. By interrupting the downstream continuum of sediment supply and transport, dams can result in increased bed scour and bank erosion downstream (Kondolf and Matthews 1993). Given the large number of mainstem dams on the Connecticut River, any gravel coming in from tributaries becomes very important to the system. However, many of the tributaries in the project reach have also been dammed, predominantly for flood control. Therefore, there is reason to be concerned about the effects the project dams are having on river processes and physical habitat. Currently, the projects operate as hydro-peaking facilities as is evident from the USGS stream flow gauge at North Walpole, NH; with large water releases below the dam that increase shear stress on the river bed, substrate is mobilized that otherwise would only be moved during seasonal high flow events. Operations of the existing TransCanada hydroelectric projects likely affect channel morphology and fluvial processes including substrate mobility, and particle size distribution. Project-induced changes to natural fluvial processes and channel morphology and substrate composition can have negative impacts on aquatic resources. For example, changes in sediment composition could relocate or decrease important walleye and sea lamprey spawning habitat. In a similar fashion, project-induced changes could make some habitats unsuitable for aquatic invertebrates, including the federally-endangered dwarf wedgemussel. The Vermont Agency of Natural Resources requests a study investigating the impacts of project operations on fluvial processes, substrate composition and stability as it relates to aquatic benthic habitat. Results of this study will be used to develop potential license requirements to protect aquatic habitat in the project-affected areas, and may be used to inform other studies that evaluate project effects on related resources. Possible mitigation measures could include gravel augmentation, changes in flow regulation, and instream channel restoration.

An example of the water level fluctuations that occur in Lower Connecticut River due to hydropower generation is shown below.



Proposed Methodology

Geomorphology studies are generally conducted during hydroelectric relicensing projects to determine channel condition, and substrate composition, and determine whether changes in project operations or sediment measures are necessary and/or whether channel restoration is necessary to improve aquatic benthic habitat.

The Agency recommends a methodology similar to previously approved FERC studies (FERC No. 2246 and 2206). Specific study methods include but are limited to utilizing a combination of historical aerial photographs, pebble counts, and HEC-RAS flow modeling to document and compare temporal changes in morphology and sediment transport dynamics in the Project effected areas.

Additional study methods can be found in the FERC Project No. 2246, Yuba County Water Agencies Study Plan Determination: Study 1.1. Lemonds (2006) also conducted an empirical-based study for the Yadkin-Pee Dee River Hydroelectric Project No. 2206.

The study plan should be developed in consultation with the Agency.

Level of Effort and Cost

At a minimum the study would require a combination of historical aerial photographs, pebble counts, and HEC-RAS flow modeling. Cross-section data from the gauging stations could be used to determine the mean water depth and bed elevation for each cross-section measurement. TransCanada has not proposed any studies to meet this need.

Literature Cited

Curtis, K.E., C.E. Renshaw, F. J. Magilligan, and W.B. Dade. 2010. Temporal and spatial scales of geomorphic adjustments to reduced competency following flow regulation in bedload-dominated systems. Geomorphology. 118: 105–117

Gore, J. A., and F. D. Shields. 1995. Can large rivers be restored? Bioscience 45:142-152.

Kart, J., R. Regan, S.R. Darling, C. Alexander, K. Cox, M. Ferguson, S. Parren, K. Royar, B. Popp, editors. 2005. Vermont's Wildlife Action Plan. Vermont Fish & Wildlife Department. Waterbury, Vermont. http://www.vtfishandwildlife.com/swg_cwcs_report.cfm. (Accessed September 10, 2012).

Kondolf, G.M. and W.V.G. Matthews, 1993. Management of Coarse Sediment on Regulated Rivers. University of California, Water Resources Center, University of California Report No. 80, 123 pp.

Lemonds, R.W. 2006. Delineating River Bottom Substrate using Very High-Resolution Digital Imagery derived from Large Scale Aerial Photography. North Carolina State University Master's Thesis.

Lewis. L. 2005. Arkansas River navigation project mitigation proposal and the Arkansas River conservation initiative. United States Fish and Wildlife Service Concept Paper.

Miller, A. C. 1988. Experimental gravel bar habitat creation in the Tombigbee River Mississippi. U.S. Army Engineer Research and Development Center. Technical Note 07-4.

Svendsen, K.M., C. E. Renshaw, F. J. Magilligan, K. H. Nislow and J. M. Kaste. 2009. Flow and sediment regimes at tributary junctions on a regulated river: impact on sediment residence time and benthic macroinvertebrate communities. Hydrological Processes. 23: 284–296.

Vernon Hydroelectric Project – FERC No. 1904-073

Study Request 9: Juvenile shad outmigration

Goals and Objectives

Determine if project operations affect juvenile American shad outmigration survival, recruitment, and production. The following objectives will address this request:

- Assess project operation effects of Vernon Dam on the timing, routes, migration rates, and survival of juvenile shad;
- Determine the proportion of juvenile shad that as a downstream passage route choose or are directed to existing downstream bypass structures, gate structures, or are entrained into the station turbines and assess delay, survival, timing, and related impacts with these locations under a full range of operational conditions, over the period of outmigration;
- Determine survival rates for juvenile shad entrained into Vernon Station units.

If it is determined that the project operations or related effects are adversely affecting juvenile shad survival, migration timing, or other deleterious population effects are noted, identify operational solutions or other solutions that will reduce and minimize impacts, within the project affected area. This study will require two years of field data to capture inter-annual variability of river discharge, water temperature, and variability in run size and juvenile production (and timing of developmental stages) and variability in outmigration timing which may relate to spring, summer and fall conditions.

Resource Management Goals

The Agency's goals related to aquatic natural resources are to:

1. Protect, enhance, or restore, diverse high quality habitat necessary to sustain healthy aquatic and riparian plant and animal communities.
2. Provide an instream flow regime that meets the life history requirements of resident fish and wildlife (including invertebrates such as freshwater mussels) throughout the area impacted by Project operations.
3. Minimize the potential negative effects of project operation on water quality and aquatic habitat, and mitigate for loss or degradation.

The Connecticut River is classified by the state of Vermont as Class B cold water fish habitat. Vermont Water Quality Standards state that Class B waters should be managed to achieve and maintain a level of quality that fully supports aquatic biota and habitat. Furthermore, the VTFWD's mission is "the conservation of all species of fish, wildlife, and plants and their habitats for the people of Vermont" (Kart et al. 2005).

Two of the Department's planning goals are:

1. Conserve, enhance, and restore Vermont's natural communities, habitats, and species and the ecological processes that sustain them.
2. Provide a diversity of fish- and wildlife-based activities and opportunities that allow the safe and ethical viewing, regulated harvesting, and utilization of fish, plant and wildlife resources consistent with the North American model of fish and wildlife conservation.

Vermont Fish and Wildlife Department's Strategic Plan (2002 -2010) focuses towards four major areas of concern: resource conservation, fish and wildlife-based recreation and use, human health and safety, efficient operations, and effective management.

The Connecticut River Atlantic Salmon Commission (CRASC) was established by Congress in 1983 (and reauthorized in 2002 for another 20 years) through the Connecticut River Atlantic Salmon Compact (Public Law 98-138). The Vermont Fish and Wildlife Department is a CRASC member agency, and a senior biologist from the department serves on the Technical Committee. The Connecticut River Atlantic Salmon Commission developed *A Management Plan for American Shad in the Connecticut River* in 1992. Management Objectives in the plan include the following:

1. Achieve and sustain an adult population of 1.5 to 2 million individuals entering the mouth of the Connecticut River annually.
2. Maximize outmigrant survival for juvenile and spent adult shad.

The Atlantic States Marine Fisheries Commission Amendment 3 to the Interstate Fishery Management Plan for Shad and River Herring (American Shad Management), approved in 2010 includes the following objective:

- Maximize the number of juvenile recruits emigrating from freshwater stock complexes.

The Agency seeks the accomplishment of a number of resource goals and objectives through the relicensing process for the Project. General goals include the following:

1. Ensure that protection, mitigation and enhancement measures are commensurate with Project effects and help meet regional fish and wildlife objectives for the basin.
2. Conserve, protect, and enhance the habitats for fish, wildlife, and plants that continue to be affected by the Project.

Specific to American shad, the Agency's goals are:

- Minimize current and potential negative project operation effects on juvenile American shad survival, production, and recruitment.

Our study requests are intended to facilitate the collection of information necessary to conduct effects analyses and to develop reasonable and prudent conservation measures, and protection, mitigation, and enhancement measures pursuant to the Endangered Species Act of 1973, as amended (16 U.S.C. §1531 *et seq*.), the Fish and Wildlife Coordination Act, as amended (16 U.S.C. §661 *et seq*.), and the Federal Power Act (16 U.S.C. §791a, *et seq*.).

Public Interest Consideration

The requestor is a resource agency.

Existing Information

Adult shad are counted annually as they pass above the Vernon Dam. Juvenile American shad production has been monitored upstream of the Vernon Dam and immediately downstream of

that dam by Vermont Yankee Nuclear as part of an annual monitoring program using both boat electrofishing (since 1991) and beach seining (since 2000). A seasonal average annual index of juvenile American shad standing crop in Vernon reservoir has been calculated since 2000. Estimates of juvenile shad growth rates in the Vernon impoundment have been calculated annually beginning in 2004, and also in a study conducted in 1995 (Smith and Downey 1995).

Although there were numerous studies of downstream passage facilities at the Vernon Project for Atlantic salmon smolts, studies passage studies for American shad were limited to tests in 1991 and 1992 of a high frequency sound field to guide fish to the fish pipe, the primary downstream fishways in 1991 and 1992 (RMC 1993). Although the studies were deemed incomplete, the technology indicated some level of response by juvenile shad. However, despite that conclusion, there is no indication that this technology or other downstream passage studies with juvenile shad were subsequently pursued.

Project Nexus

Juvenile American shad production occurs in the river reach between the Vernon Dam and the Bellows Falls Dam, which is thought to be the historic upstream limit of the shad migration in the Connecticut River. Juvenile American shad require safe and timely downstream passage measures to have the opportunity to contribute to the restoration target population size.

There is little information available regarding the total impact of the Vernon project on downstream migration of juvenile shad. Migration delays, increased predation, mortality during passage over the dam or through turbines, and changes in route selection under different flow conditions are potential influences of the Vernon Dam on the juvenile shad population in the upper Connecticut River. Effective upstream and downstream passage and successful in-river spawning and juvenile production are necessary to help achieve shad management restoration goals for the Connecticut River, particularly in the upstream reaches. Delays in juvenile American shad outmigration may affect survival rates in the transition to the marine environment (Zydlewski et al. 2003).

Proposed Methodology

The impact to juvenile shad outmigrants would be best studied by a combination of approaches including hydroacoustics, radio telemetry (including passive integrated transponder (PIT) telemetry), and turbine balloon tags. Project discharge adjustments at the dam should be examined relative to timing, duration, and magnitude of juvenile shad migration to and through the dam, with hydroacoustic equipment for natural/wild fish information. In addition, study fish should be collected and tagged (PIT, radio, balloon) to then empirically determine rates of survival for fish passed through the project under varied operations, from minimum flows up to full spill conditions. The release of tagged fish (radio, PIT) at a number of potential sites will provide data on delay and route selection as juvenile shad move through the Vernon project area. The number and location of release sites will depend on the availability of tagged fish.

Additional hydroacoustic assessment immediately upstream and downstream of the Vernon Dam will provide information on the timing of migration to and through this area. A more focused survival study, using balloon tags, PIT tags, or other appropriate methods, should be conducted

in the second year based upon the first year of study findings relative to the frequency, magnitude, timing, and route selection of juvenile American shad through the Vernon project.

Level of Effort and Cost

TransCanada does not propose any studies to meet this need. Estimated cost for the study is expected to be up to $150,000 with the majority of costs associated with equipment (hydroacoustic gear, radio tags, radio receivers, and PIT readers) and related fieldwork labor.

Literature Cited

Kart, J., R. Regan, S.R. Darling, C. Alexander, K. Cox, M. Ferguson, S. Parren, K. Royar, B. Popp, editors. 2005. Vermont's Wildlife Action Plan. Vermont Fish & Wildlife Department. Waterbury, Vermont. http://www.vtfishandwildlife.com/swg_cwcs_report.cfm. (Access September 10, 2012).

RMC Environmental Services, Inc. 1993. Effect of ensonification on juvenile American shad movement and behavior at Vernon Hydroelectric Station, 1992 – Draft Report, March 1993.

Smith, R. L., and P. C. Downey. 1995. Vermont Yankee/Connecticut River System Analytical Bulletin 69: Relative density and growth of juvenile American shad in the Connecticut River near Vernon, Vermont, 1995.

Vermont Fish and Wildlife Department . 2006. Vermont Fish and Wildlife Strategic Plan. http://www.vtfishandwildlife.com/library/reports_and_documents/Fish_and_wildlife/Strategic_Plan.pdf

Zydlewski, J., S. D. McCormick, and J. G. Kunkel. 2003. Late migration and seawater entry is physiological disadvantageous for American shad juveniles. Journal of Fish Biology #63, 1521-1537.

Turners Falls Hydroelectric Project – FERC No. 1889-081
Northfield Mountain Pumped Storage Project – FERC No. 2485-063

Study Request 9: Juvenile shad outmigration

Goals and Objectives

Determine if project operations affect juvenile American shad outmigration survival, recruitment, and production. The following objectives will address this request:

- Assess project operations effects of NMPS and Turners Falls Dam on the timing, orientation, routes, migration rates, and survival of juvenile shad;
- Determine the proportion of juvenile shad that select the Gatehouse into the power canal versus the dam spill gates as a downstream passage route, under varied operational conditions, including a range of spill conditions up to full spill;
- Determine if there are any delays with downstream movement related to either spill via dam gates or through the Gatehouse and within the impoundment due to operations (i.e., NMPS pumping and generation);
- Determine survival rates for juvenile spilled over/through dam gates, under varied operation conditions, including up to full spill during the annual fall power canal outage period;
- Determine the juvenile downstream passage timing and route selection in the power canal to: Station 1; Cabot Station; and the Cabot Station log sluice bypass, and assess delays associated with each of these locations and with project operations (e.g., stockpiling in the canal);
- Based upon year 1 study results on route selection, determine the survival rate for juvenile shad entrained into Station 1; and
- Determine the survival rates for juvenile shad entrained into Cabot Station units;

If it is determined that the Project operations are adversely affecting juvenile shad survival, migration timing, or other deleterious population effects , identify operational solutions or other passage measures that will reduce and minimize these impacts within the project area. This study will require two years of field data to capture inter-annual variability of river discharge, water temperatures, and variability in the timing and abundance of juvenile production and their outmigration timing, which may relate to spring, summer, and fall conditions. This study will compliment the NMPS Fish Entrainment Study Request which includes assessment of impacts to juvenile shad.

Resource Management Goals

The Agency's goals related to aquatic natural resources are to:

1. Protect, enhance, or restore, diverse high quality habitat necessary to sustain healthy aquatic and riparian plant and animal communities.
2. Provide an instream flow regime that meets the life history requirements of resident fish and wildlife (including invertebrates such as freshwater mussels) throughout the area impacted by Project operations.
3. Minimize the potential negative effects of project operation on water quality and aquatic habitat, and mitigate for loss or degradation.

The Connecticut River is classified by the state of Vermont as Class B cold water fish habitat. Vermont Water Quality Standards state that Class B waters should be managed to achieve and maintain a level of quality that fully supports aquatic biota and habitat. Furthermore, the VTFWD's mission is "the conservation of all species of fish, wildlife, and plants and their habitats for the people of Vermont" (Kart et al. 2005).

Two of the Department's planning goals are:

1. Conserve, enhance, and restore Vermont's natural communities, habitats, and species and the ecological processes that sustain them.
2. Provide a diversity of fish- and wildlife-based activities and opportunities that allow the safe and ethical viewing, regulated harvesting, and utilization of fish, plant and wildlife resources consistent with the North American model of fish and wildlife conservation.

Vermont Fish and Wildlife Department's Strategic Plan (2002 -2010) focuses towards four major areas of concern: resource conservation, fish and wildlife-based recreation and use, human health and safety, efficient operations, and effective management.

The Connecticut River Atlantic Salmon Commission (CRASC) was established by Congress in 1983 (and reauthorized in 2002 for another 20 years) through the Connecticut River Atlantic Salmon Compact (Public Law 98-138). The Vermont Fish and Wildlife Department is a CRASC member agency, and a senior biologist from the department serves on the Technical Committee.

The Connecticut River Atlantic Salmon Commission developed *A Management Plan for American Shad in the Connecticut River* in 1992. Management Objectives in the plan include the following:

1. Achieve and sustain an adult population of 1.5 to 2 million individuals entering the mouth of the Connecticut River annually.
2. Maximize outmigrant survival for juvenile and spent adult shad.

The Atlantic States Marine Fisheries Commission *Amendment 3 to the Interstate Fishery Management Plan for Shad and River Herring (American Shad Management*), approved in 2010 includes the following objective:

- Maximize the number of juvenile recruits emigrating from freshwater stock complexes.

and Recommendation:

- To enhance survival at dams during emigration, evaluate survival of post spawning and juvenile fish passed via each route (e.g., turbines, spillage, bypass facilities, or a combination of the three) at any given facility, and implement measures to pass fish via the route with the best survival rate.

The Agency seeks the accomplishment of a number of resource goals and objectives through the relicensing process for the Project. General goals include the following:

1. Ensure that protection, mitigation and enhancement measures are commensurate with Project effects and help meet regional fish and wildlife objectives for the basin.

2. Conserve, protect, and enhance the habitats for fish, wildlife, and plants that continue to be affected by the Project.

Specific to American shad, the Agency's goals are:

- Minimize current and potential negative project operation effects on juvenile American shad survival, production, and recruitment.

Our study requests are intended to facilitate the collection of information necessary to conduct effects analyses and to develop reasonable and prudent conservation measures, and protection, mitigation, and enhancement measures pursuant to the Endangered Species Act of 1973, as amended (16 U.S.C. §1531 *et seq*.), the Fish and Wildlife Coordination Act, as amended (16 U.S.C. §661 *et seq*.), Silvio O. Conte National Fish and Wildlife Refuge Act (P.L. 102-212; H.R. 794), the Federal Power Act (16 U.S.C. §791a, *et seq*.), the Atlantic States Marine Fisheries Compact (P.L. 539, 77th Congress, as amended by P.L. 721, 81st Congress), and the Atlantic Coastal Fisheries Cooperative Management Act (16 U.S.C. 5107).

Public Interest Consideration

The requestor is a resource agency.

Existing Information

Since the construction of the Turners Falls Dam upstream fishways in 1980, American shad have had access to spawning and rearing habitat upstream of Turners Dam. A number of modifications to the Turners Falls fishways have occurred since that time, with the numbers of adult shad passed at Gatehouse Ladder (into Turners Falls Dam impoundment) reaching as much 60,089 in 1992 when a record 721,764 shad passed upstream of Holyoke Dam. However, since 1980 an average of only 3.6 % of the adult shad passed upstream of Holyoke Dam subsequently have passed upstream of Turners Falls Dam, and this value has never exceeded 11%. This value is well below the CRASC 1992 Shad Plan objective of 40-60% passage from the previous dam. In addition, population number and passage numbers past Holyoke have declined substantially, with the average Holyoke passage number over the last 10 years being 211,850. Because historic data suggests that approximately half the returning adult shad to the Connecticut River pass the Holyoke Dam, recent adult returns are far below management goals. Effective upstream and downstream passage and successful in-river spawning and juvenile production are necessary to help achieve shad management restoration goals for the Connecticut River, which extends to the Bellows Falls Dam. In 1990, FirstLight's predecessor, Northeast Utilities, CRASC and its member agencies, signed an MOA on downstream fish passage to address both juvenile and adults at the Turners Falls Project and Northfield Mountain Pumped Storage Project.

American shad broadcast spawn with the highest spawning activity occurring in runs and lowest activity in pools and riffle/pools (Ross et al. 1993). Field research by Ross et al. (1993) in the Delaware River further noted that a combination of physical characteristics that seems to be avoided by spawning adults is slow current and greater depth. American shad year-class strength has been shown to depend on parent stock size and environmental conditions during the larval life stages (Creeco and Savoy 1984). Delays in juvenile American shad outmigration may affect survival rates in the transition to the marine environment (Zydlewski et al. 2003). One published

study on the Connecticut River, identified that juvenile shad outmigration began when declining autumn temperatures reached 19C and peaked at 16C (O'Leary and Kynard 1986).

Juvenile American shad production has been monitored upstream of the Vernon Dam and immediately downstream of that dam by Vermont Yankee Nuclear as part of an annual monitoring program using both boat electrofishing (since 1991) and beach seining (since 2000). Sampling of juvenile shad was also conducted by a contractor hired by Northeast Utilities in the Turners Falls impoundment in 1992. O'Donnell and Letcher (2008) examined juvenile shad early life history and migration upstream and downstream of Turners Falls Dam. Their study results led to the decision by the agencies to require earlier operation of downstream fishways to protect early season juvenile shad out-migrants (1 September prior to 2010, 15 August in 2010, and since 2011, 1 August).

Downstream juvenile clupeid passage studies at Turners Falls were conducted in the fall of 1991 which included the objectives of determining the percentage of juvenile shad and herring that pass via the bypass log sluice or that were entrained in the Cabot Station turbines and related data (e.g., catch rates) were compared. The 1991 Downstream Clupeid Study did not assess survival rates for juveniles for either of these passage routes. The 1991 study report documented a higher rate entrainment into the project turbines (23.0 fish per minute) versus through the bypass sluice (11.6 fish per minute). It was concluded that only an estimated 54% (average bypass rate, weighted by estimated number bypassed) of the juvenile American shad approaching Cabot Station were bypassed via the log sluice. The range of the percent bypassed varied widely by date, between nearly 0 and 83%, with 'no clear explanation as to why." The report did not identify the percentage entrained into the turbines but it can be reasoned to be substantial based on the data presented in the report or assumed as the remaining balance (46%). as there were no spill events reported during this study, and therefore nowhere else for them to pass. It was further noted that entrainment rates for juveniles were consistently greatest for units 1 and 6 (ends), not uniform across all units. Although no concurrent bypass sampling occurred during the first entrainment sampling events, it was noted that "entrainment rates were relatively high during the end of September." Additional modifications have occurred over time without quantitative evaluation to improve downstream passage attraction and use to the bypass sluice, including lighting systems.

The 1994 Downstream Juvenile Shad Study report assessed juvenile shad survival from passage via the log sluice, reported to be 98%, based on tagged and recaptured fish (held for up to 48 hours). Scale loss (<20%) (22 of treatment fish) compared with scale loss of >20% (5 of treatment fish) was examined and determined to occur in an overall total of 10% of study fish (adjusted by control fish data).

Project Nexus

Adult American shad passed upstream of Turners Falls Dam utilize upstream spawning habitat. Juvenile American shad production occurs in these habitats upstream of Turners Falls Dam on an annual basis. Juvenile American shad require safe and timely downstream passage measures to have the opportunity to contribute to the fishery agencies' target restoration population size.

The Agency is not aware of any studies being conducted specifically designed to determine:

- When spill gates are open at the Turners Falls Dam?;
- What proportion of juvenile outmigrant shad take that route of passage?;
- What is the rate of survival under a range of spill and gate configurations?
- What is the timing, duration, and magnitude of juvenile shad outmigrants in summer and fall to the Turners Falls Dam and Gatehouse?
- Are there delays in migration/movement at the dam, Gatehouse, Cabot Station, or Station 1?
- For juveniles that enter the power canal, what proportion subsequently enter the Station 1 power canal?
- As there is no downstream passage facilities at Station #1, and trash rack spacing is 2.6 inches, what is the survival rate of juvenile shad entrained at Station #1?
- What is the rate of movement through the Turners Power Canal, relative to r delay to outmigrant juvenile shad and the potential accumulation of juveniles (e.g., prior to the canal drawdown in September)?
- What proportion of juvenile shad use the downstream sluice bypass versus the Cabot Station turbines under varied operational conditions given that project operations may change (PAD notes possible increase in turbine capacity at Cabot)?
- Based upon earlier facility studies (1991 Downstream Clupeid) a large proportion and number of juvenile shad are entrained into Cabot Station turbines. What are the associated impacts in terms of short-term and longer term survival and injury (i.e., scale loss)?

The Agency is concerned that project operations may impact juvenile shad outmigration survival and be contributing to the failure of the Connecticut River shad population to meet management targets. In the PAD, proposed modification include; Station 1 may be upgraded with new turbines, Station 1 may be closed, and/or the turbine capacity at Cabot may be increased. It is unclear how these scenarios will affect the questions identified in this request.

Proposed Methodology

The impact to juvenile shad outmigrants by project operations would be best studied by a combination of approaches including hydroacoustic, radio telemetry, and turbine balloon tags. Project discharge over a full range of existing and, to the extent possible, potential future operational conditions at Station 1 and Cabot, at the dam (likely increased bypass reach flows in new license) and in relation to the Gatehouse, should be examined relative to timing, duration, and magnitude of juvenile shad migration to and through these areas, with hydroacoustic equipment for natural/wild fish evaluation. In addition, study fish should be collected and tagged (PIT, radio, other mark, balloon) to also empirically determine rates of survival for fish passed over or through the dam's gates, under varied operations, including up to full spill condition that occurs annually in fall with canal outage period. The understanding of the timing, magnitude, duration of the wild fish outmigration will help inform the design, data/results, and assessment of tagged study fish. The release of tagged or marked fish (radio, PIT) upstream of the Gatehouse induction into the power canal, will provide data on concerns of delay and route selection to Station 1, Cabot Station downstream bypass, Cabot Station spill gates, and Cabot Station turbines. Additional hydroacoustic assessment at Cabot Station forebay will provide information on wild/natural juvenile fish timing, magnitude, and duration to and through this area. Based

upon Year 1 study findings relative to the frequency, magnitude, timing of juvenile American shad that end up in the forebay of Station 1, the determination of whether an entrainment survival study at that site is necessary will be made. Release sites for tagged fish will be determined based upon further consultation among the parties.

Radio tagged juvenile shad will be released in areas upstream of the NMPS facility at multiple release locations, to determine operation effects on migration rates, route, orientation, entrainment, and survival, over a full range of permitted and operational conditions.

Level of Effort and Cost

First Light does not propose any studies to meet this need. Estimated cost for the study is expected to be high, between $200,000 and $300,000, with the majority of costs associated with equipment (hydroacoustic gear, radio tags, radio receivers, and PIT readers) and related fieldwork labor.

Literature Cited

Atlantic States Marine Fisheries Commission. 2010. Amendment #3 to the Interstate Fishery Management Plan for Shad and River Herring (American Shad Management). Washington, D.C.

Crecco, V. A. and T. F. Savoy. 1984. Effects of fluctuations in hydrographic conditions on year-class strength of American shad (Alosa sapidissima) in the Connecticut River. Canadian Journal of Fisheries and Aquatic Sciences 41: 1216-1223.

Kart, J., R. Regan, S.R. Darling, C. Alexander, K. Cox, M. Ferguson, S. Parren, K. Royar, B. Popp, editors. 2005. Vermont's Wildlife Action Plan. Vermont Fish & Wildlife Department. Waterbury, Vermont. http://www.vtfishandwildlife.com/swg_cwcs_report.cfm. (Access September 10, 2012).

Layzer, J.B. 1974. Spawning Sites and Behavior of American Shad, Alosa sapidissima (Wilson), in the Connecticut River Between Holyoke and Turners Falls, Massachusetts, 1972. Master of Science Thesis. University of Massachusetts, Amherst, Massachusetts. Pp. 22-32.

O'Donnell, M and B. H. Letcher. 2008. Size and age distributions of juvenile Connecticut River American shad above Hadley Falls: influence on outmigration representation and timing River Research Applications #24: 929-940.

O'Leary, J. A. and B. Kynard. 1986. Behavior, length, and sex ration of seaward-migrating juvenile American shad and blueback herring in the Connecticut River. Transactions of the American Fisheries Society 115: 529-536

Ross, R. M., T. W. Backman, and R. M. Bennett. 1993. Evaluation of habitat suitability index models for riverine life stages of American shad, with proposed models for premigratory juveniles. Biological Report 14. U. S. DOI, U. S. Fish and Wildlife Service. Washington, D.C.

Vermont Fish and Wildlife Department . 2006. Vermont Fish and Wildlife Strategic Plan. http://www.vtfishandwildlife.com/library/reports_and_documents/Fish_and_wildlife/Strategic_Plan.pdf

Zydlewski, J., S. D. McCormick, and J. G. Kunkel. 2003. Late migration and seawater entry is physiological disadvantageous for American shad juveniles. Journal of Fish Biology #63, 1521-1537.

Vernon Hydroelectric Project – FERC No. 1904-073

Study Request 10: Shad population model for the Connecticut River

Goals and Objectives

Develop an American shad annual step, mathematical simulation population model for the Connecticut River to quantify how project operations and potential restoration/mitigation measures impact the population of shad in the Connecticut River.

The goal of the model is to assess impacts of both upstream and downstream passage at each of the Connecticut River projects and potential management options for increasing returns to the river.

Specific objectives include:

- Annual projections of returns to the Connecticut River;
- A deterministic and stochastic option for model runs
- Life history inputs of Connecticut River shad
- Understanding the effect of upstream and downstream passage delay at projects
- Calibration of the model with existing data
- Analysis of the sensitivity of model inputs
- Analysis of sensitivity to different levels of up- and downstream passage efficiencies at all projects
- Multiple output formats including a spreadsheet with yearly outputs for each input and output parameter

Resource Management Goals

The Agency's goals related to aquatic natural resources are to:

1. Protect, enhance, or restore, diverse high quality habitat necessary to sustain healthy aquatic and riparian plant and animal communities.
2. Provide an instream flow regime that meets the life history requirements of resident fish and wildlife (including invertebrates such as freshwater mussels) throughout the area impacted by Project operations.
3. Minimize the potential negative effects of project operation on water quality and aquatic habitat, and mitigate for loss or degradation.

The Connecticut River is classified by the state of Vermont as Class B cold water fish habitat. Vermont Water Quality Standards state that Class B waters should be managed to achieve and maintain a level of quality that fully supports aquatic biota and habitat. Furthermore, the VTFWD's mission is "the conservation of all species of fish, wildlife, and plants and their habitats for the people of Vermont" (Kart et al. 2005).

Two of the Department's planning goals are:

1. Conserve, enhance, and restore Vermont's natural communities, habitats, and species and the ecological processes that sustain them.

2. Provide a diversity of fish- and wildlife-based activities and opportunities that allow the safe and ethical viewing, regulated harvesting, and utilization of fish, plant and wildlife resources consistent with the North American model of fish and wildlife conservation.

Vermont Fish and Wildlife Department's Strategic Plan (2002 -2010) focuses towards four major areas of concern: resource conservation, fish and wildlife-based recreation and use, human health and safety, efficient operations, and effective management.

The Connecticut River Atlantic Salmon Commission (CRASC) developed *A Management Plan for American Shad in the Connecticut River* in 1992. Management Objectives in the plan include the following:

1. Achieve and sustain an adult population of 1.5 to 2 million individuals entering the mouth of the Connecticut River annually.
2. Achieve annual passage of 40 to 60% of the spawning run (based on a 5-year running average) at each successive upstream barrier on the Connecticut River mainstem.
3. Maximize out-migrant survival for juvenile and spent adult shad.

The Service seeks the accomplishment of a number of resource goals and objectives through the relicensing process for the Project. General goals include the following:

1. Ensure that protection, mitigation and enhancement measures are commensurate with Project effects and help meet regional fish and wildlife objectives for the basin.
2. Conserve, protect, and enhance the habitats for fish, wildlife, and plants that continue to be affected by the Project.

Specific to American shad, the Service's goals are:

- Minimize current and potential negative project operation effects on American shad spawning and recruitment.

Our study requests are intended to facilitate the collection of information necessary to conduct effects analyses and to develop reasonable and prudent conservation measures, and protection, mitigation, and enhancement measures pursuant to the Endangered Species Act of 1973, as amended (16 U.S.C. §1531 *et seq*.), the Fish and Wildlife Coordination Act, as amended (16 U.S.C. §661 *et seq*.), and the Federal Power Act (16 U.S.C. §791a, *et seq*.).

Public Interest Consideration

The requestor is a resource agency.

Existing Information

Since the construction of the first fish lift facility at Holyoke Dam in 1967, American shad have had access to spawning and rearing habitat upstream from Holyoke Dam. A number of improvements to the Holyoke fishway have occurred since that time, but while the numbers of shad lifted at Holyoke have reached as much as 721,764 and the overall shad population to the river exceeded 1.6 million shad in 1992 (CRASC 1992), total shad populations, and numbers of shad passing Holyoke, Turners Falls and Vernon Dam have not met CRASC management goals.

Population and passage numbers past Holyoke have declined substantially from those totals in recent years, with average Holyoke passage numbers since 2000 of 229,876. Whole river population estimates have shown that approximately half of the returning population of shad pass upstream of Holyoke. Recent returns to Holyoke are far below management goals. Average passage efficiency of shad at Turners Falls (Gatehouse counts) and Vernon since 2000 has been 3.1 and 20.4 % respectively. These too are well below the CRASC management goals.

Safe, timely and effective up- and downstream passage along with successful spawning and juvenile production are necessary to help achieve shad management goals for the Connecticut River.

Project Nexus

Existing project operations and fish ladder efficiencies have a direct effect on shad populations in the Connecticut River. Poor upstream passage efficiencies and delays restrict river access to returning shad. Fish unable to reach upriver spawning grounds may not spawn or have reduced fitness or survival of young. Poor downstream passage survival and downstream passage delays affect outmigration and consequently repeat spawning, an important ecological aspect of the iteroparous Connecticut River shad population (Limberg et al. 2003).

The Service is concerned that poor passage efficiencies and delays at projects may be limiting access to upstream reaches of the river, altering spawning behavior, decreasing outmigration survival and contributing to the failure of the Connecticut River shad population to meet management targets (Castro-Santos and Letcher 2010).

Development of a population model will allow an assessment of individual project impacts on the population as well as the cumulative impacts of multiple projects. The model will allow managers to direct their efforts in the most efficient manner toward remedying the conditions that most impact the shad population.

Proposed Methodology

Population models are commonly used to assess anthropomorphic and natural impacts and are consistent with accepted practice. A model similar to this request was constructed for the Susquehanna River by Exelon (FERC #405, RSP 3.4). The model is constructed in Microsoft Access

Specific parameters that would be included in the model:

- Upstream passage efficiency at Holyoke, Turners Falls (Cabot, Gatehouse and Spillway Ladders), Vernon fishways, and any impacts associated with Northfield Mountain.
- Distribution of shad approaching the Turners Falls project between the Cabot Ladder and the spillway at the dam
- Downstream passage efficiencies at Vernon, Northfield Mountain, Turners Falls, and Holyoke projects for juveniles and adults
- Entrainment at Mount Tom and Vermont Yankee
- Sex ratio of returning adults
- The proportion of virgin female adults returning at 4, 5, 6, and 7 years

- The proportion of repeat spawning females at 5, 6 and 7 years
- Spawning success of females in each reach
- Fecundity
- Percent egg deposition
- Fertilization success
- Larval and juvenile in-river survival
- Calibration factor to account for unknown parameters such as at sea survival
- Options for fry stocking and trucking as enhancement measures
- Start year and model run years
- Start population
- Rates of movement to and between barriers
- Temperature, river discharge, and other variable of influence to migration and other life history events

The model should be adaptable to allow the input of new data and other inputs.

Level of Effort and Cost

Neither First Light nor TransCanada have proposed any study to meet this need. Estimated cost for the study is expected to be low to moderate. As the model describes the impacts of multiple projects and two owners, both project owners would share the cost of model development.

Literature Cited

CRASC (Connecticut River Atlantic Salmon Commission). 1992. A management plan for American shad in the Connecticut River basin. Sunderland, MA

Castro-Santos, T and B. H. Letcher. 2010. Modeling migratory bioenergetics of Connecticut River American shad (*Alosa sapidissima*): implications for the conservation of an iteroparous anadromous fish. Can.J.Fish.Aquat.Sci. 67: 806-830

Limberg, K. E., K. A. Hattala, and A. Kahne. 2003. American shad in its native range. Pages 125-140 in K. E. Limberg and J. R. Waldman, editors. Biodiversity, status and conservation of the world's shads. American Fisheries Society, Symposium 35, Bethesda, Maryland

Bellows Falls Hydroelectric Project – FERC No. 1855-045
Vernon Hydroelectric Project – FERC No. 1904-073
Turners Falls Hydroelectric Project – FERC No. 1889-081
Northfield Mountain Pumped Storage Project – FERC No. 2485-063

Study Request 11: Impact of project operations on shad spawning, spawning habitat and egg deposition

Goals and Objectives

Determine if project operations (under the permitted and proposed operational ranges) affect American shad spawning site use and availability, spawning habitat quantity and quality, and spawning activity in the river reaches downstream from Cabot Station and in the project bypass reach of Turners Falls Dam, in the Turners Falls Dam impoundment and in relation to Northfield Mountain Pump Storage operations, downstream and upstream of the Vernon Dam, and in the project area downstream of Bellows Falls Dam. The following objectives will address this request:

- Determine areas utilized by American shad for spawning by conducting night-time visual observation of spawning activity, identify and define areas geospatially, and obtain data on physical habitat conditions effected by project operations (e.g., water depth, velocity, discharge, substrate, exposure and inundation of habitats);
- Determine project operation effects on observed spawning activity, under a range of permitted or proposed project operation conditions;
- Quantify effects (e.g., water velocity, depths, inundation, exposure of habitats) of project operation on identified spawning areas for a range of conditions, over the complete period of spawning activity;
- Quantify spawning activity as measured by night-time spawning/splash surveys and egg collection in areas of spawning activity, and downstream of these areas, to further determine project operation effects (location extent of exposure from changing water levels and flows and on associated habitats from project operations).

If it is determined that the Project operations are adversely affecting the spawning activity of American shad and impacting spawning area habitat, identify operational regimes that will reduce and minimize impacts spawning habitat and spawning success, within the project area. This study will require two years of field data to capture inter-annual variability to river discharge and water temperatures and to allow for evaluation of alternative flow regimes if year one studies determine that the present peaking regime negatively affects spawning.

Resource Management Goals

The Connecticut River Atlantic Salmon Commission (CRASC) was established by Congress in 1983 (and reauthorized in 2002 for another 20 years) through the Connecticut River Atlantic Salmon Compact (Public Law 98-138). The Vermont Fish and Wildlife Department is a CRASC member agency, and a senior biologist from the department serves on the Technical Committee.

The Connecticut River Atlantic Salmon Commission developed *A Management Plan for American Shad in the Connecticut River* in 1992. Management Objectives in the plan include the following:

1. Achieve and sustain an adult population of 1.5 to 2 million individuals entering the mouth of the Connecticut River annually.
2. Achieve annual passage of 40% to 60% of the spawning run (based on a 5-year running average) at each successive upstream barrier on the Connecticut River mainstem.

The Atlantic States Marine Fisheries Commission, Amendment 3 to the Interstate Fishery Management Plan for Shad and River Herring (American Shad Management), approved in 2010 includes the following objective:

1. Maximize the number of juvenile recruits emigrating from freshwater stock complexes and recommendations:
2. To mitigate hydrological changes from dams, consider operational changes such as turbine venting, aerating reservoirs upstream of hydroelectric plants, aerating flows downstream, and adjusting in-stream flows.
3. Natural river discharge should be taken into account when instream flow alterations are being made to a river (flow regulation) because river flow plays an important role in the migration of diadromous fish.
4. Ensure that decisions on river flow allocation (e.g., irrigation, evaporative loss, out of basin water transport, hydroelectric operations) take into account instream flow needs for American shad migration, spawning, and nursery use, and minimize deviation from natural flow regimes.
5. When considering options for restoring alosine habitat, include study of impacts and possible alteration of dam-related operations to enhance river habitat.

The Agency's goals related to aquatic natural resources are to:

1. Protect, enhance, or restore, diverse high quality habitat necessary to sustain healthy aquatic and riparian plant and animal communities.
2. Provide an instream flow regime that meets the life history requirements of resident fish and wildlife (including invertebrates such as freshwater mussels) throughout the area impacted by Project operations.
3. Minimize the potential negative effects of project operation on water quality and aquatic habitat, and mitigate for loss or degradation.

The Connecticut River is classified by the state of Vermont as Class B cold water fish habitat. Vermont Water Quality Standards state that Class B waters should be managed to achieve and maintain a level of quality that fully supports aquatic biota and habitat. Furthermore, the VTFWD's mission is "the conservation of all species of fish, wildlife, and plants and their habitats for the people of Vermont" (Kart et al. 2005).

Two of the Department's planning goals are:

1. Conserve, enhance, and restore Vermont's natural communities, habitats, and species and the ecological processes that sustain them.

2. Provide a diversity of fish- and wildlife-based activities and opportunities that allow the safe and ethical viewing, regulated harvesting, and utilization of fish, plant and wildlife resources consistent with the North American model of fish and wildlife conservation.

Vermont Fish and Wildlife Department's Strategic Plan (2002 -2010) focuses towards four major areas of concern: resource conservation, fish and wildlife-based recreation and use, human health and safety, efficient operations, and effective management.

The Agency seeks the accomplishment of a number of resource goals and objectives through the relicensing process for the Project. General goals include the following:

1. Ensure that protection, mitigation and enhancement measures are commensurate with Project effects and help meet regional fish and wildlife objectives for the basin.
2. Conserve, protect, and enhance the habitats for fish, wildlife, and plants that continue to be affected by the Project.

Specific to American shad, the Agency's goals are:

- Minimize current and potential negative project operation effects on American shad spawning and recruitment.

Our study requests are intended to facilitate the collection of information necessary to conduct effects analyses and to develop reasonable and prudent conservation measures, and protection, mitigation, and enhancement measures pursuant to the Endangered Species Act of 1973, as amended (16 U.S.C. §1531 *et seq*.), the Fish and Wildlife Coordination Act, as amended (16 U.S.C. §661 *et seq*.), Silvio O. Conte National Fish and Wildlife Refuge Act (P.L. 102-212; H.R. 794),The Federal Power Act (16 U.S.C. §791a, *et seq*.), The Atlantic States Marine Fisheries Compact (P.L. 539, 77th Congress, as amended by P.L. 721, 81st Congress), and the Atlantic Coastal Fisheries Cooperative Management Act (16 U.S.C. 5107).

Public Interest Consideration

The requestor is a state resource agency.

Existing Information

Since the construction of the first fish lift facility at Holyoke Dam in 1967, American shad have had access to spawning and rearing habitat upstream from Holyoke Dam. A number of improvements to the Holyoke fishway have occurred since that time, but while the numbers of shad lifted at Holyoke have reached as much as 721,764 and the overall shad population to the river exceeded 1.6 million shad in 1992 (CRASC 1992), total shad population, and numbers of shad passing Turners Falls and Vernon Dam have not met CRASC management plan objectives. Population number and passage numbers past Holyoke have declined substantially from those totals in recent years, with average Holyoke passage numbers over the last 10 years of 211,850. Since historically approximately half of the returning population of shad to the river passed upstream of Holyoke, recent returns are far below management goals. Effective upstream and downstream passage and successful in-river spawning and juvenile production are necessary to help achieve shad management goals for the Connecticut River.

American shad broadcast spawn in congregations over shallow flats and rocky or sandy substrates (Davis et al, 1970, Mansuetti and Kolb 1953), at depths less than 10 feet and often far shallower with spawning fish swimming vigorously near the surface in a closely packed circle (Marcy 1972, Mackenzie et al 1985). Fertilized eggs drift downstream until hatching (Mackenzie et al 1985).

American shad are known to spawn downstream from the Turners Falls Project. Layzer (1974) identified 6 spawning sites from an area below the mouth of the Deerfield River (river mile 191.9) to river mile 161.7 below the Mill River in Hatfield, MA. Kuzmeskus (1977) verified 16 different spawning sites ranging from downstream of the Cabot tailrace to just upstream of the Holyoke dam (river mile 87.1). The only parameter that all spawning sites had in common was current (Kuzmeskus 1977). The Agency is not aware of any more recent studies that document whether these 16 sites are still viable spawning locations for shad. We are not aware of any studies that have determined American shad spawning habitat or spawning sites upstream of Vernon Dam to Bellows Fall Dam (historic extent of upstream range).

First Light Power conducted studies in the late spring and summer of 2012, examined habitat conditions downstream of the Turners Falls Dam. The study documented that in low flow conditions, Cabot Station project operations produced fluctuations in water level elevations that can range over 4 feet in magnitude (daily operation) at the USGS Montague Gage Station, to lower values of 2 to 3 feet at the Route 116 Bridge, Sunderland, MA (PAD). Similar short-term, limited monitoring in the upper Turners Falls Dam impoundment identified water level changes due to project operations that d cyclically varied several feet on a sub-daily frequency.

Project Nexus

American shad are known to spawn at five locations downstream from the Turners Falls Project from an area below the mouth of the Deerfield River (river mile 191.9) and ten other locations downstream to river mile 161.7 below the Mill River in Hatfield (Layzer 1974, Kuzmeskus 1977).

Shad spawning is likely influenced by river flow, which fluctuates greatly due to the project's peaking mode of operation. These fluctuations may impact shad spawning activity by altering current velocities and water depth at the spawning sites. Effects on spawning behavior could include suspension of spawning activity, poor fertilization, flushing of eggs into unsuitable habitat due to higher peaking discharges, eggs dropping out into unsuitable substrate and being covered by sediment deposition and/or eggs becoming stranded on dewatered shoal areas as peak flows subside.

While a number of shad spawning and egg deposition studies were conducted in the 1970s, that research was aimed at assessing the potential impact of developing a nuclear power station in the Montague Plains section of the Connecticut River. The Agency is not aware of any studies being conducted specifically designed to determine if a relationship between spawning behavior, habitat use, and egg deposition and project operations effects of the Turners Falls, Northfield Mountain Pump Storage and Vernon projects and downstream of Bellows Falls Dam..

The Agency is concerned that peaking operations may be altering spawning behavior and contributing to the failure of the Connecticut River shad population to meet management targets.

Proposed Methodology

The first year of study should examine known spawning areas downstream of the Turners Falls Dam project, to determine operation effects on shad spawning behavior, activity, and success. In areas upstream of Turners Falls Dam to the Bellow Falls Dam tailrace, the study should identify areas utilized for spawning by American shad. In the second year, should results from year one determine project operations affected spawning activity, access to habitat, or success, downstream of Turners Falls Dam, then an identical more detailed assessment (identified objectives) should be conducted in spawning areas upstream of Turners Falls Dam to the Bellows Falls Dam tailwater. Measures to reduce or eliminate any documented project operation impacts should be explored and evaluated in year two, downstream of Turners Falls Dam.

The impacts to spawning behavior would best be studied by night-time observations of actual in-river spawning behavior (Ross et al. 1993). Project discharge increases or decreases during actual observed spawning activity will provide empirical evidence of change in behaviors. The observational methodology should follow the protocol specified in Layzer (1974) and/or as described in Ross et al. (1993). The analysis should utilize the observational field data in conjunction with operational data from the projects (station generation and spill on a sub-hourly basis). To assess the impacts of changes in generation flows, the study should include scheduled changes in project operation to ensure that routine generation changes that occur during the nighttime spawning period affect downstream spawning habitats selected for study while shad are spawning. Stier and Crance (1985) provide optimal water velocities during spawning to range between 1 to 3 ft/sec.

In areas used for spawning, the characteristics of those areas (e.g., location, depth, flow, substrate) should be recorded. The effect of project operations (discharge, water velocity, inundation and exposure) should be assessed. Drift nets will be used to collect eggs to quantify egg production before and after flow changes at the spawning site.

In the reaches above the Turners Falls dam, night time observations of splashing associated with shad spawning should be done in each reach as sufficient numbers of shad are passed above each dam. Observations should be done regularly until the end of the spawning season. The use of radio-tagged adult shad from a separate Study Request will aid in this effort. An estimate of the total area used for spawning and an index of spawning activity should be recorded for each site.

Level of Effort and Cost

Neither First Light or TransCanada propose any studies to meet this need. Estimated cost for the study is expected to be moderate (up to $40,000) for each owner, with the majority of costs associated with fieldwork labor.

Literature Cited

Atlantic States Marine Fisheries Commission. 2010. Amendment #3 to the Interstate Fishery Management Plan for Shad and River Herring (American Shad Management). Washington, D.C.

CRASC (Connecticut River Atlantic Salmon Commission). 1992. A management plan for American shad in the Connecticut River basin. Sunderland, MA

Kart, J., R. Regan, S.R. Darling, C. Alexander, K. Cox, M. Ferguson, S. Parren, K. Royar, B. Popp, editors. 2005. Vermont's Wildlife Action Plan. Vermont Fish & Wildlife Department. Waterbury, Vermont. http://www.vtfishandwildlife.com/swg_cwcs_report.cfm. (Access September 10, 2012).

Kuzmeskus, D. M. 1977. Egg production and spawning site distribution of Americans had, *Alosa sapidissima*, in the Holoke Pool, Connecticut River, Massachusetts. Master's thesis. University of Massachusetts, Amherst, MA.

Layzer, J.B. 1974. Spawning Sites and Behavior of American Shad, *Alosa sapidissima* (Wilson), in the Connecticut River Between Holyoke and Turners Falls, Massachusetts, 1972. Master of Science Thesis. University of Massachusetts, Amherst, Massachusetts.

MacKenzie, C., L. Weiss-Glanz, and J. Moring. 1985. Species profiles: Life histories and environmental requirements of coastal fishes and invertebrates (mid-Atlantic) American shad. U. S. Fish and Wildlife Service Biological Report No. 82 (11.37), Washington, D.C.

Mansueti, R. J. and H. Kolb. 1953. A historical review of the shad fisheries of North America. Chesapeake Biological Laboratory Publication no. 97. Solomons, MD.

Marcy, B. C. Jr. 1972. Spawning of the American shad, Alosa sapidissima, in the lower Connecticut River. Chesapeake Science 13:116-119.

Ross, R. R., T. W. H. Backman, R. M. Bennett. 1993. Evaluation of habitat suitability index models for riverine life stages of American shad, with proposed models for premigratory juveniles. Biological Report #14. U. S. Department of the Interior, Fish and Wildlife Service, Washington, D.C.

Stier, D. J. and J. H. Crance. 1985. Habitat suitability index models and instream flow suitability curves: American shad. U. S. Fish and Wildlife Service Biological Report No. 82(10.88), Washington, D.C.

Vermont Fish and Wildlife Department . 2006. Vermont Fish and Wildlife Strategic Plan. http://www.vtfishandwildlife.com/library/reports_and_documents/Fish_and_wildlife/Strategic_Plan.pdf

Vernon Hydroelectric Project – FERC No. 1904-073
Turners Falls Hydroelectric Project – FERC No. 1889-081
Northfield Mountain Pumped Storage Project – FERC No. 2485-063

Study Request 12: Telemetry study of upstream and downstream migrating adult American shad to assess passage routes, effectiveness, delays, and survival

Goals and Objectives

Assess behavior, approach routes, passage success, survival, and delay by adult American shad as they encounter the projects during both upstream and downstream migrations, under permitted project operations conditions, proposed operational conditions, and study treatment operational conditions at First Light Power's Turners Falls and Northfield Mountain Pumped Storage projects and TransCanada's Vernon Project. There are multiple fishways and issues related to both upstream and downstream passage success at the projects. Some of these issues at the Turners Falls Project are similar to and/or pertain directly to the Northfield Mountain and Vernon projects. Therefore, it is reasonable to address passage issues at all projects in a similar manner.

Telemetry Study - This requested study requires use of radio telemetry using both radio and Passive Integrated Transponder (PIT) tag types to provide information to address multiple upstream and downstream fish passage issues. The following objectives shall be addressed in these studies:

- Assessment of any migration delays resulting from the presence of the dam and peaking flow operations of the Turners Falls Project;
- Determine route selection and behavior of upstream migrating shad at the Turners Falls Project under various spill flow levels (e.g., movement to the dam, attraction to Cabot Station, attraction to Station 1 discharge, movement between locations, delay, timing, etc.). A plan and schedule for dam spill flow releases will need to be developed that provides sufficient periods of spill flow conditions, and various generating levels from Turners #1 Station coupled with Cabot Station generation flows (e.g., treatments will require multiple days of consistent discharge). Evaluated spill flows should include flows between 2,500 – 6,300 cfs, which relate to bypass flows identified as providing spawning opportunities for shortnose sturgeon in the lower bypass reach at the Rock Dam. (Kieffer and Kynard 2012). Sturgeon spawning and upstream shad passage occur concurrently;
- Assess near field, attraction to and entrance efficiency of the Spillway Ladder by shad reaching the dam spillway, under a range of spill conditions;
- Evaluate the internal efficiency of the Turners Falls Spillway Ladder;
- Continue data collection of Cabot Station Ladder and Gatehouse Ladder efficiency, to include rates of approach to fishway entrances, entry into fishways, and passage through them, under different operational conditions that occur in these areas;
- Evaluate modifications to the Cabot and/or Spillway fishways recommended by the Service if they are implemented;

- Assess upstream migration from Turners Falls to the Vernon Dam in relation to Northfield Mountain's pumping and generating operations and Vernon Project peaking generation operations. Typical existing and proposed project operation alterations should be evaluated;
- Assess near field, attraction to and entrance efficiency of the Vernon Dam Ladder;
- Assess internal efficiency of the Vernon Dam Ladder;
- Assess upstream passage past Vermont Yankee's thermal discharge (also located on the west bank of the river 0.45 mile upstream of fish ladder exit)
- Assess upstream migration from Vernon Dam in relation to the peaking generation operations of the Bellows Falls Project. Typical existing and proposed project operation alterations should be evaluated;
- Determine post-spawn downstream migration route selection, passage efficiency, delays and survival related to the Vernon Project, including evaluation of the impact of the Vermont Yankee heated water discharge plume on downstream passage route, migrant delay/timing, efficiency and survival;
- Assess impacts of Northfield Mountain operations on up- and downstream adult shad migration, including delays, entrainment, and behavioral changes and migration direction shifts under existing and proposed project operations;
- Determine downstream passage route selection, timing/delay, and survival under varied project operational flows into the power canal and spill flows at Turners Falls Dam;
- Determine downstream passage route selection, timing/delay in the canal, Cabot Station fish bypass facility effectiveness, and survival of Cabot-bypassed adult shad that enter the Turners Falls Canal system;
- Compare rates and or measures of delay, movement and survival etc., among project areas or routes utilized (e.g., spill at dam vs. power canal) under the range of permitted and proposed conditions; and
- Utilize available data sets and further analyze raw data (e.g., 2003- 2012 Conte Lab Studies) where possible to address these questions and inform power analyses and experimental design.

Information to address all of these questions would rely on the tagging of upstream migrating adult shad at Holyoke Dam and releasing them to migrate naturally from Holyoke through the Turners Falls and Vernon projects and back downstream after spawning. Additional tagged individuals would likely need to be released farther upstream (Turners Falls Canal, upstream of Turners Falls Dam, and upstream of Vernon Dam), to ensure that enough tagged individuals encounter project dams on both upstream and downstream migrations, that these individuals are exposed to a sufficient range of turbine and operational conditions to test for project effects, and to provide adequate samples sizes for statistically valid data analyses to address the many objectives listed. This study will require two years of field data collection to attempt to account for inter-annual variability in river discharge and water temperatures.

Evaluation of Past Study Data- In addition to collection and analysis of new telemetry data, substantial data has already been collected at Turners Falls from multiple years of passage assessments conducted for First Light by U.S. Geological Survey's Conte Anadromous Fish Research Center (Conte Lab) researchers and there are also data from the 2011 and 2012 full river study conducted by the Conte Lab that address Turners Falls, Northfield Mountain and

Vernon project migration and passage questions that have not yet been analyzed. These data include several million records each year from more than 30 radio telemetry receivers deployed between Middletown, CT and Vernon Dam. This data will provide substantial information free from the field data collection costs and therefore should be analyzed as part of this study. This data analysis should be completed in 2013 to help inform the design of subsequent field studies.

Evaluation of Methods to Get Shad Past Cabot Station for Spillway Passage at the Turners Falls Dam – The poor passage efficiency of the Cabot Ladder, the first and most used fishway encountered by shad arriving at the Turners Falls Project, and at the entrance to the Gatehouse Ladder, which all Cabot fishway-passed fish must use, has resulted in very poor overall shad passage efficiency at the project. An alternative to passing fish at the Cabot Station is to install a fish lift at the dam that would put fish directly into the Turners Falls pool, thereby eliminating problems with the Cabot Fishways, and the Gatehouse Fishway entrance and the variable passage efficiency of the Gatehouse Fishways. For this to be effective, attraction of shad to the Cabot Station discharge and associated delays would need to be overcome. It is possible that spillway flow releases coupled with behavioral measures at Cabot Station that dissuade shad from that tailrace could achieve this end. In order to assess the possibilities, we recommend the following study:

1. A literature search and desk-top assessment of the possible behavioral measures that could be effective in getting shad to pass Cabot Station tailrace and continue upstream to the dam.

2. Based on results of the desk-top assessment, possible evaluation of behavioral measures that are likely to be effective.

3. Field evaluation of the effect of different levels of spill at the dam that would induce fish to move past the Cabot Station into the bypass reach and up to the dam (as noted in objectives).

Besides passage success and delays at passage facilities, these studies would assess the impacts of project operations on migration passage delay, route, timing, injury, mortality, and passage structure attraction, retention, and success. Of particular interest will be fish behavior during periods when flow releases from the project increase from the required minimum flows to peak generation flows and when flows subside from peak generation flows to minimum flows and the operation of NMPS in pumping and generation modes.

Resource Management Goals

The Connecticut River is classified by the state of Vermont as Class B cold water fish habitat. Vermont Water Quality Standards state that Class B waters should be managed to achieve and maintain a level of quality that fully supports aquatic biota and habitat.

The Agency's goals related to aquatic natural resources are to:

1. Protect, enhance, or restore, diverse high quality habitat necessary to sustain healthy aquatic and riparian plant and animal communities.

2. Provide an instream flow regime that meets the life history requirements of resident fish and wildlife (including invertebrates such as freshwater mussels) throughout the area impacted by Project operations.
3. Minimize the potential negative effects of project operation on water quality and aquatic habitat, and mitigate for loss or degradation.

Furthermore, the VTFWD's mission is "the conservation of all species of fish, wildlife, and plants and their habitats for the people of Vermont" (Kart et al. 2005).

Two of the Department's planning goals are:
1. Conserve, enhance, and restore Vermont's natural communities, habitats, and species and the ecological processes that sustain them.
2. Provide a diversity of fish- and wildlife-based activities and opportunities that allow the safe and ethical viewing, regulated harvesting, and utilization of fish, plant and wildlife resources consistent with the North American model of fish and wildlife conservation.

Vermont Fish and Wildlife Department's Strategic Plan (2002 -2010) focuses towards four major areas of concern: resource conservation, fish and wildlife-based recreation and use, human health and safety, efficient operations, and effective management.

The Connecticut River Atlantic Salmon Commission (CRASC) was established by Congress in 1983 (and reauthorized in 2002 for another 20 years) through the Connecticut River Atlantic Salmon Compact (Public Law 98-138). The Vermont Fish and Wildlife Department is a CRASC member agency, and a senior biologist from the department serves on the Technical Committee. The CRASC developed *A Management Plan for American Shad in the Connecticut River* in 1992. Management Objectives in the plan include the following
1. Achieve and sustain an adult population of 1.5 to 2 million individuals entering the mouth of the Connecticut River annually. (Table 1)
2. Achieve annual passage of 40 to 60% of the spawning run (based on a 5-year running average) at each successive upstream barrier on the Connecticut River mainstem.
3. Maximize outmigrant survival for juvenile and spent adult shad.

The Atlantic States Marine Fisheries Commission, Amendment 3 to the Interstate Fishery Management Plan for Shad and River Herring (American Shad Management), approved in 2010 includes the following objective:

- Maximize the number of juvenile recruits emigrating from freshwater stock complexes and recommendations:

Upstream Passage –
1. American shad must be able to locate, enter, and pass the passage facility with little effort and without stress.
2. Where appropriate, improve upstream fish passage effectiveness through operational or structural modifications at impediments to migration.
3. Fish that have ascended the passage facility should be guided/routed to an appropriate area so that they can continue upstream migration, and avoid being swept back downstream below the obstruction.

Downstream Passage –

- To enhance survival at dams during emigration, evaluate survival of post spawning and juvenile fish passed via each route (e.g., turbines,, spillage, bypass facilities, or a combination of the three) at any given facility, and implement measures to pass fish via the route with the least delay and best survival rate.

Based on the CRASC plan, the Agency seeks the accomplishment of a number of resource goals and objectives through the relicensing process for the Project. General goals include the following:

1. Ensure that protection, mitigation and enhancement measures are commensurate with Project effects and help meet regional fish and wildlife objectives for the basin.
2. Conserve, protect, and enhance the habitats for fish, wildlife, and plants that continue to be affected by the Project.

Specific to American shad movement and migration, the Agency's goals are:

- Minimize current and potential negative project operation effects such as migration delays, false attraction, turbine entrainment, survival of project passage routes, and trashrack impingement that could hinder management goals and objectives.

Our study requests are intended to facilitate the collection of information necessary to conduct effects analyses and to develop reasonable and prudent conservation measures, and protection, mitigation, and enhancement measures pursuant to the Endangered Species Act of 1973, as amended (16 U.S.C. §1531 *et seq*.), the Fish and Wildlife Coordination Act, as amended (16 U.S.C. §661 *et seq*.), Silvio O. Conte National Fish and Wildlife Refuge Act (P.L. 102-212; H.R. 794), the Federal Power Act (16 U.S.C. §791a, *et seq*.), the Atlantic States Marine Fisheries Compact (P.L. 539, 77th Congress, as amended by P.L. 721, 81st Congress), and the Atlantic Coastal Fisheries Cooperative Management Act (16 U.S.C. 5107).

Public Interest Consideration

The requestor is a state natural resource agency.

Existing Information

Passage of adult shad at the Turners Falls fishway complex has been the subject of intense study by the Conte Lab since before 1999. These studies have clearly demonstrated that passage through the existing fishways at Cabot and Spillway is poor (<10% in many years). Passage through the Gatehouse fishway is better, but still rarely exceeds 80%, despite the short length of this ladder. In addition to poor passage for fish entering the ladders, shad that ascend the Cabot Fishway experience extensive delays before entry into the Gatehouse Fishway. Shad that ascend Spillway frequently fall back into the canal and are also subject to these upstream delays. A new entrance to the Gatehouse Fishway installed in 2007 led to dramatic improvements in passage out of the canal (from 5% to over 50% in 2011), but passage still falls well short of management goals. In addition, shad spend considerable time (up to several weeks) attempting to pass. These delays likely influence spawning success and survival. Adult shad, unable to pass Gatehouse, experience similar delays in downstream passage, even after they have stopped trying to pass

Gatehouse. Without spill, all outmigrating shad that have passed Gatehouse must enter the canal at the Gatehouse and may be subject to delays exiting the canal.

During the course of these studies a very large dataset has been compiled that could yield useful information for further improving passage of shad out of the canal in both the upstream and downstream directions. A unique feature of these data is a 2-dimensional array covering the canal just downstream of Gatehouse, documenting fine scale movements and occupancy of this zone. These data should be combined with computational fluid dynamics (CFD) and real-time hydraulic data to determine how canal hydraulics influence the ability of shad to locate and enter the fishway, and to identify modifications that are likely to lead to improvements in approach and entry rates. A separate CFD modeling study is requested that includes modeling of the Gatehouse Fishway entrance are at the head of the power canal.

In addition, whole-river shad telemetry studies performed in 2011 and 2012 will likely provide useful information and should be analyzed. These data should allow quantification of delay below Turners Falls, and could help guide studies requested above. Preliminary analyses of data through 2011 have been made available to FirstLight and the resource agencies (Castro-Santos and Haro 2005; Castro-Santos and Haro 2010).

The whole-river studies have also shown that, at least in 2011, most shad that pass Turners Falls rapidly progress upstream to Vernon Dam where extensive delays also occur. Data from the 2012 study were not available at this time, but Dr. Castro-Santos stated similar patterns were noted in the data between the years on the topic of upstream delay (personal communication, Dr. Theodore Castro-Santos). Similarly, concerns relative to the downstream passage of spent shad also remain relative to delays, with existing unpublished USGS telemetry data sets suggesting this is an issue within the Turners Falls canal.

Since the first year of operation of the Turners Falls upstream fishways (1980), the percent passage of American shad annually passed upstream of Turners Falls Dam compared to the number passed at the Holyoke Fish Lift has averaged 3.6% (1980-2012 data). The highest values for this metric has not exceed 11% and are well below the noted CRASC Management Plan target range for this objective noted earlier as 40-60% on a five year running average.

Since the first year of operation of the Vernon Dam upstream fish ladder (1981), the percent passage of American shad annually passed at Vernon compared to the number passed upstream of Turners Falls Dam (Gatehouse counts) has averaged 39.4%, ranging from 0.42% to 116.4% (> 100% due to counting error at one or both facilities, unknown).

Project Nexus

Existing project operations (peaking power generation) and limited bypass flows have a direct impact on instream flow and zones of passage (migration corridors). Project flow releases affect passage route selection, entry into fishways, and create delays to upstream migration. Inefficient downstream bypasses can result in migration delays and increased turbine passage. Mortality of adult shad passing through these turbines is expected to be high (Bell and Kynard 1985), additional stresses associated with passage and delay may cause mortality as shad are unable to return to salt water in a timely manner. The project's upstream and downstream passage

facilities need to be designed and operated to provide timely and effective upstream and downstream fish passage to meet restoration goals of passage to upstream habitat and maximize post-spawn survival. These factors are all critically important to the success of restoration efforts.

Proposed Methodology

Use of radio including passive-integrated transponder (PIT) telemetry is widely accepted as the best method to assess fish migratory behavior and passage success and has been used extensively to assess migration and passage issues at Turners Falls as well as other Connecticut River projects. These studies include one conducted in 2011 and 2012 by the Service and U.S. Geological Survey's Conte Anadromous Fish Research Center, which has provided substantial information related to some of the issues identified here. The requested study will build and expand on the information collected over the past two years.

The study design must specify sample sizes, tag configurations and receiver configurations, to ensure that rates of entry and exit to the tailraces, fishways, downstream bypasses, and the bypassed reach can be calculated with sufficient precision to determine effectiveness of flow and ensonification treatments (separate Study Request). For project assessments at Turners Falls (e.g., Cabot, Spillway and Gatehouse ladder attraction and entry, route selection, operational effects), double tagged (radio and PIT) shad will be required for release from Holyoke Dam. Additional shad must be released directly into the Turners Falls Canal to support assessment of the various operational and structural conditions in effect, to be modified in this period, and proposed conditions within the Turners Falls power canal relative to entrances to the Gatehouse fishway. A related request on CFD modeling in the Cabot Station tailrace, the upper power canal near Gatehouse, and in the area around the entrance of the Spillway Ladder will address related project operational effects that will also address identified objectives in this telemetry request. Shad captured at Holyoke and tagged and release upstream of Turners Falls Dam, or tagged out of Gatehouse Ladder, would help to ensure an adequate sample size for evaluations in the vicinity of NMPS and to the Vernon Dam and the ability to address identified study objectives in those project areas. Additional tagged shad are expected to be required for release upstream of the Vernon Dam, which should ensure adequate sample for a separate study request, where shad spawn upstream of Vernon Dam as well as ensuring there is an adequate number of outmigrating spent adults to address related study objectives for adult outmigrants. The required number of tagged fish to address study objectives may be adjusted accordingly from area to area depending on target numbers (i.e., best information on resultant viable tagged fish and power analyses to detect effects) to account for typical passage rates, survival rates, and handling effects as examples.

Existing information on captured, handled, tagged fish performance (e.g., percent that drop back, unsuitable for tracking) and factors such as timing of tagging and potentially transport, must all be carefully considered to ensure an adequate sample size of healthy (e.g., viable to characterize behavior, survival, etc.) tagged fish is available to address the many questions identified in this request (as supported by a statistical power analysis). Additionally, ensuring adequate downstream adult fish sample sizes (to address project effect questions above) requires close consideration as expected losses of healthy tagged fish during upstream passage, natural

mortality rates, and tagging related effects, are expected to reduce sample sizes on downstream passage objectives/questions as the season progresses. The use of single PIT tagged fish can help improve sample sizes, but will be of limited use to answer some of the passage questions we have identified.

Due to environmental variability, two years of study work will be necessary. A large array of stationary monitoring stations (radio and PIT) will be needed to address the issues identified among the project areas. A sufficient level of radio receiver and PIT reader coverage will be required, to provide an appropriate level of resolution, for data analyses, to answer these questions on project operational effects. The study will provide information on a variety of structural and operational aspects of fish migration, relative to route selection, timing, survival, and up and downstream passage attraction, retention, delay, efficiency, survival as some examples at three projects (Turners Falls, NMPS, and Vernon). The use of video monitoring may also be utilized for specific study areas such as the Spillway Ladder, to provide additional information on shad entrance activity, with the understanding of some data limitations associated with this approach (fish identification, water visibility). This study will be coordinated with the proposed study request to evaluate ensonification as a shad behavioral deterrent at the Cabot Station tailrace which will be an additional treatment of the telemetry study.

In addition to the tagging studies, use of video monitoring of the Spillway Fishway would provide additional overall data on Spillway Fishway efficiency as all shad attempting to pass could be monitored versus just those shad that have been tagged.

Level of Effort and Cost

The requested study is extensive and will require a substantial effort and cost to capture, PIT tag, and radio tag a sufficient number of shad at Holyoke to release at upstream locations. We are not aware of any other study technique that would provide project specific fish behavior and migration information to adequately assess existing project operations and provide insight in possible alternative operations and measures needed to address observed negative impacts to fish migration success. Cost for the entire multi-project tagging, tracking and data analysis are expected to range from $400,000 to $500,000 based on past Turners Falls' studies and the 2011 and 2012 shad telemetry studies. Video monitoring of the Spillway fishway would add a modest cost to this study.

Due to the fact tagged shad will move throughout the larger five project area, to varying degrees, there will be expected cost savings (e.g., radio tags) to both owner/operators, provided cooperation in study planning and implementation occurs.

Literature Cited

Atlantic States Marine Fisheries Commission. 2010. Amendment #3 to the interstate fishery management plan for shad and river herring (American shad management). Washington, D.C.

Bell, C. E. and B. Kynard. 1985. Mortality of adult American shad passing through a 17-megawatt Kaplan turbine at a low-head hydro-electric dam. North American Journal of Fisheries Management, 5:33-38.

Castro-Santos, T. 2011. Analysis of American shad passage at Vernon Dam 2011. USGS Conte Lab Internal Report

Castro-Santos, T. and A. Haro. 2005. Turners Falls fish passage studies 2005: results from PIT and radio telemetry studies. CAFRC Internal Report # 2005—04.

Castro-Santos, T. and A. Haro. 2010. Gatehouse fishway telemetry studies: progress report, 2008-2010. USGS CAFRC Internal Report.

Kieffer, M. and B. Kynard. 2012. Spawning and non-spawning migrations, spawning, and effects of river regulation on spawning success of Connecticut River shortnose sturgeon. In Life history and behavior of Connecticut River shortnose sturgeon and other sturgeons. B. Kynard, P. Bronzi, and H. Rosenthal Editors. World Sturgeon Conservation Society: Special Publication #4. Norderstedt, Germany.

Wilder Hydroelectric Project – FERC No. 1892-026
Bellows Falls Hydroelectric Project – FERC No. 1855-045
Vernon Hydroelectric Project – FERC No. 1904-073

Study Request 13: Fish assemblage in project-affected areas

Goals and Objectives
The goal of this study request is to determine the occurrence, distribution, and relative abundance of fish species present in the project-affected areas of the Vernon, Bellows Falls and Wilder Projects, which potentially includes Species of Greatest Conservation Need (SGCN) for both New Hampshire and Vermont.

Specific objectives include:
1) Document fish species occurrence, distribution and abundance within the project-affected areas along spatial and temporal gradients.

2) Compare historical records of fish species occurrence in the project-affected areas to results of this study.

Resource Management Goals
The Agency's goals related to aquatic natural resources are to:
1. Protect, enhance, or restore, diverse high quality habitat necessary to sustain healthy aquatic and riparian plant and animal communities.
2. Provide an instream flow regime that meets the life history requirements of resident fish and wildlife (including invertebrates such as freshwater mussels) throughout the area impacted by Project operations.
3. Minimize the potential negative effects of project operation on water quality and aquatic habitat, and mitigate for loss or degradation.

The Connecticut River is classified by the state of Vermont as Class B cold water fish habitat. Vermont Water Quality Standards state that Class B waters should be managed to achieve and maintain a level of quality that fully supports aquatic biota and habitat. Furthermore, the VTFWD's mission is "the conservation of all species of fish, wildlife, and plants and their habitats for the people of Vermont" (Kart et al. 2005).

Two of the Department's planning goals are:

1. Conserve, enhance, and restore Vermont's natural communities, habitats, and species and the ecological processes that sustain them.
2. Provide a diversity of fish- and wildlife-based activities and opportunities that allow the safe and ethical viewing, regulated harvesting, and utilization of fish, plant and wildlife resources consistent with the North American model of fish and wildlife conservation.

Vermont Fish and Wildlife Department's Strategic Plan (2002 -2010) focuses towards four major areas of concern: resource conservation, fish and wildlife-based recreation and use, human health and safety, efficient operations, and effective management.

Riverine fish species are an important component of the river's ecology and are the basis for the sport fishery. Furthermore, several of the states' SGCN have been documented in the project-affected area.

Determining species occurrence, distribution and abundance will help address research and monitoring needs for species whose populations are poorly known. For example, as outlined in Vermont's Wildlife Action Plan (Kart et al.2005), research and monitoring needs for SGCN include monitoring and assessing populations and habitats for current conditions and future changes, and identifying and monitoring problems for species and their habitats.

A study that aims to provide a comprehensive investigation that documents which fish species are utilizing the project-affected areas in relation to spatial, temporal and environmental gradients (i.e. temperature, dissolved oxygen, pH, turbidity) will allow for a fuller understanding and examination of potential impacts that the Vernon, Bellows Falls and Wilder Project's operations have on the species that reside there. As noted below, there is little information concerning riverine fish in the project-affected areas as related to this study request.

Public Interest Consideration
The requestor is a state natural resource agency.

Existing Information
A thorough and comprehensive assessment of the fish assemblage present in the project-affected areas of the Bellows Falls and Wilder Projects is lacking. The PAD for the Bellows Falls Project acknowledges that, "Little comprehensive information is available regarding characterization of the fish community in relation to the Project." The PAD for the Wilder Project states, "No targeted studies have been conducted to characterize the fish community in relation to the Project."

The most relevant fish study related to the Bellows Falls and Wilder project-affected areas is a Connecticut River electrofishing survey conducted in 2008 (Yoder et al., 2009). While some sampling was conducted in both project-affected areas during the 2008 survey, this survey did not have the same goals and objectives as those outlined above. Additionally, both the Bellows Falls and Wilder PADs acknowledged that fish species assemblage data are limited and that the synthesized data may not be a full representation of species occurrence in the project-affected areas. Although, fish data has been collected by Vermont Yankee for many years in the Vernon Dam project-affected area, objectives and methodology for those fish surveys differ from those stated here, and gear types were generally limited to boat electrofishing which may not be suitable for properly assessing all species present in the project-affected areas. It is unknown if other species may inhabit or utilize aquatic habitats in the projects area that to this date have not been documented by previous surveys. It follows that without more information on the fish community in the project-affected areas, project impacts on fish species are also unknown.

Project Nexus

Project operations have the potential to directly impact fish species life history requirements, biological interactions, and habitat quantity and quality. For example, headpond and tailwater water level fluctuations could dewater important spawning areas or change available habitat, thus limiting productivity of important game fish species by direct impacts to their spawning success or indirectly by limiting the spawning success of forage fish species. Furthermore, several of New Hampshire and Vermont's SGCN have been documented in the project-affected area. Accordingly, a thorough understanding of the current fish assemblage structure and associated metrics are needed in order to examine any potential project-related impacts.

Proposed Methodology

An accepted and robust field sampling design (e.g., as described in Pollock et al. 2002 or MacKenzie et al. 2006) and accepted methods for collecting fish species likely to be present in the project-affected areas (Bonar et al. 2009) should be used to conduct field surveys. Randomly sampling multiple habitat types using a multi-gear approach will be required to ensure that all fish species present are sampled. The spatial scope of the study will be from the most upstream area influenced by the Wilder Dam to the most downstream area influenced by the Vernon Project. Sampling should occur at each selected site across multiple seasons (spring, summer, and fall). Digital photographs should be taken to avoid misidentifying certain species such as Cyprinids.

The sampling design should include replicate samples for estimation of species detection probability. Sample replicates may be gathered temporally, using different methods, by independent observers, or by randomly sampled spatial replicates (MacKenzie et al. 2006). For each replicate sample, data that may be important for describing variation in species occurrence and presence/absence should be collected and recorded, such as gear type, mesohabitat type, depth, velocity, flow, water temperature, substrate, time of day, day of year, presence of cover, proportion of vegetation cover, size of individuals collected (juveniles may select different habitat), and other factors as determined by a qualified biologist. Species detection, occurrence, and/or abundance as related to these parameters should be estimated using methods as described by Kery et al. (2005), MacKenzie et al. (2006), Wenger and Freeman (2008), or Zipkin et al. (2010).

Based on first year study results, specific studies examining impacts of project operations on specific fish species may be requested. A second year of study may be required if first year data collection is limited due to environmental or other conditions, or if river discharge in the first year prove to be atypical (outside of 25-75th percentile of average weekly flow values) during the study period.

Level of Effort and Cost

The cost of the study will be moderate to high as seasonal sampling with several types of gear will be required. However, cost will also be partially dependent on the number of sites sampled, the number of sample replicates, and the extent of the covariate data that are measured. Provided

the collected data are of high quality, analysis and synthesis should take approximately 10-20 days. TransCanada did not propose any studies specifically addressing this issue

Literature Cited

Bonar, S.A., W.A Hubert, and D.W. Willis, editors. 2009. Standard methods for sampling North American freshwater fishes. American Fisheries Society, Bethesda, Maryland.

Kart, J., R. Regan, S.R. Darling, C. Alexander, K. Cox, M. Ferguson, S. Parren, K. Royar, B. Popp, editors. 2005. Vermont's Wildlife Action Plan. Vermont Fish & Wildlife Department. Waterbury, Vermont. http://www.vtfishandwildlife.com/swg_cwcs_report.cfm. (Accessed September 10, 2012).

Kery, M., J.A. Royle, and H. Schmid. 2005. Modeling avian abundance from replicated counts using binomial mixture models. Ecological Applications 15:1450-1461.

MacKenzie, D.I., J.D. Nichols, J.A. Royle, K.H. Pollock, L.L. Bailey, and J.E. Hines. 2006. Occupancy estimation and modeling: inferring patterns and dynamics of species occurrence. Elsevier: San Diego, California.

Pollock, K.H., J.D. Nichols, T.R. Simons, G.L. Farnsworth, L.L. Bailey, and J.R. Sauer. 2002. Large scale wildlife monitoring studies: statistical methods for design and analysis. Environmetrics 13:105-119.

Wenger, S.J., and M.C. Freeman. 2008. Estimating species occurrence, abundance, and detection probability using zero-inflated distributions. Ecology 89:2953-2959.

Yoder, C.O., L.E. Hersha, and B. Appel. 2009. Fish assemblage and habitat assessment of the Upper Connecticut River: preliminary results and data presentation. Final Project Report to: U.S. EPA, Region 1, Boston, MA. Center for Applied Bioassessment & Biocriteria. Midwest Biodiversity Institute. Columbus, OH.

Vermont Fish and Wildlife Department . 2006. Vermont Fish and Wildlife Strategic Plan. http://www.vtfishandwildlife.com/library/reports_and_documents/Fish_and_wildlife/Strategic_Plan.pdf

Zimmerman, J.K.H. 2006. Response of physical processes and ecological targets to altered hydrology in the Connecticut River basin. The Nature Conservancy, Connecticut River Program, Northampton, MA.

Zipkin, E.F., J.A. Royle, D.K. Dawson, and S. Bates. 2010. Multi-species occurrence models to evaluate the effects of conservation and management actions. Biological Conservation 134:479-484.

Turners Falls Hydroelectric Project – FERC No. 1889-081
Northfield Mountain Pumped Storage Project – FERC No. 2485-063

Study Request 13: Fish assemblage in project-affected areas

Goals and Objectives
The goal of this request is to determine the occurrence, distribution, and relative abundance of fish species present in the Project affected areas of the Turners Falls and Northfield Mountain Project Areas, which potentially includes Species of Greatest Conservation Need (SGCN) for Massachusetts, New Hampshire, and Vermont.

Specific objectives include:
1) Document fish species occurrence, distribution and abundance within the project affected area along spatial and temporal gradients.

2) Compare historical records of fish species occurrence in the project affected area to results of this study.

Resource Management Goals
The Agency's goals related to aquatic natural resources are to:
1. Protect, enhance, or restore, diverse high quality habitat necessary to sustain healthy aquatic and riparian plant and animal communities.
2. Provide an instream flow regime that meets the life history requirements of resident fish and wildlife (including invertebrates such as freshwater mussels) throughout the area impacted by Project operations.
3. Minimize the potential negative effects of project operation on water quality and aquatic habitat, and mitigate for loss or degradation.

The Connecticut River is classified by the state of Vermont as Class B cold water fish habitat. Vermont Water Quality Standards state that Class B waters should be managed to achieve and maintain a level of quality that fully supports aquatic biota and habitat. Furthermore, the VTFWD's mission is "the conservation of all species of fish, wildlife, and plants and their habitats for the people of Vermont" (Kart et al. 2005).

Two of the Department's planning goals are:
1. Conserve, enhance, and restore Vermont's natural communities, habitats, and species and the ecological processes that sustain them.
2. Provide a diversity of fish- and wildlife-based activities and opportunities that allow the safe and ethical viewing, regulated harvesting, and utilization of fish, plant and wildlife resources consistent with the North American model of fish and wildlife conservation.

Vermont Fish and Wildlife Department's Strategic Plan (2002 -2010) focuses towards four major areas of concern: resource conservation, fish and wildlife-based recreation and use, human health and safety, efficient operations, and effective management.

Riverine fish species are an important component of the river's ecology and are the basis for the sport fishery. Furthermore, several of the states' SGCN have been documented in the project-affected area.

Determining species occurrence, distribution, and abundance will better clarify what species occur in the project area both spatially and temporally, relative to habitats which may be affected by project operations of the Turners Falls or Northfield Mountain Pump Storage projects. This information will better inform other results from other study requests that will be examining project operation effects on various aquatic habitats, water quality and other related concerns such as entrainment concerns at NFMPS. This information will be used to make recommendations and provide full consideration for all species, including those that might not otherwise be known to occur in the project-affected area and impacts that may affect their population status through direct or indirect effects of the projects.

Public Interest Consideration
The requestor is a natural resource agency.

Existing Information
A thorough and comprehensive assessment of the fish assemblage present in the project-affected areas of the Turners Falls and NFMPS projects is lacking. The PAD for these projects sites notes resident fish surveys conducted by the State of Massachusetts in the early to mid 1970s and a limited 2008 sampling effort by Midwest Biodiversity Inst. (contracted by EPA). The PAD identifies a total of 22 fish species in the project area which omits, as an example of its limited information basis, northern pike, tessellated darter, burbot, eastern silvery minnow, and channel catfish (Ken Sprankle, USFWS, and Jessie Leddick, MADFW, personal communication). It is unknown how many other species may inhabit or utilize aquatic habitats in the projects area, potentially including species of greatest conservation need.

The most relevant recent fish survey study related to the project affected areas is a Connecticut River electrofishing survey conducted in 2008 (Yoder et al., 2009). While some sampling was conducted in both project areas during the 2008 survey, this survey did not have the same goals and objectives as those outlined above. Due to the design of the study limitations in geographic/habitat type coverage both spatially and temporally, and the use of a single gear type, limits the use of these data and that synthesized data may not be a full representation of species occurrence in the project affected areas. It follows that since information is limited regarding the composition of the fish community and their use of habitats in the project-affected area, project impacts on fish species are also unknown.

Project Nexus
Project operations have the potential to directly impact fish species life history requirements, biological interactions, and habitat quantity and quality. For example, headpond and tailwater water level fluctuations could dewater important spawning areas, or affect habitat availability, thus limiting productivity of fish species by direct impacts to their spawning success or indirectly by limiting the spawning success of forage fish species. Accordingly, a thorough understanding of the current fish assemblage structure and associated metrics are needed in order to examine any potential project-related impacts. A Study Request to examine project effects on aquatic

habitats, as well as impacts to spawning habitats (e.g., sea lamprey and black bass) has been submitted and will compliment this request.

Proposed Methodology

An accepted and robust field sampling design (e.g., as described in Pollock et al. 2002 or MacKenzie et al. 2006) and accepted methods for collecting fish species likely to be present in the project-affected areas (Bonar et al. 2009) should be used to conduct field surveys. Randomly sampling multiple habitat types using a multi-gear approach will be required to ensure that all fish species present are sampled. The spatial scope of the study will be from the headwaters of the Turners Falls pool downstream to Sunderland, Massachusetts, and will omit the upper reservoir of Northfield Mountain Pump Storage Project. Sampling should occur at each selected site across multiple seasons (spring, summer, and fall). Digital photographs should be taken to avoid misidentification of certain species such as Cyprinids.

The sampling design should include replicate samples for estimation of species detection probability. Sample replicates may be gathered temporally, using different methods, by independent observers, or by randomly sampled spatial replicates (MacKenzie et al. 2006). For each replicate sample, data that may be important for describing variation in species occurrence and presence/absence should be collected and recorded, such as gear type, mesohabitat type, depth, velocity, flow, water temperature, substrate, time of day, day of year, presence of cover, proportion of vegetation cover, size of individuals collected (juveniles may select different habitat), and/or other factors as determined by a qualified biologist. Species detection, occurrence, and/or abundance and related habitat measures on these parameters should be estimated using methods as described by Kery et al. (2005), MacKenzie et al. (2006), Wenger and Freeman (2008), or Zipkin et al. (2010).

This will be a one year study provided river discharge conditions fall within 25^{th} to 75^{th} percentile for weekly averages. Based upon this study's results, and the additional information obtained on requests to survey aquatic habitats and littoral zone fish spawning, an additional study may be required if evidence of project operation affects on population status or habitat for identified species.

Level of Effort and Cost

The cost of the study will be moderate to high as seasonal sampling with several types of gear will be required. However, cost will also be partially dependent on the number of sites sampled, the number of sample replicates, and the extent of the covariate data that are measured, all which may be flexible. Based on first year study results, a second year of sampling or specific studies examining impacts of project operations on specific fish species may be needed and requested. Provided the collected data are of high quality, analysis and synthesis should take approximately 10-20 days. FirstLight did not propose any studies specifically addressing this issue.

Literature Cited

Bonar, S.A., W.A Hubert, and D.W. Willis, editors. 2009. Standard methods for sampling North American freshwater fishes. American Fisheries Society, Bethesda, Maryland.

Kart, J., R. Regan, S.R. Darling, C. Alexander, K. Cox, M. Ferguson, S. Parren, K. Royar, B. Popp, editors. 2005. Vermont's Wildlife Action Plan. Vermont Fish & Wildlife Department. Waterbury, Vermont. http://www.vtfishandwildlife.com/swg_cwcs_report.cfm. (Access September 10, 2012).

Kery, M., J.A. Royle, and H. Schmid. 2005. Modeling avian abundance from replicated counts using binomial mixture models. Ecological Applications 15:1450-1461.

MacKenzie, D.I., J.D. Nichols, J.A. Royle, K.H. Pollock, L.L. Bailey, and J.E. Hines. 2006. Occupancy estimation and modeling: inferring patterns and dynamics of species occurrence. Elsevier: San Diego, California.

Pollock, K.H., J.D. Nichols, T.R. Simons, G.L. Farnsworth, L.L. Bailey, and J.R. Sauer. 2002. Large scale wildlife monitoring studies: statistical methods for design and analysis. Environmetrics 13:105-119.

Vermont Fish and Wildlife Department . 2006. Vermont Fish and Wildlife Strategic Plan. http://www.vtfishandwildlife.com/library/reports_and_documents/Fish_and_wildlife/Strategic_Plan.pdf

Wenger, S.J., and M.C. Freeman. 2008. Estimating species occurrence, abundance, and detection probability using zero-inflated distributions. Ecology 89:2953-2959.

Yoder, C.O., L.E. Hersha, and B. Appel. 2009. Fish assemblage and habitat assessment of the Upper Connecticut River: preliminary results and data presentation. Final Project Report to: U.S. EPA, Region 1, Boston, MA. Center for Applied Bioassessment & Biocriteria. Midwest Biodiversity Institute. Columbus, OH.

Zimmerman, J.K.H. 2006. Response of physical processes and ecological targets to altered hydrology in the Connecticut River basin. The Nature Conservancy, Connecticut River Program, Northampton, MA.

Zipkin, E.F., J.A. Royle, D.K. Dawson, and S. Bates. 2010. Multi-species occurrence models to evaluate the effects of conservation and management actions. Biological Conservation 134:479-484.

Wilder Hydroelectric Project – FERC No. 1892-026
Bellows Falls Hydroelectric Project – FERC No. 1855-045
Vernon Hydroelectric Project – FERC No. 1904-073

Study Request 14: Impacts of downstream water fluctuations on resident fish spawning

Goals and Objectives
The goal of this study is to determine if the full range of project induced flow and water level fluctuations in the project-affected areas below the Vernon, Bellows Falls and Wilder Dams negatively impact resident fish spawning (smallmouth bass, common white sucker, walleye and fallfish), and if impacts are found to occur, to develop appropriate mitigation measures.

Specific objectives include:
1) Conduct field studies in the project-affected areas downstream from the Vernon, Bellows Falls and Wilder Dams to assess timing and location of fish spawning. Nesting locations should be mapped.

2) Conduct field studies in the Project affected areas below the Vernon, Bellows Falls and Wilder Dams to evaluate potential impacts of the full range of project induced water level fluctuations on nest abandonment, spawning fish displacement and egg dewatering. The study should also evaluate if changes in fluctuation range would mitigate for identified impacts and/or if other mitigative measures would lessen these impacts.

Resource Management Goals
The Agency's goals related to aquatic natural resources are to:
1. Protect, enhance, or restore, diverse high quality habitat necessary to sustain healthy aquatic and riparian plant and animal communities.
2. Provide an instream flow regime that meets the life history requirements of resident fish and wildlife (including invertebrates such as freshwater mussels) throughout the area impacted by Project operations.
3. Minimize the potential negative effects of project operation on water quality and aquatic habitat, and mitigate for loss or degradation.

The Connecticut River is classified by the state of Vermont as Class B cold water fish habitat. Vermont Water Quality Standards state that Class B waters should be managed to achieve and maintain a level of quality that fully supports aquatic biota and habitat. Furthermore, the VTFWD's mission is "the conservation of all species of fish, wildlife, and plants and their habitats for the people of Vermont" (Kart et al. 2005).

Two of the Department's planning goals are:

1. Conserve, enhance, and restore Vermont's natural communities, habitats, and species and the ecological processes that sustain them.
2. Provide a diversity of fish- and wildlife-based activities and opportunities that allow the safe and ethical viewing, regulated harvesting, and utilization of fish, plant and wildlife resources consistent with the North American model of fish and wildlife conservation.

Resident fish species are an important component of the river's ecology and in some cases are the basis for a sport fishery. This requested study will help protect and conserve resident fish species by ensuring Project operations do not negatively impact their spawning success.

Public Interest Consideration
The requestor is a resource agency.

Existing Information
To our knowledge, no information exists related to this requested study.

Project Nexus
Project operations have the potential to impact fish species by influencing spawning success and spawning habitat quality and quantity. For example, flow and water level changes due to Project operations could create conditions where fish eggs are exposed to air, where quality spawning habitat is dewatered, and/or where fish abandon nests containing eggs. A study of a regulated river found temporal fluctuations of streamflow appeared to be the most important abiotic factor determining smallmouth bass nesting success or failure (Lukas and Orth 1995). Similarly, other research suggests stream discharge during and immediately after spawning could be important to smallmouth bass recruitment success (Smith et al. 2005). Current can also impact early survival of walleye by moving eggs and larvae from spawning sites (Humphrey et al. 2012).

Proposed Methodology
Common tools to evaluate fish spawning would be used including electrofishing, visual observations, and telemetry. Specific areas of interest are locations in project-affected areas below the Vernon, Bellows Falls and Wilder Dams where it is determined that the before mentioned fish species spawn. A second year of study may be required if first year data collection is limited due to environmental or other conditions, or if river discharge in the first year prove to be atypical (outside of 25-75th percentile of average weekly flow values) during the study period.

Level of Effort and Cost
TransCanada does not propose any studies to meet this need. Estimated cost for the study is moderate.

Literature Cited

Humphrey, S, Y.M. Zhao and D. Higgs. 2012. The effects of water currents on walleye (Sander vitreus) eggs and larvae and implications for the early survival of walleye in Lake Erie. Canadian Journal of Fisheries and Aquatic Sciences 69: 1959-1967.

Lukas, J.A. and D.J. Orth. 1995. Factors affecting nesting success of smallmouth bass in a regulated Virginia stream. Transactions of the American Fisheries Society 124: 726-735.

Smith, S.M., J.S. Odenkirk, and S.J. Reeser. 2005. Smallmouth bass recruitment variability and its relation to stream discharge in three Virginia rivers. North American Journal of Fisheries Management 25: 1112-1121.

Wilder Hydroelectric Project – FERC No. 1892-026
Bellows Falls Hydroelectric Project – FERC No. 1855-045
Vernon Hydroelectric Project – FERC No. 1904-073

Study Request 15: Upstream American eel survey

Goals and Objectives
The goal of this study is to provide baseline data relative to the presence of American eel upstream of the Vernon, Bellows Falls, and Wilder dams.

The objective of the study is to determine the relative abundance and distribution of American eel upstream of the Vernon, Bellows Falls and Wilder dams in both riverine and lacustrine habitat.

Resource Management Goals
The Agency's goals related to aquatic natural resources are to:
1. Protect, enhance, or restore, diverse high quality habitat necessary to sustain healthy aquatic and riparian plant and animal communities.
2. Provide an instream flow regime that meets the life history requirements of resident fish and wildlife (including invertebrates such as freshwater mussels) throughout the area impacted by Project operations.
3. Minimize the potential negative effects of project operation on water quality and aquatic habitat, and mitigate for loss or degradation.

The Connecticut River is classified by the state of Vermont as Class B cold water fish habitat. Vermont Water Quality Standards state that Class B waters should be managed to achieve and maintain a level of quality that fully supports aquatic biota and habitat. Furthermore, the VTFWD's mission is "the conservation of all species of fish, wildlife, and plants and their habitats for the people of Vermont" (Kart et al. 2005).

Two of the Department's planning goals are:

1. Conserve, enhance, and restore Vermont's natural communities, habitats, and species and the ecological processes that sustain them.
2. Provide a diversity of fish- and wildlife-based activities and opportunities that allow the safe and ethical viewing, regulated harvesting, and utilization of fish, plant and wildlife resources consistent with the North American model of fish and wildlife conservation.

Vermont Fish and Wildlife Department's Strategic Plan (2002 -2010) focuses towards four major areas of concern: resource conservation, fish and wildlife-based recreation and use, human health and safety, efficient operations, and effective management.

The American eel (*Anguilla rostrata*), is listed as one of both New Hampshire's and Vermont's Species of Greatest Conservation Need (SGCN). The status for conservation need in Vermont is listed as high priority (Kart et al. 2005), and the species is listed as "vulnerable" in New Hampshire. As identified in Vermont's Wildlife Action Plan (Kart et al. 2005), threats to the species include the

construction of large dams on rivers which obstruct juvenile fish access to critical rearing habitats, as well as mortality associated with passing through hydroelectric facilities' turbines during their outmigration to sea.

As outlined in Vermont's Wildlife Action Plan (Kart et al. 2005), research and monitoring needs for this SGCN include determining their distribution and abundance, as the contribution of eels in northern regions to overall stock is unknown. One of the conservation strategies for this species is to support efforts to enhance access of American eels to Vermont waters by eliminating or minimizing impacts of dams and other obstructions along the Richelieu, St. Lawrence, and Connecticut Rivers.

The Atlantic States Marine Fisheries Commission has developed two documents related to the management of American eel:

1. Interstate Fishery Management Plan for American Eel. April 2000. Atlantic States Marine Fisheries Commission.

2. Addendum II to the Fishery Management Plan for American Eel. Atlantic States Marine Fisheries Commission. Approved October 23, 2008. 8 pp.

Objectives of the management plan include: (1) protect and enhance American eel abundance in all watersheds where eel now occur; and (2) where practical, restore American eel to those waters where they had historical abundance but may now be absent by providing access to inland waters for glass eel, elvers, and yellow eel and adequate escapement to the ocean for pre-spawning adult eel.

Addendum II contains specific recommendations for improving upstream and downstream passage of American eel, including requesting that member states and jurisdictions seek special consideration for American eel in the FERC relicensing process.

The Connecticut River Atlantic Salmon Commission (CRASC) was established by Congress in 1983 (and reauthorized in 2002 for another 20 years) through the Connecticut River Atlantic Salmon Compact (Public Law 98-138). The Vermont Fish and Wildlife Department is a CRASC member agency, and a senior biologist from the department serves on the Technical Committee. The CRASC developed A Management Plan for American Eel (*Anguilla rostrata*) in the Connecticut River Basin in 2005. The goal of the plan is "to protect and enhance the abundance of the American eel resource to ensure its continued role in the Connecticut River Basin ecosystem…" Management objectives in the plan include the following:

1. Protect and enhance eel populations where they currently exist;

2. Where practical, restore populations to waters where they had historical abundance;

3. Provide effective upstream and downstream fish passage around dams and other barriers within the species' range in the basin; and

4. Comply with all requirements of the Fishery Management Plan of the ASMFC.

Based on these plans, the Agency seeks the accomplishment of a number of resource goals and objectives through the relicensing process for the Project. General goals include the following:

1. Ensure that protection, mitigation and enhancement measures are commensurate with Project effects and help meet regional fish and wildlife objectives for the basin.
2. Conserve, protect, and enhance the habitats for fish, wildlife, and plants that continue to be affected by the Project.

Specific to American eels, the Agency's goals are:

3. Protect, enhance, or restore, diverse high quality aquatic and riparian habitats for plants, animals, food webs, and communities in the watershed and mitigate for loss or degradation of these habitats.
4. Understand the baseline condition with respect to the presence of American eel within and upstream of the project area.
5. Minimize current and potential negative project operation effects on American eel inhabiting the project area and/or moving through the area during upstream and downstream migrations

Our study request is intended to facilitate the collection of information necessary to conduct effects analyses and to develop reasonable and prudent conservation measures, and protection, mitigation, and enhancement measures pursuant to the Endangered Species Act of 1973, as amended (16 U.S.C. §1531 *et seq*.), the Fish and Wildlife Coordination Act, as amended (16 U.S.C. §661 *et seq*.), and the Federal Power Act (16 U.S.C. §791a, *et seq*.).

Public Interest Consideration

The requestor is a resource agency.

Existing Information

According to the PADs, very few American eels were collected in the Fish Assemblage and Habitat Assessment of the Upper Connecticut River (Yoder et al., 2009). In the Vernon Project area upstream of the dam, only one eel was collected; no eels were collected from the Bellows Falls pool, and none were found upstream of the Wilder Dam. However, in 2012 over 200 eels were documented using the upstream fish ladder at the Vernon Project and the New Hampshire Fish and Game Department has observed eels upstream of the Bellows Falls and Wilder dams. More recently, eels have been observed in Lake Morey, Vermont, which is located upstream of Wilder Dam (Lael Will, VDFW, personal communication). Therefore, while it is clear that some eels are passing all three dams (Vernon, Bellows Falls, and Wilder), it remains unknown how many eels may be rearing in the mainstem habitat upstream of the dams or in tributaries and lakes and ponds that feed into the mainstem river.

No targeted eel surveys have been conducted to determine the abundance and distribution of American eels in riverine and lacustrine habitat upstream of the three projects. This information gap needs to be filled so resource agencies can evaluate properly the need for, and timing of, downstream passage and protection measures for outmigrating silver phase eels.

It should be noted that within the past seven years, the USFWS has received two petitions to list the American eel under the Endangered Species Act. The first petition was received on

November 18, 2004. On July 6, 2005 the USFWS issued a substantial 90-day finding on the petition and initiated a 12-month status review that concluded on February 2, 2007 with a finding that listing was not warranted. The second petition was filed on April 30, 2010 by the Council for Endangered Species Act Reliability. On September 29, 2011 the USFWS issued a substantial 90-day finding and initiated a 12-month status review. The USFWS is still accepting new American eel information for the ongoing status review. The USFWS also is currently in settlement negotiations with CESAR on their legal complaint that the USFWS failed to complete the 12-month finding within the statutory timeframe. It is likely that the USFWS's 12-month finding on the latest petition will be made prior to any new licenses being issued for the projects.

Project Nexus

The project configurations present problems with respect to providing safe, timely and effective passage for outmigrating eels. The intakes are deep and, while no specification for the trashracks were provided in the PADs, it is unlikely that they would prevent impingement and/or entrainment of eels. Existing anadromous downstream passage facilities at the projects also would not be expected to be effective for eels; the target anadromous species are surface-oriented, while eels tend to move much deeper in the water column. If eels are utilizing habitat upstream of the dams, then appropriate protection and downstream passage measures will be needed.

In order to understand the need for, and timing of, downstream eel passage at the projects, we are requesting that TransCanada undertake eel surveys in the Connecticut River upstream of the three dams and in tributaries feeding into the mainstem river within the project areas. Surveying tributary habitat is necessary because surveying the mainstem alone may lead to an underestimation of eel abundance, particularly if there are relatively short tributary streams that lead to a lake or pond (where eels may accumulate, leading to true high densities).

Proposed methodology

The Agency requests an eel survey be conducted in the mainstem river an tributaries upstream from the three projects. The methodology should be similar to that used in the relicensing of the Saluda Hydroelectric Project, FERC No. 516 (Appendix A), the eel assessment for the Merrimack River completed by the USFWS's Central New England Fishery Resources Office (Appendix B), and the proposed study plan for the relicensing of the Eastman Falls Project (FERC No. 2457)[3].

In general, a combination of electroshocking (backpack in wadeable rivers and boat-mounted in larger rivers and lakes) and eel pots should be used to collect eels and determine catch rates. Sampled habitat should include: the mainstem Connecticut River from upstream of Vernon Dam to below the Ryegate Dam; tributaries to the Connecticut within that stretch where eels have been collected previously; and lakes and ponds (such as, but not limited to, Spofford Lake and Lake Morey), where eels have been collected previously. Sampling should occur during the summer (July through September).

[3] FERC Accession No. 20121214-5121

Level of Effort and Cost

The expected level of effort and anticipated costs will be comparable to that experienced on similar FERC projects of this size. A study plan recently submitted for the Eastman Falls Project (FERC No. 2457) on the Pemigewasset River in New Hampshire, which is utilizing a similar methodology, estimated that sampling a nine-mile-long impoundment with shocking and eel pots would cost $25,000. They estimated the effort to be two nights for the electrofishing survey. Given the much larger area that will need to be sampled under this request, we estimate moderate cost and effort will be required (20 days of shocking mainstem habitat plus another 5-10 days for tributaries and associated lake/pond habitat).

Literature Cited

Kart, J., R. Regan, S.R. Darling, C. Alexander, K. Cox, M. Ferguson, S. Parren, K. Royar, B. Popp, editors. 2005. Vermont's Wildlife Action Plan. Vermont Fish & Wildlife Department. Waterbury, Vermont. http://www.vtfishandwildlife.com/swg_cwcs_report.cfm. (Accessed September 10, 2012).

Vermont Fish and Wildlife Department . 2006. Vermont Fish and Wildlife Strategic Plan. http://www.vtfishandwildlife.com/library/reports_and_documents/Fish_and_wildlife/Strategic_Plan.pdf

Wilder Hydroelectric Project – FERC No. 1892-026
Bellows Falls Hydroelectric Project – FERC No. 1855-045
Vernon Hydroelectric Project – FERC No. 1904-073

***Study Request 16: Project effects on populations of tessellated darter,* Etheostoma olmstedi**

Goals and Objectives
The goal of this study is to evaluate the effects of project operations on populations of tessellated darter (*Etheostoma olmstedi*), a New Hampshire species of greatest conservation concern and known host species for the federally-endangered dwarf wedgemussel (*Alasmidonta heterodon*). The specific objectives of the study are to:

1. Determine the distribution and abundance of tessellated darter within project-affected areas; and
2. Determine the effects of project operations on the distribution and abundance of tessellated darter.

Resource Management Goals
The Agency's goals related to aquatic natural resources are to:

1. Protect, enhance, or restore, diverse high quality habitat necessary to sustain healthy aquatic and riparian plant and animal communities.
2. Provide an instream flow regime that meets the life history requirements of resident fish and wildlife (including invertebrates such as freshwater mussels) throughout the area impacted by Project operations.
3. Minimize the potential negative effects of project operation on water quality and aquatic habitat, and mitigate for loss or degradation.

The Connecticut River is classified by the state of Vermont as Class B cold water fish habitat. Vermont Water Quality Standards state that Class B waters should be managed to achieve and maintain a level of quality that fully supports aquatic biota and habitat. Furthermore, the VTFWD's mission is "the conservation of all species of fish, wildlife, and plants and their habitats for the people of Vermont" (Kart et al. 2005).

Two of the Department's planning goals are:

1. Conserve, enhance, and restore Vermont's natural communities, habitats, and species and the ecological processes that sustain them.
2. Provide a diversity of fish- and wildlife-based activities and opportunities that allow the safe and ethical viewing, regulated harvesting, and utilization of fish, plant and wildlife resources consistent with the North American model of fish and wildlife conservation.

Vermont Fish and Wildlife Department's Strategic Plan (2002 -2010) focuses towards four major areas of concern: resource conservation, fish and wildlife-based recreation and use, human health and safety, efficient operations, and effective management.

The tessellated darter is one of only three fish species in the Upper Connecticut River that serve as hosts for the glochidia of the federally-endangered dwarf wedgemussel, the others being the slimy sculpin (*Cottus cognatus*) and the Atlantic salmon (*Salmo salar*) (Wicklow 2005).

Tessellated darters may be the most important hosts for the dwarf wedgemussel in the Upper Connecticut for the following reasons:

- The USFWS has decided to end its program of stocking hatchery-reared salmon in the Connecticut River basin and accordingly it is unlikely that salmon parr will be available as potential hosts.
- The tessellated darter appears to be more widespread than the slimy sculpin in the Bellow Falls and Wilder project areas where the dwarf wedgemussel is known to exist. Yoder et. al. (2009) found the darter in the project areas upstream and downstream of both dams, while the sculpin was not found in either project area.

The dwarf wedge mussel is state and federally listed as endangered. Populations in the Upper Connecticut River are dependent on healthy tessellated darter populations, and therefore a better understanding of how dam operations affect the darter is crucial to the recovery of the dwarf wedgemussel.

A mission of both the New Hampshire Fish and Game Department and the Vermont Fish and Wildlife Department is to protect and conserve fish and wildlife and their habitats. Riverine fish species are an important component of the river's ecology. Tessellated darter is identified by New Hampshire as a Species of Greatest Concern.

Public Interest Consideration
The requestor is a resource agency.

Existing Information
In the Preliminary Application Documents (PADs)s for the Wilder, Bellows Falls, and Vernon projects, the applicant acknowledges that tessellated darter is one of the confirmed hosts of dwarf wedgemussel. It also identifies the occurrence of tessellated darter both upstream and downstream of each project. However, studies that specifically target small-bodied benthic species are lacking in project-affected areas. It is therefore likely that results of previous investigations are biased and underestimate true population size. An effective evaluation of project effects on a population will require robust, unbiased estimates of population parameters such as abundance or occupancy and similar estimates of population parameters under known conditions of low to no effect.

Existing literature indicates that tessellated darters may be found in a variety of habitats (Scott and Crossman 1979, Van Snik Gray and Stauffer 1999, Hartel 2002, Van Snik Gray et al. 2005, Henry and Grossman 2008), but these habitats are not necessarily equal in their ability to support the population or its function as host to dwarf wedgemussel. We cannot be certain that habitat use infers preference, nor that habitat use will be consistent from basin to basin. Therefore, habitat use within project-affected areas should be evaluated, and should be evaluated in concert with population parameters. By estimating population parameters (e.g., abundance, occupancy, extinction/colonization) as functions of habitat, we may determine whether habitat contributes to any differences in populations and if so, what specific habitat is preferred for stable and persistent populations.

Project Nexus

Operations at the Wilder, Bellows Falls, and Vernon projects alter natural river flow and consequently cause changes in the availability of instream habitat on which the tessellated darter and other lotic species depend. Habitat for tessellated darters is directly related to project operations in terms of flow (water depth and velocity, and their timing, duration, frequency, and rate of change) as well as the interactions of flow with other habitat variables such as substrata, vegetation, and cover. Operations both upstream (changes to the reservoir) and downstream (changes to the flow regime) may affect habitat, and may consequently lead to changes in the distribution, abundance, and behavior of tessellated darters that could in turn potentially affect the federally-endangered dwarf wedge mussel, for which the tessellated darter is a host species.

The information collected for this requested study will help determine whether project operations have a substantial effect on populations of tessellated darter, or whether population parameters are consistent with those of other populations in the region. If there is an effect of project operations on darter populations, study results will also permit identification of those habitat components related to operations that are most important for maintenance of stable and persistent populations of tessellated darter. This will in turn provide information that will assist the development of recommendations aimed to maintain populations of dwarf wedgemussel.

Proposed Methodology

Using an accepted and robust field sampling design (e.g., as described in Pollock et al. 2002 or MacKenzie et al. 2006) and accepted methods for collecting tessellated darters and other similar small-bodied fishes, conduct a field survey for tessellated darters within all project-affected areas from the headwaters of the Wilder pool downstream to the Vernon dam, as well as in selected areas outside of the project-affected areas with known stable populations of tessellated darter and/or dwarf wedgemussel. Such a sampling design should include replicate samples for estimation of species detection probability. For each replicate sample, collect and record data that may be important for describing differences in populations of tessellated darter, such as presence or abundance of other species (e.g., dwarf wedgemussel, slimy sculpin *Cottus cognatus*), depth, velocity, water temperature, substrata, time of day, presence of cover, proportion of vegetation cover, size of individuals collected (juveniles may select different habitat; larger individuals may outcompete smaller individuals for preferred habitat), and other factors as determined by a qualified biologist. Include also as covariates any relevant flow characteristics (Zimmerman 2006) that may differ among sites.

Using methods as described by Kery et al. (2005), MacKenzie et al. (2006), or Wenger and Freeman (2008), determine whether population estimates of tessellated darter are different in project-affected areas and, if so, which measured factors or flow characteristics are most important in describing these differences.

Level of Effort and Cost

The cost for collecting the data for this study is entirely dependent on the number of sites, number of sample replicates, and the extent of the covariate data that are measured, all of which and should be determined during the development of the study plan in consultation with fishery agencies and other parties, and may be adjusted during the course of field sampling. In general, if a species is common and easily captured, few replicates and many sites produce the best

estimates, whereas more replicates and fewer sites are preferable for rare species. In general, the more replicates added, the lower the errors in detection probability, and the more sites sampled, the lower the errors in population parameters. The number of people required in the field will be dependent on the sampling method that is selected, but should be at least two individuals. Provided the collected data are of high quality, analysis and synthesis should take at most 5-10 days.

Literature Cited

Henry, B.E., and G.D. Grossman. 2008. Microhabitat use by blackbanded (*Percina nigrofasciata*), turquoise (*Etheostoma inscriptum*), and tessellated *(E. olmstedi*) darters during drought in a Georgia piedmont stream. Environmental Biology of Fishes 83:171-182.

Hartel, K.E., D.B. Halliwell, and A.E. Launer. 2002. *Inland Fishes of Massachusetts*. Massachusetts Audubon Society: Lincoln, MA.

Kart, J., R. Regan, S.R. Darling, C. Alexander, K. Cox, M. Ferguson, S. Parren, K. Royar, B. Popp, editors. 2005. Vermont's Wildlife Action Plan. Vermont Fish & Wildlife Department. Waterbury, Vermont. http://www.vtfishandwildlife.com/swg_cwcs_report.cfm. (Accessed September 10, 2012).

Kery, M., J.A. Royle, and H. Schmid. 2005. Modeling avian abundance from replicated counts using binomial mixture models. Ecological Applications 15:1450-1461.

MacKenzie, D.I., J.D. Nichols, J.A. Royle, K.H. Pollock, L.L. Bailey, and J.E. Hines. 2006. Occupancy estimation and modeling: inferring patterns and dynamics of species occurrence. Elsevier: San Diego, California.

Pollock, K.H., J.D. Nichols, T.R. Simons, G.L. Farnsworth, L.L. Bailey, and J.R. Sauer. 2002. Large scale wildlife monitoring studies: statistical methods for design and analysis. Environmetrics 13:105-119.

Scott, W.B. and E.J. Crossman. 1979. Freshwater fishes of Canada. The Bryant Press Limited: Ottawa, Canada.

Van Snik Gray, E. and J.R. Stauffer, Jr. 1999. Comparative microhabitat use of ecologically similar benthic fishes. Environmental Biology of Fishes 56:443-453.

Van Snik Gray, E., K.A. Kellogg, and J.R. Stauffer, Jr. 2005. Habitat shift of a native darter *Etheostoma olmstedi* (Teleostei: Percidae) in sympatry with a non-native darter *Etheostoma zonale*. American Midland Naturalist 154:166-177.

Vermont Fish and Wildlife Department . 2006. Vermont Fish and Wildlife Strategic Plan. http://www.vtfishandwildlife.com/library/reports_and_documents/Fish_and_wildlife/Strategic_Plan.pdf

Wenger, S.J., and M.C. Freeman. 2008. Estimating species occurrence, abundance, and detection probability using zero-inflated distributions. Ecology 89:2953-2959.

Wicklow, B. 2005. in New Hampshire Wildlife Action Plan. New Hampshire Fish and Game Department, Concord, NH, 03301. pp. A26-A35.

Yoder, C.O., L.E. Hersha, & B. Appel. 2009. Fish assemblage and habitat assessment of the Upper Connecticut River: preliminary results and data presentation. Final Project Report to:

U.S. EPA, Region 1, Boston, MA. Center for Applied Bioassessment & Biocriteria. Midwest Biodiversity Institute. Columbus, OH.

Zimmerman, J.K.H. 2006. Response of physical processes and ecological targets to altered hydrology in the Connecticut River basin. The Nature Conservancy, Connecticut River Program, Northampton, MA.

Wilder Hydroelectric Project – FERC No. 1892-026
Bellows Falls Hydroelectric Project – FERC No. 1855-045
Vernon Hydroelectric Project – FERC No. 1904-073

Study Request 17: Assessment of adult sea lamprey (*Petromyzon marinus*) spawning within the project areas

Goals and Objectives

The goal of this project is to assess the level of spawning activity by sea lamprey in the Wilder, Bellows Falls, and Vernon project areas and determine whether operations at these projects are affecting the success (i.e., survival to emergence) of lamprey spawning.

The objectives are:

Identify areas within the Wilder, Bellows Falls, and Vernon project areas where suitable spawning habitat exists for sea lamprey.

Conduct a telemetry study of sea lamprey during their upstream migration period in the spring, focusing on areas of suitable spawning habitat, and areas of known spawning.

Conduct spawning ground surveys to observe the utilization of this habitat for spawning purposes, and hence, confirm suitability.

Obtain data on redd characteristics including location, size, substrate, depth and velocity.

Determine if the operations at the Wilder, Bellows Falls and Vernon projects are adversely affecting these spawning areas (i.e. if flow alterations are causing dewatering and/or scouring of sea lamprey redds). If it is determined that the operations of the projects are adversely affecting the spawning success of sea lamprey, identify operational regimes that will reduce and minimize impacts to sea lamprey spawning habitat and spawning success within the project area.

Resource Management Goals

The Agency's goals related to aquatic natural resources are to:

1. Protect, enhance, or restore, diverse high quality habitat necessary to sustain healthy aquatic and riparian plant and animal communities.
2. Provide an instream flow regime that meets the life history requirements of resident fish and wildlife (including invertebrates such as freshwater mussels) throughout the area impacted by Project operations.
3. Minimize the potential negative effects of project operation on water quality and aquatic habitat, and mitigate for loss or degradation.

The Connecticut River is classified by the state of Vermont as Class B cold water fish habitat. Vermont Water Quality Standards state that Class B waters should be managed to achieve and maintain a level of quality that fully supports aquatic biota and habitat. Furthermore, the

VTFWD's mission is "the conservation of all species of fish, wildlife, and plants and their habitats for the people of Vermont" (Kart et al. 2005).

Two of the Department's planning goals are:

1. Conserve, enhance, and restore Vermont's natural communities, habitats, and species and the ecological processes that sustain them.
2. Provide a diversity of fish- and wildlife-based activities and opportunities that allow the safe and ethical viewing, regulated harvesting, and utilization of fish, plant and wildlife resources consistent with the North American model of fish and wildlife conservation.

Vermont Fish and Wildlife Department's Strategic Plan (2002 -2010) focuses towards four major areas of concern: resource conservation, fish and wildlife-based recreation and use, human health and safety, efficient operations, and effective management.

The sea lamprey (*Petromyzon marinus*), within the Connecticut River drainage, is one of New Hampshire and Vermont's Species of Greatest Conservation Need (SGCN). The conservation status of sea lamprey in New Hampshire is listed as "vulnerable." One of the threats identified in Vermont's Wildlife Action Plan (Kart et al. 2005) is degraded spawning habitat, which is second to habitat fragmentation.

As outlined in Vermont's Wildlife Action Plan (Kart et al. 2005), research and monitoring needs for SGCN include monitoring and assessing populations and habitats for current conditions and future changes, and identifying and monitoring problems for species and their habitats.

One of the conservation strategies identified in the Vermont Wildlife Action Plan, is protecting and restoring aquatic and riparian habitats through improved water quality; flow, water level and temperature regimes; sediment reduction; establishment of streamside buffers; and suitable aquatic habitat structure, diversity and complexity.

In support of conservation strategies and research needs listed above, identifying potential impacts that the Wilder, Bellows Falls, and Vernon Projects have on sea lamprey spawning is paramount. Results of the study will be used to develop flow-related license requirements and/or other mitigation measures that will optimize spawning habitat for a New Hampshire and Vermont SGCN.

Public Interest Consideration

The requestor is a state resource agency.

Existing Information

It is known that sea lamprey spawn in the Connecticut River main stem at least as far upstream as Wilder Dam, as well as tributary waters including the West, Williams, Black and White Rivers (Kart et al. 2005).

The PAD discusses sea lamprey distribution as: "FWS (2012) lists the current upstream extent of sea lamprey range as Bellows Falls Dam, noting, however, that reproduction has been

documented as far north as the White River, Vermont, in the Wilder Project area. In certain years hundreds to thousands of sea lamprey have been recorded passing upstream of Bellow Falls dam, and in at least one year (2008) sea lamprey were documented passing upstream via the Wilder Dam fish ladder. In 2008 surveys, Yoder et al. (2009) documented sea lamprey just downstream of the confluence of the White River."

In 2012 at total of 99 sea lamprey were observed passing the Bellows Falls Dam, and a total of 696 sea lamprey were observed passing the Vernon Dam.

To date no studies have been conducted that aim to identify spawning habitat and spawning activity of sea lamprey within in the Wilder, Bellows Falls, and Vernon project areas and whether Project operations are affecting these activities.

Project Nexus

The operation of the Wilder, Bellows Falls and Vernon projects including minimum flows and large and rapid changes in flow releases from the dam have the potential to cause direct adverse effects on spawning habitat and spawning activity downstream of the dam. If adult sea lampreys are actively spawning in the project area, it is important to assess whether operations of the projects are having any adverse effects (i.e. dewatering and scouring) on these activities.

Proposed Methodology

Although a relatively new practice, the tagging and tracking of adult Pacific lamprey to determine final destination, has been successfully conducted in the Columbia River (Noyes et al. 2012). Similarly, from 2005-2009, radio telemetry was used to determine adult lamprey overwintering and spawning habitats, and spawn timing in the lower Deschutes River Subbasin (Fox et al. 2009).

In Vermont, factors affecting sea lamprey survival were examined (Smith and Marsden 2009). It was found that predation, water currents, and displacement of eggs from the nest, played a role in survival.

As part of the Wells Hydroelectric project (FERC No. 2149), Pacific lamprey spawning ground surveys were conducted to determine project effects on spawning success.

In 2010, redd surveys were completed in Shitike and Beaver Creeks to identify recent redds for placement of an experimental redd cap. The purpose of capping lamprey redds was to enumerate emerging larvae and to document timing of emergence with respect to estimated date of redd construction and water temperature (Fox et al. 2010). Therefore, to determine project effects on the spawning success of sea lamprey methods should follow Fox et al. (2010).

Level of Effort and Cost

The estimated level of effort and costs for this recommended study is expected to be moderate to high. The applicant did not propose any alternative studies in its PAD to address this specific issue.

Literature Cited

Fox, M. J.C. Graham, and S. Frank. 2009. Determining Adult Pacific Lamprey Abundance and Spawning Habitat in the Lower Dechutes River Sub-Basin, Oregon. Department of Natural Resources Confederated Tribes of the Warm Springs Reservation, Oregon

Fox, M. J.C. Graham, and S. Frank. 2010. Determining Adult Pacific Lamprey Abundance and Spawning Habitat in the Lower Dechutes River Sub-Basin, Oregon. Department of Natural Resources Confederated Tribes of the Warm Springs Reservation, Oregon

Kart, J., R. Regan, S.R. Darling, C. Alexander, K. Cox, M. Ferguson, S. Parren, K. Royar, B. Popp, editors. 2005. Vermont's Wildlife Action Plan. Vermont Fish & Wildlife Department. Waterbury, Vermont. http://www.vtfishandwildlife.com/swg_cwcs_report.cfm. (Accessed September 10, 2012).

Le, Bao and S. Kreiter. 2008. An assessment of Adult Pacific Lamprey Spawning within the Wells Project. Wells Hydroelectric Project NO. 2149.

Noyes, C.J., C.C. Caudill, T.S. Clabough, D.C. Joosten, E.L. Johnson, M.L. Keefer, and G.P. Naughton. 2011. Adult Pacific lamprey migration behavior and escapement in the Bonneville Reservoir and Lower Columbia River monitored using the juvenile salmonid acoustic telemetry system (JSATS). Technical Report 2012-4-Draft

Smith, S. J. and J. E. Marsden. 2009. Factors Affecting Sea Lamprey Egg Survival. North American Journal of Fisheries Management 29:859–868.

Vermont Fish and Wildlife Department . 2006. Vermont Fish and Wildlife Strategic Plan. http://www.vtfishandwildlife.com/library/reports_and_documents/Fish_and_wildlife/Strategic_Plan.pdf

Wilder Hydroelectric Project – FERC No. 1892-026
Bellows Falls Hydroelectric Project – FERC No. 1855-045
Vernon Hydroelectric Project – FERC No. 1904-073

Study Request 18: Impacts of impoundment water level fluctuations on resident fish spawning

Goals and Objectives
The goal of this study is to determine if the full range of water level fluctuations in the Vernon, Bellows Falls and Wilder Hydroelectric Projects negatively impact resident fish species (smallmouth bass, largemouth bass, yellow perch, black crappie, common sunfish, bluegill, chain pickerel, northern pike, golden shiner, common white sucker, spottail shiner, walleye and fallfish) in the impoundments, and if impacts are found to occur, to develop appropriate mitigation measures.

Specific objectives include:
1) Conduct field studies in the mainstem, tributaries and backwaters of project affected areas to assess timing and location of fish spawning. Nesting locations should be mapped.

2) Conduct field studies in the mainstem, tributaries and backwaters of project-affected areas to evaluate potential impacts of impoundment fluctuation on spawning habitat, nest abandonment, spawning fish displacement and egg dewatering. The study should also evaluate if changes in impoundment fluctuation range would mitigate for identified impacts and if other mitigative measures would lessen these impacts.

Resource Management Goals
The Agency's goals related to aquatic natural resources are to:
1. Protect, enhance, or restore, diverse high quality habitat necessary to sustain healthy aquatic and riparian plant and animal communities.
2. Provide an instream flow regime that meets the life history requirements of resident fish and wildlife (including invertebrates such as freshwater mussels) throughout the area impacted by Project operations.
3. Minimize the potential negative effects of project operation on water quality and aquatic habitat, and mitigate for loss or degradation.

The Connecticut River is classified by the state of Vermont as Class B cold water fish habitat. Vermont Water Quality Standards state that Class B waters should be managed to achieve and maintain a level of quality that fully supports aquatic biota and habitat. Furthermore, the VTFWD's mission is "the conservation of all species of fish, wildlife, and plants and their habitats for the people of Vermont" (Kart et al. 2005).

Two of the Department's planning goals are:
1. Conserve, enhance, and restore Vermont's natural communities, habitats, and species and the ecological processes that sustain them.
2. Provide a diversity of fish- and wildlife-based activities and opportunities that allow the safe and ethical viewing, regulated harvesting, and utilization of fish, plant and wildlife resources consistent with the North American model of fish and wildlife conservation.

Vermont Fish and Wildlife Department's Strategic Plan (2002 -2010) focuses towards four major areas of concern: resource conservation, fish and wildlife-based recreation and use, human health and safety, efficient operations, and effective management.

Riverine fish species are an important component of the river's ecology and in some cases are the basis for a sport fishery. This requested study will help protect and conserve resident fish species by ensuring project operations do not negatively impact their spawning success.

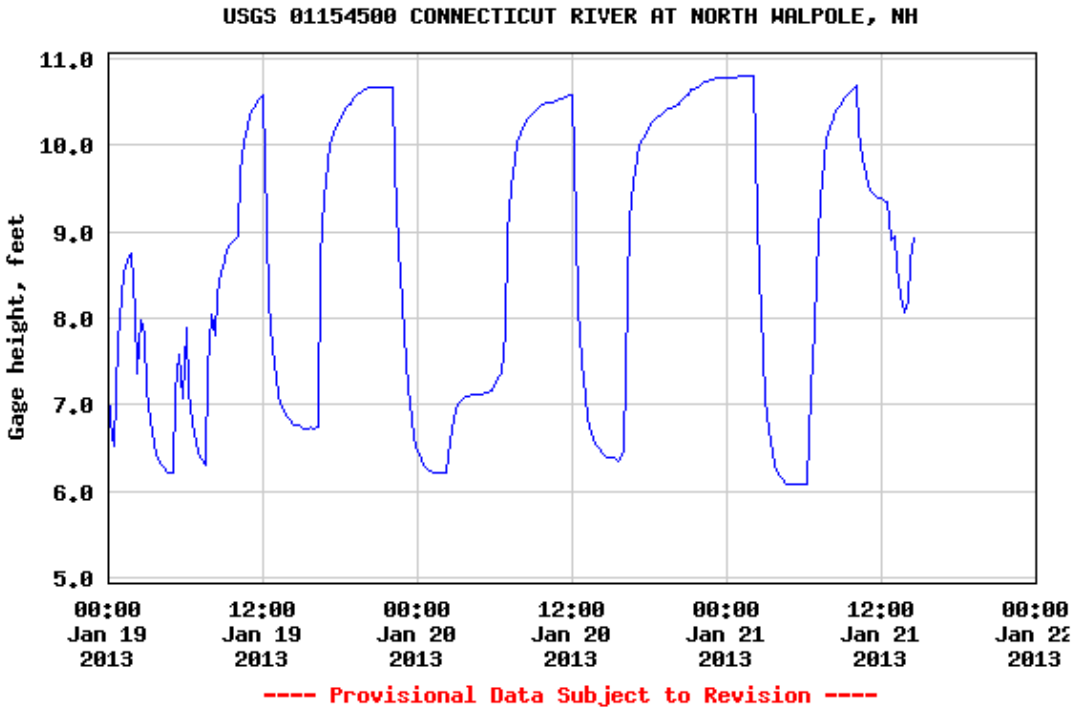
Public Interest Consideration

The New Hampshire Fish and Game Department, the Vermont Fish and Wildlife Department, and the New Hampshire Department of Environmental Services are requesting this study. The requestors are state natural resource agencies.

Existing Information

To our knowledge, no information exists related to this requested study.

An example of the water level fluctuations that occur in the Lower Connecticut River due to hydropower generation is shown below.



Project Nexus

Project operations have the potential to impact fish species by influencing spawning success and spawning habitat quality and quantity. For example, water level changes due to project operations could create conditions where fish eggs are exposed to air, where quality spawning

habitat is dewatered, and/or where fish abandon nests containing eggs. The New Hampshire Fish and Game Department has received several calls in past springs regarding "acres" of yellow perch eggs being dewatered in the Bellows Falls Impoundment.

The projects operate within normal, permitted and flood-condition reservoir fluctuation limits that include during high flow events, the dropping of stanchion bays that cannot be raised without a subsequent drawdown of the impoundment beyond normal project operating ranges. The full range of reservoir fluctuations, including periodic drawdowns for stanchion bay replacement, need to be addressed in this study.

Proposed Methodology

Common tools to evaluate fish spawning and habitat would be used including, but not limited, electrofishing, visual observations, telemetry and habitat measurements. The study area for this request includes all impounded waters, including tributaries and backwaters, within the project-affected areas of the Vernon, Bellows Falls and Wilder Hydroelectric Projects. A second year of study may be required if first year data collection is limited due to environmental or other conditions, or if river discharge in the first year prove to be atypical (outside of 25-75th percentile of average weekly flow values) during the study period.

Level of Effort and Cost

TransCanada does not propose any studies to meet this need. Estimated cost for the study is moderate to high but is dependent on the amount of field study that is needed.

Literature Cited

Kart, J., R. Regan, S.R. Darling, C. Alexander, K. Cox, M. Ferguson, S. Parren, K. Royar, B. Popp, editors. 2005. Vermont's Wildlife Action Plan. Vermont Fish & Wildlife Department. Waterbury, Vermont. http://www.vtfishandwildlife.com/swg_cwcs_report.cfm. (Access September 10, 2012).

Vermont Fish and Wildlife Department . 2006. Vermont Fish and Wildlife Strategic Plan. http://www.vtfishandwildlife.com/library/reports_and_documents/Fish_and_wildlife/Strategic_Plan.pdf

Turners Falls Hydroelectric Project – FERC No. 1889-081
Northfield Mountain Pumped Storage Project – FERC No. 2485-063

Study Request 18: Impacts of impoundment water level fluctuations on resident fish spawning

Goals and Objectives

The goal of this study is to determine if project operations and water level fluctuations in the Turners Falls Project impoundment negatively impact anadromous and resident fish species including but not limited, to sea lamprey, white sucker, fall fish, smallmouth bass, yellow perch, spottail shiners, bluegill, black crappie, chain pickerel, northern pike, common sunfish, and walleye, and if impacts are found to occur, to develop appropriate mitigation measures. This study complements a separate study requests specific to American shad spawning and also on habitats affected by water level manipulations. An additional instream flow study request will address fish habitat effects for species of concern downstream of the Turners Falls Dam.

Specific objectives include:

1. Conduct field studies in the main stem, tributaries and backwaters of project affected areas to assess timing and location of fish spawning.
2. Conduct field studies in the main stem, tributaries and backwaters of project affected areas to evaluate potential impacts of impoundment fluctuation on nest abandonment, spawning fish displacement and egg dewatering. The study should also evaluate if changes in impoundment fluctuation range would mitigate for identified impacts and if other mitigative measures would lessen these impacts.

A second year of study may be required should river discharge in the first year prove to be atypical (outside of 25-75th percentile of average weekly flow values) during the study period (end of March through mid July). Similarly, water temperatures should be closely considered, to ensure representative conditions occurred to reduce bias in observations.

Resource Management Goals

The Agency's goals related to aquatic natural resources are to:

1. Protect, enhance, or restore, diverse high quality habitat necessary to sustain healthy aquatic and riparian plant and animal communities.
2. Provide an instream flow regime that meets the life history requirements of resident fish and wildlife (including invertebrates such as freshwater mussels) throughout the area impacted by Project operations.
3. Minimize the potential negative effects of project operation on water quality and aquatic habitat, and mitigate for loss or degradation.

The Connecticut River is classified by the state of Vermont as Class B cold water fish habitat. Vermont Water Quality Standards state that Class B waters should be managed to achieve and maintain a level of quality that fully supports aquatic biota and habitat. Furthermore, the VTFWD's mission is "the conservation of all species of fish, wildlife, and plants and their habitats for the people of Vermont" (Kart et al. 2005).

Two of the Department's planning goals are:

1. Conserve, enhance, and restore Vermont's natural communities, habitats, and species and the ecological processes that sustain them.
2. Provide a diversity of fish- and wildlife-based activities and opportunities that allow the safe and ethical viewing, regulated harvesting, and utilization of fish, plant and wildlife resources consistent with the North American model of fish and wildlife conservation.

Vermont Fish and Wildlife Department's Strategic Plan (2002 -2010) focuses towards four major areas of concern: resource conservation, fish and wildlife-based recreation and use, human health and safety, efficient operations, and effective management.

Riverine fish species are an important component of the river's ecology and in some cases are the basis for a sport fishery. This requested study will help protect and conserve resident fish species by ensuring Project operations do not negatively impact their spawning success and spawning habitats.

Public Interest Consideration
The requestor is a resource agency.

Existing Information
To our knowledge, no information exists related to this requested study. The Massachusetts Integrated List of Waters shows the Project Area from the VT/NH state line to the Turners Falls Dam impaired due to "other flow regime alterations."

Project Nexus
Project operations have the potential to impact fish species by influencing spawning success and spawning habitat quality and quantity. For example, water level changes due to Project operations could create conditions where fish eggs are exposed to air, where spawning habitat is dewatered, and/or where fish abandon nests containing eggs.

Proposed Methodology
Common tools to evaluate fish spawning would be used including visual observations of habitats and sampled fish (i.e., in spawning condition, coloration, gonads mature, and other external features that become developed with spawning) collected by gears such as electrofishing, seining and other net gears during defined environmental and or time windows for spawning activity. Project operation impacted areas, should be quantified to identify and define areas subject to dewatering and mapped relative to observations of fish nests, spawning fish, egg deposits. During identified spawning periods for these species, suitable spawning habitats subjected to daily project operational fluctuations will be surveyed to document the type and extent of project effects on nests or spawning habitat (fall fish nests, lamprey nests, bass and sunfish nests, white sucker eggs/larvae) and observable eggs or larvae, relative to water level and other environmental condition, including water temperature and water velocity in noted areas.

Level of Effort and Cost
FirstLight Power does not propose any studies to meet this need. Estimated cost for the study is moderate.

Literature Cited

Kart, J., R. Regan, S.R. Darling, C. Alexander, K. Cox, M. Ferguson, S. Parren, K. Royar, B. Popp, editors. 2005. Vermont's Wildlife Action Plan. Vermont Fish & Wildlife Department. Waterbury, Vermont. http://www.vtfishandwildlife.com/swg_cwcs_report.cfm. (Access September 10, 2012).

Vermont Fish and Wildlife Department . 2006. Vermont Fish and Wildlife Strategic Plan. http://www.vtfishandwildlife.com/library/reports_and_documents/Fish_and_wildlife/Strategic_Plan.pdf

Wilder Hydroelectric Project – FERC No. 1892-026
Bellows Falls Hydroelectric Project – FERC No. 1855-045
Vernon Hydroelectric Project – FERC No. 1904-073

Study Request 19: Impacts of project operations on tributary and backwater area access and habitats.

Goals and Objectives
One goal of this study is to determine if water level fluctuations from the Vernon, Bellows Falls and Wilder Hydroelectric Projects result in a barrier(s) to fish movement in and out of tributaries and backwaters to the impoundments and riverine reaches below dams.

A second goal is to determine if water level fluctuations in the Vernon, Bellows Falls and Wilder Project impoundments impact water levels, available fish habitat and water quality in tributaries and backwaters to the impoundments and riverine reaches below dams, and if impacts are found, to ascertain how spatially far reaching they are and develop mitigation measures.

Results of this study may also be used to help determine the adequacy of existing downstream minimum flow requirements.

Specific objectives include:
1) Conduct a field study of tributaries and backwaters, including water velocity and habitat data where appropriate, to evaluate potential impacts of impoundment fluctuation on fish access to tributaries and backwater areas. The study should also evaluate if changes in impoundment fluctuation range would mitigate for any identified impacts and if other mitigative measures would improve access.

2) Conduct a field study to examine potential impacts of impoundment fluctuations on water levels, available habitat and water quality in tributaries and backwaters. The evaluation should also evaluate if changes in impoundment fluctuation range would mitigate for identified impacts and if other mitigative measures would lessen these impacts.

Resource Management Goals
The Agency's goals related to aquatic natural resources are to:
1. Protect, enhance, or restore, diverse high quality habitat necessary to sustain healthy aquatic and riparian plant and animal communities.
2. Provide an instream flow regime that meets the life history requirements of resident fish and wildlife (including invertebrates such as freshwater mussels) throughout the area impacted by Project operations.
3. Minimize the potential negative effects of project operation on water quality and aquatic habitat, and mitigate for loss or degradation.

The Connecticut River is classified by the state of Vermont as Class B cold water fish habitat. Vermont Water Quality Standards state that Class B waters should be managed to achieve and maintain a level of quality that fully supports aquatic biota and habitat. Furthermore, the

VTFWD's mission is "the conservation of all species of fish, wildlife, and plants and their habitats for the people of Vermont" (Kart et al. 2005).

Two of the Department's planning goals are:

1. Conserve, enhance, and restore Vermont's natural communities, habitats, and species and the ecological processes that sustain them.
2. Provide a diversity of fish- and wildlife-based activities and opportunities that allow the safe and ethical viewing, regulated harvesting, and utilization of fish, plant and wildlife resources consistent with the North American model of fish and wildlife conservation.

Vermont Fish and Wildlife Department's Strategic Plan (2002 -2010) focuses towards four major areas of concern: resource conservation, fish and wildlife-based recreation and use, human health and safety, efficient operations, and effective management.

Diadromous and resident riverine fish species are an important component of the river's ecology and in some cases are the basis for a sport fishery. Furthermore, two of the states' Species of Greatest Conservation Need (SGCN) that would potentially be impacted have been documented in the project-affected areas.

This requested study will help promote tributary and backwater access and protect valuable fish habitat and maintain appropriate water quality conditions for diadromous and riverine fish species in project-affected areas. Maintaining connectivity between the mainstem of the Connecticut River and tributaries and backwaters is vital to the fish populations in these systems, as many fish species utilize these areas for spawning, rearing, refuge, and feeding.

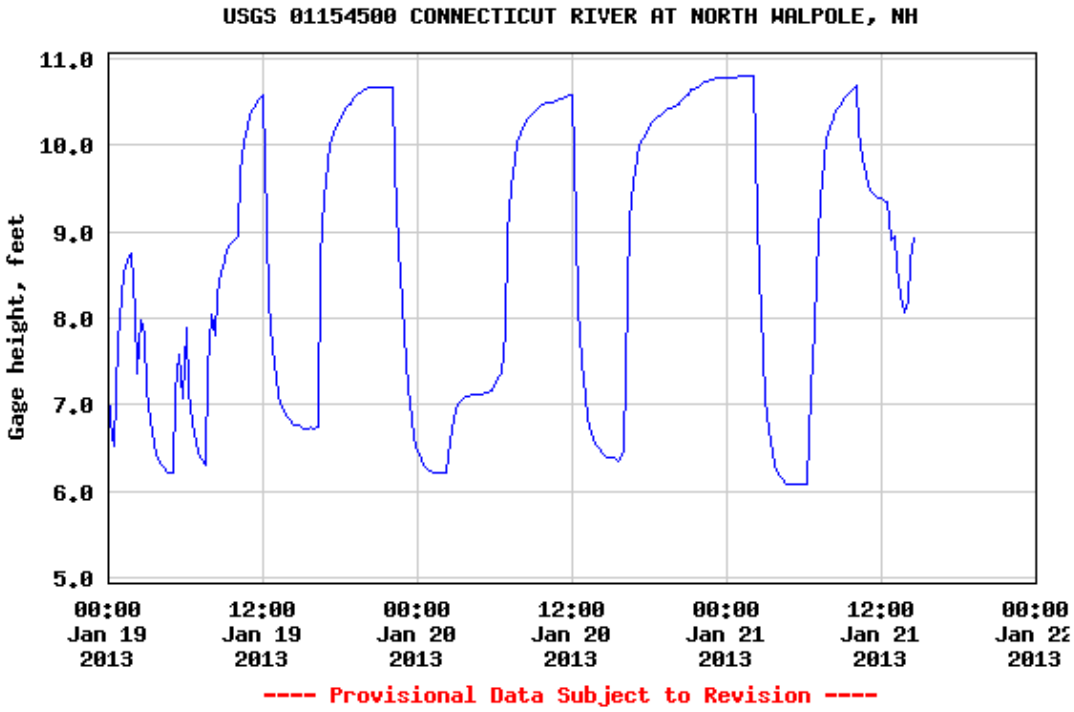
Public Interest Consideration

The New Hampshire Fish and Game Department, the Vermont Fish and Wildlife Department, and the New Hampshire Department of Environmental Services are requesting this study. The requestors are state natural resource agency.

Existing Information

To our knowledge, no information exists related to this requested study.

An example of the water level fluctuations that occur in the Lower Connecticut River due to hydropower generation is shown below.



Project Nexus

Project operations have the potential to impact fish species life history requirements, biological interactions, and habitat quantity and quality. For example, water level changes due to project operations could create conditions that could impede free movement of fish between tributaries/backwaters and the mainstem of the Connecticut River, thus limiting access to spawning habitat and/or growth opportunities. Additionally, water level changes could also alter tributary and backwater fish habitat quality, quantity, and also water quality, thus decreasing productivity and available habitat. Furthermore, two of New Hampshire and Vermont's SGCN that could be impacted have been documented in the project-affected areas.

Proposed Methodology

Common tools to evaluate water level impacts would be used including: bathymetric mapping, substrate, depth and velocity measurements, and water quality information (dissolved oxygen, temperature, turbidity, and pH). Studies should be conducted throughout the year.

The study area for tributary and backwater fish sampling should cover all tributaries and backwaters within the project-affected areas of the Vernon, Bellows Falls and Wilder Hydroelectric Projects. A second year of study may be required if first year data collection is limited due to environmental or other conditions, or if river discharge in the first year prove to be atypical (outside of 25-75th percentile of average weekly flow values) during the study period.

Level of Effort and Cost

TransCanada does not propose any studies to meet this need. Estimated cost for the study is relatively low.

Literature Cited

Kart, J., R. Regan, S.R. Darling, C. Alexander, K. Cox, M. Ferguson, S. Parren, K. Royar, B. Popp, editors. 2005. Vermont's Wildlife Action Plan. Vermont Fish & Wildlife Department. Waterbury, Vermont. http://www.vtfishandwildlife.com/swg_cwcs_report.cfm. (Access September 10, 2012).

Vermont Fish and Wildlife Department . 2006. Vermont Fish and Wildlife Strategic Plan. http://www.vtfishandwildlife.com/library/reports_and_documents/Fish_and_wildlife/Strategic_Plan.pdf

Turners Falls Hydroelectric Project – FERC No. 1889-081
Northfield Mountain Pumped Storage Project – FERC No. 2485-063

Study Request 19: Impacts of project operations on tributary and backwater area access and habitats.

Goals and Objectives
One goal of this study is to determine if water level fluctuations from the Turners Falls and Northfield Mountain Pumped Storage projects result in a barrier(s) to fish movement in and out of tributaries and backwaters to the impoundments and riverine reaches below dams.

A second goal is to determine if water level fluctuations in the Turners Falls and Northfield Mountain Pumped Storage project impoundments impact water levels, available fish habitat and water quality in tributaries and backwaters to the impoundments and riverine reaches below dams, and if impacts are found, to ascertain how spatially far reaching they are and develop mitigation measures.

Results of this study may also be used to help determine the adequacy of existing downstream minimum flow requirements.

Specific objectives include:
1) Conduct a field study of tributaries and backwaters, including water velocity and habitat data where appropriate, to evaluate potential impacts of impoundment fluctuation on fish access to tributaries and backwater areas. The study should also evaluate if changes in impoundment fluctuation range would mitigate for any identified impacts and if other mitigative measures would improve access.

2) Conduct a field study to examine potential impacts of impoundment fluctuations on water levels, available habitat and water quality in tributaries and backwaters. The evaluation should also evaluate if changes in impoundment fluctuation range would mitigate for identified impacts and if other mitigative measures would lessen these impacts.

Resource Management Goals
The Agency's goals related to aquatic natural resources are to:
1. Protect, enhance, or restore, diverse high quality habitat necessary to sustain healthy aquatic and riparian plant and animal communities.
2. Provide an instream flow regime that meets the life history requirements of resident fish and wildlife (including invertebrates such as freshwater mussels) throughout the area impacted by Project operations.
3. Minimize the potential negative effects of project operation on water quality and aquatic habitat, and mitigate for loss or degradation.

The Connecticut River is classified by the state of Vermont as Class B cold water fish habitat. Vermont Water Quality Standards state that Class B waters should be managed to achieve and maintain a level of quality that fully supports aquatic biota and habitat. Furthermore, the

VTFWD's mission is "the conservation of all species of fish, wildlife, and plants and their habitats for the people of Vermont" (Kart et al. 2005).

Two of the Department's planning goals are:
1. Conserve, enhance, and restore Vermont's natural communities, habitats, and species and the ecological processes that sustain them.
2. Provide a diversity of fish- and wildlife-based activities and opportunities that allow the safe and ethical viewing, regulated harvesting, and utilization of fish, plant and wildlife resources consistent with the North American model of fish and wildlife conservation.

Vermont Fish and Wildlife Department's Strategic Plan (2002 -2010) focuses towards four major areas of concern: resource conservation, fish and wildlife-based recreation and use, human health and safety, efficient operations, and effective management.

This requested study will help promote tributary and backwater access and protect valuable fish habitat and maintain appropriate water quality conditions for diadromous and riverine fish species in project-affected areas. Maintaining connectivity between the mainstem of the Connecticut River and tributaries and backwaters is vital to the fish populations in these systems, as many fish species utilize these areas for spawning, rearing, refuge, and feeding.

Public Interest Consideration
The requestor is a state natural resource agency.

Existing Information
To our knowledge, limited information exists related to this requested study.

Project Nexus
Project operations have the potential to impact fish species life history requirements, biological interactions, and habitat quantity and quality. For example, water level changes due to project operations could create conditions that could impede free movement of fish between tributaries/backwaters and the mainstem of the Connecticut River, thus limiting access to spawning habitat and/or growth opportunities. Additionally, water level changes could also alter tributary and backwater fish habitat quality, quantity, and also water quality, thus decreasing productivity and available habitat.

Proposed Methodology
Common tools to evaluate water level impacts would be used including: bathymetric mapping, substrate, depth and velocity measurements, and water quality information (dissolved oxygen, temperature, turbidity, and pH). Studies should be conducted throughout the year.

The study area for tributary and backwater fish sampling should cover all tributaries and backwaters within the project-affected areas of the Turners Falls and Northfield Mountain Pumped Storage projects. A second year of study may be required if first year data collection is limited due to environmental or other conditions, or if river discharge in the first year prove to be atypical (outside of 25-75th percentile of average weekly flow values) during the study period.

Level of Effort and Cost

First Light does not propose any studies to meet this need. Estimated cost for the study is moderate.

Literature Cited

Kart, J., R. Regan, S.R. Darling, C. Alexander, K. Cox, M. Ferguson, S. Parren, K. Royar, B. Popp, editors. 2005. Vermont's Wildlife Action Plan. Vermont Fish & Wildlife Department. Waterbury, Vermont. http://www.vtfishandwildlife.com/swg_cwcs_report.cfm. (Access September 10, 2012).

Vermont Fish and Wildlife Department . 2006. Vermont Fish and Wildlife Strategic Plan. http://www.vtfishandwildlife.com/library/reports_and_documents/Fish_and_wildlife/Strategic_Plan.pdf

Wilder Hydroelectric Project – FERC No. 1892-026
Bellows Falls Hydroelectric Project – FERC No. 1855-045
Vernon Hydroelectric Project – FERC No. 1904-073
Turners Falls Hydroelectric Project – FERC No. 1889-081
Northfield Mountain Pumped Storage Project – FERC No. 2485-063

Study Request 20: Evaluation of timing of downstream migratory movements of American eels on the mainstem Connecticut River

Goals and Objectives
The goal of this study is to better understand migration timing of adult, silver-phase American eels as it relates to environmental factors and operations of mainstem hydropower projects on the Connecticut River.

The objective of this study is to quantify and characterize the general migratory timing and presence of adult, silver-phase American eels in the Connecticut River relative to environmental factors and operations of mainstem river hydroelectric projects

Resource Management Goals
The Connecticut River is classified by the state of Vermont as Class B cold water fish habitat. Vermont Water Quality Standards state that Class B waters should be managed to achieve and maintain a level of quality that fully supports aquatic biota and habitat. Furthermore, the VTFWD's mission is "the conservation of all species of fish, wildlife, and plants and their habitats for the people of Vermont" (Kart et al. 2005).

Two of the Department's planning goals are:
1. Conserve, enhance, and restore Vermont's natural communities, habitats, and species and the ecological processes that sustain them.
2. Provide a diversity of fish- and wildlife-based activities and opportunities that allow the safe and ethical viewing, regulated harvesting, and utilization of fish, plant and wildlife resources consistent with the North American model of fish and wildlife conservation.

Vermont Fish and Wildlife Department's Strategic Plan (2002 -2010) focuses towards four major areas of concern: resource conservation, fish and wildlife-based recreation and use, human health and safety, efficient operations, and effective management.

The Agency's goals related to aquatic natural resources are to:
1. Protect, enhance, or restore, diverse high quality habitat necessary to sustain healthy aquatic and riparian plant and animal communities.
2. Provide an instream flow regime that meets the life history requirements of resident fish and wildlife (including invertebrates such as freshwater mussels) throughout the area impacted by Project operations.
3. Minimize the potential negative effects of project operation on water quality and aquatic habitat, and mitigate for loss or degradation.

The American eel (*Anguilla rostrata*), is listed as one of both New Hampshire's and Vermont's Species of Greatest Conservation Need (SGCN). The status for conservation need in Vermont is listed as high priority (Kart et al. 2005), and the species is listed as "vulnerable" in New Hampshire. As identified in Vermont's Wildlife Action Plan (Kart et al. 2005), threats to the species include the construction of large dams on rivers which obstruct juvenile fish access to critical rearing habitats, as well as mortality associated with passing through hydroelectric facilities' turbines during their outmigration to sea.

As outlined in Vermont's Wildlife Action Plan (Kart et al. 2005), research and monitoring needs for this SGCN include determining their distribution and abundance, as the contribution of eels in northern regions to overall stock is unknown. One of the conservation strategies for this species is to support efforts to enhance access of American eels to Vermont waters by eliminating or minimizing impacts of dams and other obstructions along the Richelieu, St. Lawrence, and Connecticut Rivers.

The Atlantic States Marine Fisheries Commission has developed two documents related to the management of American eel:

1. Interstate Fishery Management Plan for American Eel. April 2000. Atlantic States Marine Fisheries Commission.
2. Addendum II to the Fishery Management Plan for American Eel. Atlantic States Marine Fisheries Commission. Approved October 23, 2008. 8 pp.

Objectives of the management plan include: (1) protect and enhance American eel abundance in all watershed where eel now occur; and (2) where practical, restore American eel to those waters where they had historical abundance but may now be absent by providing access to inland waters for glass eel, elvers, and yellow eel and adequate escapement to the ocean for pre-spawning adult eel.

Addendum II contains specific recommendations for improving upstream and downstream passage of American eel, including requesting that member states and jurisdictions seek special consideration for American eel in the FERC relicensing process.

The Connecticut River Atlantic Salmon Commission (CRASC) was established by Congress in 1983 (and reauthorized in 2002 for another 20 years) through the Connecticut River Atlantic Salmon Compact (Public Law 98-138). The Vermont Fish and Wildlife Department is a CRASC member agency, and a senior biologist from the department serves on the Technical Committee. In addition, the CRASC developed A Management Plan for American Eel (*Anguilla rostrata*) in the Connecticut River Basin in 2005. The goal of the plan is "to protect and enhance the abundance of the American eel resource to ensure its continued role in the Connecticut River Basin ecosystem…" Management objectives in the plan include the following:

1. Protect and enhance eel populations where they currently exist;
2. Where practical, restore populations to waters where they had historical abundance;
3. Provide effective upstream and downstream fish passage around dams and other barriers within the species' range in the basin; and
4. Comply with all requirements of the Fishery Management Plan of the ASMFC.

Based on these plans, the Agency seeks the accomplishment of a number of resource goals and objectives through the relicensing process for the Project. General goals include the following:

1. Ensure that protection, mitigation and enhancement measures are commensurate with Project effects and help meet regional fish and wildlife objectives for the basin.
2. Conserve, protect, and enhance the habitats for fish, wildlife, and plants that continue to be affected by the Project.

Specific to downstream passage of American eel, the Agency goals are:

1. Minimize current and potential negative project operation effects that could hinder management goals and objectives.
2. Minimize project-related sources of downstream passage delay, injury, stress, and mortality in order to maximize the number of silver eels migrating to the spawning grounds.

Our study requests are intended to facilitate the collection of information necessary to conduct effects analyses and to develop reasonable and prudent conservation measures, and protection, mitigation, and enhancement measures pursuant to the Endangered Species Act of 1973, as amended (16 U.S.C. §1531 *et seq*.), the Fish and Wildlife Coordination Act, as amended (16 U.S.C. §661 *et seq*.), and the Federal Power Act (16 U.S.C. §791a, *et seq*.).

Public Interest Consideration

The requester is a state resource agency.

Existing Information

Data on timing of downstream migratory movements and rates of American eels in the mainstem Connecticut River are sparse and relatively incomplete. Preliminary data on presence of "eel-sized" acoustic targets have been collected (Haro et al. 1998) within the Turners Falls Project's Cabot Station forebay that were somewhat confirmed by video monitoring at the Cabot Station downstream fish bypass; however, these were short-term studies, with acoustic monitoring only performed from 17 September to 5 October and video monitoring only conducted between 18 September to 22 October.

Some daily monitoring of the downstream bypass at the Holyoke Dam (canal louver array) was performed in 2004 and 2005 (Kleinschmidt, Inc. 2005, 2006, Normandeau Associates 2007); these studies also were of relatively short duration (spanning from October 5 to November 10 in 2004 and September 9 to November 11 in 2005) and the sampler was only operated at night.

To date, no other directed studies of eel migratory movements have been conducted at any location on the Connecticut River mainstem. This information gap needs to be filled, as it relates directly to when downstream passage and protection measures need to be operated.

We also note that within the past seven years, the United States Fish and Wildlife Service (USFWS) has received two petitions to list the American eel under the Endangered Species Act. The first petition was received on November 18, 2004. On July 6, 2005 the USFWS issued a substantial 90-day finding on the petition and initiated a 12-month status review that concluded

on February 2, 2007 with a finding that listing was not warranted. The second petition was filed on April 30, 2010 by the Council for Endangered Species Act Reliability. On September 29, 2011 the USFWS issued a substantial 90-day finding and initiated a 12-month status review. The USFWS is still accepting new American eel information for the ongoing status review. The USFWS also is currently in settlement negotiations with CESAR on their legal complaint that the USFWS failed to complete the 12-month finding within the statutory timeframe. Although the date for completion of the USFWS's 12-month finding on the latest petition is uncertain, it is likely that it will be made before any new licenses are issued for the projects.

Project Nexus

The timing of downstream migration of adult eels is poorly defined for the Connecticut River; therefore the general effects of hydroelectric project operations on eel survival to the ocean are unknown. Although separate study requests have been submitted to address project-specific downstream passage route selection, delays, and mortality of eels, general characteristics of river flow and environmental conditions may have significant relationships with project operation and eel migratory success and survival. For example, eels may tend to move immediately before or during periods of significant precipitation (or consequently river flow); times at which projects may be generating at maximum capacity or spilling, which may (or may not) present a higher passage risk to eels. Conversely, periods of low flow may be associated with a significant proportion of total river flow passing through turbine units, which present additional (or different) passage risk to eels. If discrete conditions which promote eel downstream migration are known, it may be possible to take actions with respect to project operations which reduce or minimize passage risk; i.e., operation of a bypass, reduction of intake approach velocities, directed spillage through a “safe” route, etc. These studies should provide baseline information on river-specific downstream migration to predict when silver-phase eels are expected to be migrating in the mainstem Connecticut River, from which project operations could be modified to minimize passage risks.

The studies are proposed for a single or multiple sites; the results will be relevant to all sites on the Connecticut River mainstem.

Proposed Methodology

Quantification of downstream movements of American eels in river systems requires systematic sampling of migrants throughout the migratory season. This can be accomplished with traditional active trapping methods; i.e., fyke or stow net sampling, weirs, or eel racks, but these methods are technically challenging on larger mainstem rivers, due to the scale of flows that need to be sampled, difficulties in operation throughout all flow conditions, and high debris loading during fall flows. Passive monitoring of migrant eels using hydroacoustic methods offers an alternative to active trapping. However, passive monitoring requires verification of potential acoustic targets with some level of active (collection) or visual (traditional optical or acoustic video) sampling.

Two potential locations offer opportunities to conduct simultaneous passive and active sampling: the Cabot Station (Turners Falls project) canal/forebay and the Holyoke Dam forebay and canal louver/bypass system. Each location possesses a route of downstream passage which conducts a

significant proportion of river flow (Cabot canal and Holyoke forebay or canal), and each has a proximal bypass equipped with a sampler so that fish can be concentrated/collected from the passage route and identified to species. Project operations do influence the relative proportion of flow (and thus numbers of downstream migrant eels) in each passage route, so numbers of eels sampled in each route represent only a proportion of the total number of eels migrating downstream within the entire river. Because the absolute proportion of eels using a specific route at any one time is unknown, numbers of eels quantified within a route must serve as a relative index of the degree of migratory movement.

This study shall quantify eel movements in either one, or preferably both, locations for two consecutive years (since environmental conditions strongly influence migratory timing of eels, which can vary significantly from year to year; Haro 2003). Eels will be quantified using methods similar to Haro et al. (1999), by continuously monitoring a fixed location at the projects with hydroacoustics. Because eels tend to concentrate in areas of dominant flow (Brown et al. 2009, EPRI 2001), the zone to be monitored should pass a dominant proportion of project flow throughout most periods of operation (i.e., forebay intake area). Hydroacoustic monitoring shall encompass the entire potential migratory season, beginning in mid-August and ending in mid-December, and shall operate 24 hours per day. Data will be recorded for later processing and archiving.

Systematic active quantification of eels at downstream bypass samplers shall be performed simultaneously with passive hydroacoustic monitoring, to verify presence of eels and relative abundance of eel-sized hydroacoustic targets from the hydroacoustic data. Although daily operation of the bypass sampler could be performed, a more comprehensive technique is to monitor eels entering the bypass with an acoustic camera (i.e. DIDSON, BlueView, etc.). The acoustic camera will afford positive visual identification of eels as they enter the bypass, which is a concentration point for migrating eels. Acoustic camera monitoring will also allow monitoring to be performed 24 hours a day, and will be relatively unaffected by water turbidity (which influences effectiveness of traditional optical video monitoring). The acoustic camera system will be operated during the same time period as acoustic monitoring, and images will be recorded for later processing and archiving.

Data analyses of hydroacoustic, acoustic camera, bypass sampling, and environmental/ operational data will follow standard methodology.

Project operation (flows, levels, gate openings, number of units operating and operation level) and environmental conditions (river flow, temperature, turbidity, air temperature, precipitation) will be monitored regularly (hourly measurements if possible) throughout the duration of the studies.

These methodologies are consistent with accepted practice.

Level of Effort and Cost

The level of cost and effort for the downstream migrant eel migratory timing study would be moderate, given the level of cost for instrumentation, deployment, and data review/analysis. Cost is estimated at $50,000 per year for the study.

The applicant did not propose any studies to meet this need in the PAD.

Literature Cited

Brown, L.S. 2005. Characterizing the downstream passage behavior of silver phase American eels at a small hydroelectric facility. M.Sc. Thesis, Department of Natural Resource Conservation, University of Massachusetts, Amherst, Massachusetts. 110 pp.

Brown, L., A. Haro, and T. Castro-Santos. 2009. Three-dimensional movement of silver-phase American eels in the forebay of a small hydroelectric facility. Pages 277-291in: J. Casselman et al. editors. Eels at the Edge: Science, Status, and Conservation Concerns. American Fisheries Society, Bethesda, MD.

EPRI (Electric Power Research Institute). 2001. Review and documentation of research and technologies on passage and protection of downstream migrating catadromous eels at hydroelectric facilities. EPRI Technical Report No. 1000730, Palo Alto, California 270 pp.

Haro, A. 2003. Downstream migration of silver-phase anguillid eels. Pages 215-222 in: Aida, K., K. Tsukamoto, and K. Yamauchi, eds. Eel Biology. Springer, Tokyo.

Haro, A., D. Degan, J. Horne, B. Kulik, and J. Boubée. 1999. An investigation of the feasibility of employing hydroacoustic monitoring as a means to detect the presence and movement of large, adult eels (Genus *Anguilla*). S. O. Conte Anadromous Fish Research Center Internal Report No. 99-01. Turners Falls, Massachusetts. 36 pp.

Kart, J., R. Regan, S.R. Darling, C. Alexander, K. Cox, M. Ferguson, S. Parren, K. Royar, B. Popp, editors. 2005. Vermont's Wildlife Action Plan. Vermont Fish & Wildlife Department. Waterbury, Vermont. http://www.vtfishandwildlife.com/swg_cwcs_report.cfm. (Access September 10, 2012).

Kleinschmidt, Inc. 2005. Factors influencing the timing of emigration of silver-phase American Eels, *Anguilla rostrata*, in the Connecticut River at Holyoke MA. Submitted to the City of Holyoke Holyoke Gas and Electric Department. 27 pp.

Kleinschmidt, Inc. 2006. Holyoke Project (FERC No. 2004) silver-phased American eel flow priority plan. Submitted to the City of Holyoke Holyoke Gas and Electric Department. 51 pp.

Normandeau Associates, Inc. 2007. American eel emigration approach and downstream passage routes at the Holyoke Project, 2006. Submitted to the City of Holyoke Holyoke Gas and Electric Department. Final report. Normandeau Associates, Inc., Westmoreland, New Hampshire. 81 pp.

Vermont Fish and Wildlife Department . 2006. Vermont Fish and Wildlife Strategic Plan. http://www.vtfishandwildlife.com/library/reports_and_documents/Fish_and_wildlife/Strategic_Plan.pdf

Wilder Hydroelectric Project – FERC No. 1892-026
Bellows Falls Hydroelectric Project – FERC No. 1855-045
Vernon Hydroelectric Project – FERC No. 1904-073

Study Request 21: Downstream American eel passage

Goals and Objectives

The goal of this study is to determine the impact of three hydroelectric projects on the outmigration of silver eels in the Connecticut River. Entrainment at the conventional turbines at the Vernon, Bellows Falls, and Wilder projects can result in mortality or injury. It is important to understand the passage routes at each project and the potential for delay, injury, and mortality to assess alternative management options to increase survival.

The objectives of this study are:

1. Quantify the movement rates (including delays) and relative proportion of eels passing via various routes at the projects (i.e. through the turbines, through the downstream bypasses; spilled at the dams, etc.).
2. Evaluate instantaneous and latent mortality and injury of eels passed via each potential route.

Resource Management Goals

The Agency's goals related to aquatic natural resources are to:

1. Protect, enhance, or restore, diverse high quality habitat necessary to sustain healthy aquatic and riparian plant and animal communities.
2. Provide an instream flow regime that meets the life history requirements of resident fish and wildlife (including invertebrates such as freshwater mussels) throughout the area impacted by Project operations.
3. Minimize the potential negative effects of project operation on water quality and aquatic habitat, and mitigate for loss or degradation.

The Connecticut River is classified by the state of Vermont as Class B cold water fish habitat. Vermont Water Quality Standards state that Class B waters should be managed to achieve and maintain a level of quality that fully supports aquatic biota and habitat. Furthermore, the VTFWD's mission is "the conservation of all species of fish, wildlife, and plants and their habitats for the people of Vermont" (Kart et al. 2005).

Two of the Department's planning goals are:

1. Conserve, enhance, and restore Vermont's natural communities, habitats, and species and the ecological processes that sustain them.
2. Provide a diversity of fish- and wildlife-based activities and opportunities that allow the safe and ethical viewing, regulated harvesting, and utilization of fish, plant and wildlife resources consistent with the North American model of fish and wildlife conservation.

Vermont Fish and Wildlife Department's Strategic Plan (2002 -2010) focuses towards four major areas of concern: resource conservation, fish and wildlife-based recreation and use, human health and safety, efficient operations, and effective management.

The American eel (*Anguilla rostrata*), is listed as one of both New Hampshire's and Vermont's Species of Greatest Conservation Need (SGCN). The status for conservation need in Vermont is listed as high priority (Kart et al. 2005), and the species is listed as "vulnerable" in New Hampshire. As identified in Vermont's Wildlife Action Plan (Kart et al. 2005), threats to the species include the construction of large dams on rivers which obstruct juvenile fish access to critical rearing habitats, as well as mortality associated with passing through hydroelectric facilities' turbines during their outmigration to sea.

As outlined in Vermont's Wildlife Action Plan (Kart et al. 2005), research and monitoring needs for this SGCN include determining their distribution and abundance, as the contribution of eels in northern regions to overall stock is unknown. One of the conservation strategies for this species is to support efforts to enhance access of American eels to Vermont waters by eliminating or minimizing impacts of dams and other obstructions along the Richelieu, St. Lawrence, and Connecticut Rivers.

The Atlantic States Marine Fisheries Commission has developed two documents related to the management of American eel:

1. Interstate Fishery Management Plan for American Eel. April 2000. Atlantic States Marine Fisheries Commission.
2. Addendum II to the Fishery Management Plan for American Eel. Atlantic States Marine Fisheries Commission. Approved October 23, 2008. 8 pp.

Objectives of the management plan include: (1) protect and enhance American eel abundance in all watershed where eel now occur; and (2) where practical, restore American eel to those waters where they had historical abundance but may now be absent by providing access to inland waters for glass eel, elvers, and yellow eel and adequate escapement to the ocean for pre-spawning adult eel.

Addendum II contains specific recommendations for improving upstream and downstream passage of American eel, including requesting that member states and jurisdictions seek special consideration for American eel in the FERC relicensing process.

The Connecticut River Atlantic Salmon Commission (CRASC) was established by Congress in 1983 (and reauthorized in 2002 for another 20 years) through the Connecticut River Atlantic Salmon Compact (Public Law 98-138). The Vermont Fish and Wildlife Department is a CRASC member agency, and a senior biologist from the department serves on the Technical Committee. The CRASC developed A Management Plan for American Eel (*Anguilla rostrata*) in the Connecticut River Basin in 2005. The goal of the plan is "to protect and enhance the abundance of the American eel resource to ensure its continued role in the Connecticut River Basin ecosystem…" Management objectives in the plan include the following:

1. Protect and enhance eel populations where they currently exist;
2. Where practical, restore populations to waters where they had historical abundance;

3. Provide effective upstream and downstream fish passage around dams and other barriers within the species' range in the basin; and
4. Comply with all requirements of the Fishery Management Plan of the ASMFC.

Based on these plans, the Agency seeks the accomplishment of a number of resource goals and objectives through the relicensing process for the Project. General goals include the following:
1. Ensure that protection, mitigation and enhancement measures are commensurate with Project effects and help meet regional fish and wildlife objectives for the basin.
2. Conserve, protect, and enhance the habitats for fish, wildlife, and plants that continue to be affected by the Project.

Specific to downstream passage of American eel, the Agency's goals are:
1. Minimize current and potential negative project operation effects that could hinder management goals and objectives.
2. Minimize project-related sources of downstream passage delay, injury, stress, and mortality in order to maximize the number of silver eels migrating to the spawning grounds.

Our study requests are intended to facilitate the collection of information necessary to conduct effects analyses and to develop reasonable and prudent conservation measures, and protection, mitigation, and enhancement measures pursuant to the Endangered Species Act of 1973, as amended (16 U.S.C. §1531 *et seq*.), the Fish and Wildlife Coordination Act, as amended (16 U.S.C. §661 *et seq*.), and the Federal Power Act (16 U.S.C. §791a, *et seq*.).

Public Interest Consideration

The requester is a state resource agency.

Existing Information

The PAD contains information on the biology and life history of the American eel. It also summarizes eel collection data within the Vernon and Bellows Falls project areas. Eels have been collected both upstream and downstream of the Vernon Project and also have been counted passing the upstream anadromous fish ladder. Eels also have been documented upstream of the Bellows Falls and Wilder projects.

To date, no directed studies of eel entrainment or mortality have been conducted at any of the projects. These information gaps need to be filled so resource agencies can assess the relative and cumulative impact of project operations on outmigrating eels and develop adequate passage and protection measures to meet management goals and objectives.

We also note that within the past seven years, the USFWS has received two petitions to list the American eel under the Endangered Species Act. The first petition was received on November 18, 2004. On July 6, 2005 the USFWS issued a substantial 90-day finding on the petition and initiated a 12-month status review that concluded on February 2, 2007 with a finding that listing was not warranted. The second petition was filed on April 30, 2010 by the Council for

Endangered Species Act Reliability (CESAR). On September 29, 2011 the USFWS issued a substantial 90-day finding and initiated a 12-month status review. The USFWS is still accepting new American eel information for the ongoing status review. The USFWS also is currently in settlement negotiations with CESAR on their legal complaint that the USFWS failed to complete the 12-month finding within the statutory timeframe. Although the date for completion of the USFWS's 12-month finding on the latest petition is uncertain, it is likely that it will be made before any new licenses are issued for the projects.

Project Nexus

The Vernon, Bellows Falls, and Wilder projects operate as peaking facilities, except during periods when inflow exceeds the hydraulic capacities of the stations. Silver eels outmigrate during the mid- summer through late fall, a time of year when flows are generally within the operating capacities of the stations. Therefore, the projects would be expected to spill infrequently during the silver eel outmigration.

The project configurations present problems with respect to providing safe, timely and effective passage for outmigrating eels. The intakes likely are deep and, while no specification for the trashracks were provided in the PADs, it is unlikely that they would prevent impingement and/or entrainment of eels. Existing anadromous downstream passage facilities at the projects also would not be expected to be effective for eels; the target anadromous species are surface-oriented, while eels tend to move much deeper in the water column. Eels are known to occur upstream of the dams; therefore, it is necessary to understand how eels move through the projects and the level of injury or mortality caused by entrainment through the projects' turbines.

Proposed Methodology

In order to understand the movements of outmigrating silver eels as they relate to operations at the Vernon, Bellows Falls, and Wilder projects, radio telemetry technology should be utilized. Radio telemetry is an accepted technology that has been used for a number of studies associated with hydropower projects, including at the Muddy Run Project (FERC No. 2355).

Studies should be designed to investigate route selection (i.e., entrainment vs. spill) independently from estimation of mortality/injury, because these metrics require different telemetric methodologies. Studies also will likely benefit from data collected over both study years (especially route selection studies, which may be more significantly affected by environmental conditions during a given season that mortality/injury studies). It is also envisioned that results from route selection studies can guide design of turbine mortality studies. Therefore, it is proposed, at a minimum, that route selection studies be conducted in multiple years, but mortality/injury studies may be conducted after the first year of route selection studies has been completed.

1. Objective 1: Route Selection

This study will involve systematic releases of radio-tagged silver phase eels at strategic points above areas of interest, to assess general routes of passage (i.e., via spill, bypass, or turbines). Active downstream migrants should be collected within-basin if possible (i.e., Cabot or Holyoke bypass samplers), but fish sourced from out of basin may be

acceptable to meet sample size demands. Experimental fish must meet morphometric (e.g. eye diameter relative to body size) criteria to ensure they are migrant silver phase. Collections should be made within the migratory season (late Aug to mid Oct), and eels should be tagged and released within 21 days after capture, but preferably within seven days (particularly if the test eels are from out-of-basin).

All telemetered eels will be radio and passive integrated transponder (PIT) tagged. PIT antennas will be installed at bypasses at Vernon and Bellows Falls and monitored continuously to verify passage of eels via bypass channels.

Vernon Project Route Selection Study:
A minimum number of 50 telemetered eels (e.g., 5 separate groups of approximately 10 eels each) will be required to maximize the data return. Tagged eels should be released at least 5 km upstream of the Vernon project. Groups of eels should be released during spill and non-spill periods if possible. Telemetry receivers and antennas should be located to assess passage via the following potential routes: Vernon spillway; Fishway attraction water intake (if operational); Vernon downstream bypasses; and Vernon Station turbines.

Eels from the Bellows Falls route studies migrating to the Vernon Dam may be used to supplement (but not serve in lieu of) these release groups.

Bellows Falls Dam Route Selection Study:
A minimum number of 50 telemetered eels (e.g., 5 separate groups of approximately 10 eels each) will be required to maximize the data return. Groups of eels should be released during spill (if any) and non-spill and during periods of low, moderate, and high generation conditions, if possible. Tagged eels should be released at least 5 km upstream of the Bellows Falls Dam. If significant spillage occurs during releases, up to 50 additional eels should be released in the upper canal and allowed to volitionally descend through the canal to assure that sufficient number of eels are exposed to canal and powerhouse intake conditions. Telemetry receivers and antennas should be located upstream and downstream of the spillway, at the canal entrance, within the canal, in the fish downstream fish bypass entrance and turbine intakes and in mainstem below Bellows Falls Station to assess passage via the following potential routes: entrainment into the canal; passage over the spillway; into the upstream fishway attraction water intake (this should operate during the study to assess its use by eels as it may be operational in the future for riverine or eel passage as addressed in the Resident Fish Passage study request); the downstream fish bypass; and station turbines.

Eels from the Wilder route study migrating to the Bellow Falls Project may be used to supplement (but not serve in lieu of) these release groups.

Wilder Project Route Selection Study:
A minimum number of 50 telemetered eels (e.g., 5 separate groups of approximately 10 eels each) should be required to maximize the data return.

Tagged eels should be released at least 5 km upstream of the Wilder Project. Groups of eels should be released during spill and non-spill periods if possible. Telemetry receivers and antennas should be located to assess passage via the following potential routes: Wilder spillway; Fishway attraction water intake (if operational); Wilder downstream bypasses; and Wilder Station turbines.

Mobile tracking (i.e., via boat) in river reaches between release sites and several km downstream of Vernon Station will be performed at regular intervals during and after releases to confirm routes and fates of passed fish, or fish lost to follow-up.

Movement rates (time between release and detection at radio antenna locations, and between radio antenna locations) of eels passing the projects by various routes will also be quantified.

The route selection portion of this study should occur in both study years.

2. Objective 2: Spill, Bypass, and Turbine Mortality/Injury Studies

Spill, bypass, and turbine mortality will be assessed using a radio-telemetric balloon tag method. A minimum number of 50 tagged eels (e.g., 5 separate groups of approximately 10 eels each) will be required at each location (dam spillways, downstream bypasses, and station turbines) to maximize the data return.

For spill mortality sites (dam spillways and downstream bypasses), tagged eels will be injected or released into spill flow at points where water velocity exceeds 10 ft/sec, to minimize the possibility of eels swimming upstream into the headpond or canal. Passed balloon-tagged eels will be recovered below areas of spill and held for 48 hours in isolated tanks for observation of injury and latent mortality; unrecovered balloon-tagged eels will be censored from the data.

For turbine mortality sites (Vernon, Bellows Falls, and Wilder stations), tagged eels will be injected into intakes of units operating at or near full generation at points where intake water velocity exceeds 10 ft/sec, to minimize the possibility of eels swimming back upstream through the intakes. Passed balloon-tagged eels will be recovered in the tailrace and held for 48 hours in isolated tanks for observation of injury and latent mortality; unrecovered balloon-tagged eels will be censored from the data.

If the balloon tag mortality component of the study occurs in Study Year 1 then all possible route selection sites would need to be evaluated. If the balloon tag mortality component of the study occurs in Study Year 2, then results from the route selection study (Year 1) could be used to inform which sites need to be evaluated for mortality.. Eels recovered from balloon tag studies should not be used for route selection studies.

Data analyses of route selection and turbine mortality (instantaneous and latent) will follow standard methodology.

Project operation (flows, levels, gate openings, number of units operating and operation level) and environmental conditions (river flow, temperature, turbidity, air temperature, precipitation) will be monitored regularly (hourly measurements if possible) throughout the duration of the studies.

These methodologies are consistent with accepted practice.

Level of Effort and Cost

The level of cost and effort for the downstream eel passage study would be moderate to high; silver eels would need to be collected, tagged, and released in several locations over the course of the migration season. Antennas and receivers would need to be installed at the intakes of all stations as well as at the dam spillways and Station bypasses, and monitored regularly. Data would need to be retrieved periodically, then analyzed. A multi-site route selection study conducted by the USGS Conte Lab on the Shetucket River in Connecticut cost approximately $75,000 for the first year of study. Costs are estimated at $100,000 per year for the Route Selection studies and $75,000 per year for the Spill, Bypass, and Turbine Mortality/Injury Studies, for each project.

The applicant did not propose any studies to meet this need in the PAD.

Literature Cited

Brown, L.S. 2005. Characterizing the downstream passage behavior of silver phase American eels at a small hydroelectric facility. M.Sc. Thesis, Department of Natural Resource Conservation, University of Massachusetts, Amherst, Massachusetts. 110 pp.

Brown, L., A. Haro, and T. Castro-Santos. 2009. Three-dimensional movement of silver-phase American eels in the forebay of a small hydroelectric facility. Pages 277-291in: J. Casselman et al. editors. Eels at the Edge: Science, Status, and Conservation Concerns. American Fisheries Society, Bethesda, MD.

EPRI (Electric Power Research Institute). 2001. Review and documentation of research and technologies on passage and protection of downstream migrating catadromous eels at hydroelectric facilities. EPRI Technical Report No. 1000730, Palo Alto, California 270 pp.

Kart, J., R. Regan, S.R. Darling, C. Alexander, K. Cox, M. Ferguson, S. Parren, K. Royar, B. Popp, editors. 2005. Vermont's Wildlife Action Plan. Vermont Fish & Wildlife Department. Waterbury, Vermont. http://www.vtfishandwildlife.com/swg_cwcs_report.cfm. (Accessed September 10, 2012).

Vermont Fish and Wildlife Department . 2006. Vermont Fish and Wildlife Strategic Plan. http://www.vtfishandwildlife.com/library/reports_and_documents/Fish_and_wildlife/Strategic_Plan.pdf

Turners Falls Hydroelectric Project – FERC No. 1889-081
Northfield Mountain Pumped Storage Project – FERC No. 2485-063

Study Request 21: Downstream American eel passage

Goals and Objectives

The goal of this study is to determine the impact of two hydroelectric projects on the outmigration of silver eels in the Connecticut River. Entrainment of eels at the Northfield Mountain Pumped Storage Station (NFMPS) removes eels from the river, effectively extirpating them from the population. Entrainment at the conventional turbines at Station 1 and Cabot Station of the Turners Falls Project can result in mortality or injury. It is important to understand the passage routes at each project and the potential for mortality to assess alternative management options to increase survival.

The objectives of this study are:

1. Quantify the movement rates (including delays) and relative proportion of eels passing via various routes at the projects; i.e. for NFMPS, the proportion entrained into the intake; for Turners Falls Dam, the proportion entrained into the power canal and spilled via bascule and Tainter gates; for the Cabot Canal, proportion of fish passing via spillways, turbines, and the downstream bypass.
2. Evaluate instantaneous and latent mortality and injury of eels passed via the Turners Falls Dam routes, including bascule and Tainter gates, spillways, turbines, and the downstream bypass.

Resource Management Goals

The Agency's goals related to aquatic natural resources are to:

1. Protect, enhance, or restore, diverse high quality habitat necessary to sustain healthy aquatic and riparian plant and animal communities.
2. Provide an instream flow regime that meets the life history requirements of resident fish and wildlife (including invertebrates such as freshwater mussels) throughout the area impacted by Project operations.
3. Minimize the potential negative effects of project operation on water quality and aquatic habitat, and mitigate for loss or degradation.
4.

The Connecticut River is classified by the state of Vermont as Class B cold water fish habitat. Vermont Water Quality Standards state that Class B waters should be managed to achieve and maintain a level of quality that fully supports aquatic biota and habitat. Furthermore, the VTFWD's mission is "the conservation of all species of fish, wildlife, and plants and their habitats for the people of Vermont" (Kart et al. 2005).

Two of the Department's planning goals are:

1. Conserve, enhance, and restore Vermont's natural communities, habitats, and species and the ecological processes that sustain them.

2. Provide a diversity of fish- and wildlife-based activities and opportunities that allow the safe and ethical viewing, regulated harvesting, and utilization of fish, plant and wildlife resources consistent with the North American model of fish and wildlife conservation.

Vermont Fish and Wildlife Department's Strategic Plan (2002 -2010) focuses towards four major areas of concern: resource conservation, fish and wildlife-based recreation and use, human health and safety, efficient operations, and effective management.

The American eel (*Anguilla rostrata*), is listed as one of both New Hampshire's and Vermont's Species of Greatest Conservation Need (SGCN). The status for conservation need in Vermont is listed as high priority (Kart et al. 2005), and the species is listed as "vulnerable" in New Hampshire. As identified in Vermont's Wildlife Action Plan (Kart et al. 2005), threats to the species include the construction of large dams on rivers which obstruct juvenile fish access to critical rearing habitats, as well as mortality associated with passing through hydroelectric facilities' turbines during their outmigration to sea.

As outlined in Vermont's Wildlife Action Plan (Kart et al. 2005), research and monitoring needs for this SGCN include determining their distribution and abundance, as the contribution of eels in northern regions to overall stock is unknown. One of the conservation strategies for this species is to support efforts to enhance access of American eels to Vermont waters by eliminating or minimizing impacts of dams and other obstructions along the Richelieu, St. Lawrence, and Connecticut Rivers.

The Atlantic States Marine Fisheries Commission has developed two documents related to the management of American eel:

1. Interstate Fishery Management Plan for American Eel. April 2000. Atlantic States Marine Fisheries Commission.
2. Addendum II to the Fishery Management Plan for American Eel. Atlantic States Marine Fisheries Commission. Approved October 23, 2008. 8 pp.

Objectives of the management plan include: (1) protect and enhance American eel abundance in all watershed where eel now occur; and (2) where practical, restore American eel to those waters where they had historical abundance but may now be absent by providing access to inland waters for glass eel, elvers, and yellow eel and adequate escapement to the ocean for pre-spawning adult eel.

Addendum II contains specific recommendations for improving upstream and downstream passage of American eel, including requesting that member states and jurisdictions seek special consideration for American eel in the FERC relicensing process.

In addition, the Connecticut River Atlantic Salmon Commission (CRASC) developed A Management Plan for American Eel (*Anguilla rostrata*) in the Connecticut River Basin in 2005. The goal of the plan is "to protect and enhance the abundance of the American eel resource to ensure its continued role in the Connecticut River Basin ecosystem…" Management objectives in the plan include the following:

1. Protect and enhance eel populations where they currently exist;

2. Where practical, restore populations to waters where they had historical abundance;
3. Provide effective upstream and downstream fish passage around dams and other barriers within the species' range in the basin; and
4. Comply with all requirements of the Fishery Management Plan of the ASMFC.

Based on these plans, the Agency seeks the accomplishment of a number of resource goals and objectives through the relicensing process for the Project. General goals include the following:

1. Ensure that protection, mitigation and enhancement measures are commensurate with Project effects and help meet regional fish and wildlife objectives for the basin.
2. Conserve, protect, and enhance the habitats for fish, wildlife, and plants that continue to be affected by the Project.

Specific to downstream passage of American eel, the Agency's goals are:

1. Minimize current and potential negative project operation effects that could hinder management goals and objectives.
2. Minimize project-related sources of downstream passage delay, injury, stress, and mortality in order to maximize the number of silver eels migrating to the spawning grounds.

Our study requests are intended to facilitate the collection of information necessary to conduct effects analyses and to develop reasonable and prudent conservation measures, and protection, mitigation, and enhancement measures pursuant to the Endangered Species Act of 1973, as amended (16 U.S.C. §1531 *et seq*.), the Fish and Wildlife Coordination Act, as amended (16 U.S.C. §661 *et seq*.), and the Federal Power Act (16 U.S.C. §791a, *et seq*.).

Public Interest Consideration

The requester is a resource agency.

Existing Information

The PAD contains information on the biology, life history, and regulatory status of American eel. It also discusses 2-D and 3-D telemetry studies that were conducted at Cabot Station in 1996, 1997, 2002 and 2003. Results of those studies indicate that a significant proportion of eels entering the Cabot forebay become entrained (90% in 2002, 100% in 2003; Brown 2005, Brown et al. 2009). The PAD notes that the study done in 2003 determined that 15 of the 29 test eels were detected at the Hadley Falls Station. However, that study was not designed to assess turbine mortality.

To date, no directed studies of eel mortality at Cabot Station or eel entrainment or mortality at either Station 1 or the NFMPS facility have been conducted. These information gaps need to be filled so resource agencies can assess the relative and cumulative impact of project operations on outmigrating eels and develop adequate passage and protection measures to meet management goals and objectives.

We also note that within the past seven years, the USFWS has received two petitions to list the American eel under the Endangered Species Act. The first petition was received on November

18, 2004. On July 6, 2005 the USFWS issued a substantial 90-day finding on the petition and initiated a 12-month status review that concluded on February 2, 2007 with a finding that listing was not warranted. The second petition was filed on April 30, 2010 by the Council for Endangered Species Act Reliability (CESAR). On September 29, 2011 the USFWS issued a substantial 90-day finding and initiated a 12-month status review. The USFWS is still accepting new American eel information for the ongoing status review. The USFWS also is currently in settlement negotiations with CESAR on their legal complaint that the USFWS failed to complete the 12-month finding within the statutory timeframe. Although the date for completion of the USFWS's 12-month finding on the latest petition is uncertain, it is likely that it will be made prior to any new licenses are issued for the projects.

Project Nexus

The Turners Falls Project operates as a peaking facility, except during periods when inflow exceeds the hydraulic capacity of Cabot Station and Station 1. Silver eels outmigrate during the mid- summer through late fall, a time of year when flows are generally near the maximum operating capacity of the stations. Therefore, the project would be expected to spill infrequently during the silver eel outmigration beyond the nominal amount required in the bypass reach.

Racks at Cabot Station, Station 1, and NFMPS facility are not designed to protect eels from entrainment. At Cabot, the racks have one-inch clear spacing on the top 11-feet, with five-inch clear spacing on the bottom 20 feet of racks. The approach velocity at the racks is approximately 2.0 feet per second at maximum hydraulic capacity. At Station 1, the racks have 2.6-inch clear spacing and an approach velocity of 1.2 feet per second. Eels can readily pass through a 2.6-inch clear space. NFMPS has 48-foot-deep trashracks with six-inch clear spacing over the intake and an approach velocity of 3.5 feet per second at full pumping capacity (15,000 cfs).

As mentioned above, previous studies conducted at Cabot Station documented eel entrainment. Cabot Station has existing downstream passage facilities designed for anadromous species, but studies have documented few eels utilizing the surface bypass (likely because Cabot has a relatively deep, wide intake area). Station 1 has no passage and protection facilities. NFMPS has a seasonally-deployed barrier net to minimize entrainment of Atlantic salmon smolts, but it is only operated from April through June 15 annually. While no studies have been conducted at Station 1 or NFMPS facility, the rack spacing is wide enough to allow for entrainment.

Proposed Methodology

In order to understand the movements of outmigrating silver eels as they relate to operations at the Northfield Mountain Pump Storage Facility, Station 1, and Cabot Station, radio telemetry technology should be utilized. Radio telemetry is an accepted technology that has been used for a number of studies associated with hydropower projects, including at the Muddy Run Project (FERC No. 2355).

Studies should be designed to investigate route selection (i.e., entrainment vs. spill) independently from estimation of mortality/injury, because these metrics require different telemetric methodologies. Studies also will likely benefit from data from several seasons (especially route selection studies, which may be more significantly affected by environmental

conditions during a given season that mortality/injury studies). It is also envisioned that results from route selection studies can guide design of turbine mortality studies. Therefore, it is proposed, at a minimum, that route selection studies be conducted in multiple years, but mortality/injury studies may be conducted after the first year of route selection studies have been completed.

1. Objective 1: Route Selection

This study will involve systematic releases of radio-tagged silver phase eels at strategic points above areas of interest, to assess general routes of passage (i.e., via spill, bypass, or turbines). Active downstream migrants should be collected within-basin if possible (i.e., Cabot or Holyoke bypass samplers), but fish sourced from out of basin may be acceptable to meet sample size demands. Experimental fish must meet morphometric (e.g. eye diameter relative to body size) criteria to ensure they are migrant silver phase. Collections should be made within the migratory season (late Aug to mid Oct), and eels should be tagged and released within 7 days of collection.

NFMPS Route Selection Study:
A minimum number of 50 telemetered eels (e.g., 5 separate groups of approximately 10 eels each) will be required to maximize the data return. Eels will be released at least 5 km upstream of the NFMPS project; releases should be timed so that there is a significant probability that migrating eels will encounter NFMPS during the pumping stage. Radio telemetry antennas will be strategically placed to determine times eels are present within the river reach in the vicinity of the NFMPS intakes, within the intakes themselves, and whether they are entrained into the upper reservoir.

Turners Falls Dam Route Selection Study:
A minimum number of 50 telemetered eels (e.g., 5 separate groups of approximately 10 eels each) will be required to maximize the data return. Groups of eels should be released during spill and non-spill periods if possible. Tagged eels will be released at least 3 km upstream of the Turners Falls dam but several km below the intake to NFMPS. Telemetry receivers and antennas will be located above and below the dam to assess passage via the following potential routes: entrainment into power canal; passage via spill over the bascule gates; passage via spill through the Tainter gates.

Eels from the NFMPS route study not entrained into the NFMPS intake and migrating to the Turners Falls Dam may be used to supplement (but not serve in lieu of) these release groups.

Turners Falls Project – Canal Route Selection Study:
A minimum number of 50 telemetered eels (e.g., 5 separate groups of approximately 10 eels each) will be required to maximize the data return. Groups of eels should be released during periods of low, moderate, and high generation conditions if possible. Eels will be released in the upper canal (ideally just downstream of the Gatehouse), and allowed to volitionally descend through the

canal. Telemetry receivers and antennas will be located within the canal, bypass, channel, and mainstem below Cabot Station to assess passage via the following potential routes: Spillway Fishway attraction water intake (if operational); Station 1 turbines; Cabot Station spillway; Cabot Station bypass; Cabot Station turbines

Eels from the NFMPS and Turners Falls Dam Route Studies not entrained into the NFMPS intake and migrating into the Turners Falls Canal may be used to supplement (but not serve in lieu of) these release groups.

Mobile tracking (i.e., via boat) in river reaches between release sites and several km downstream of Cabot Station will be performed at regular intervals during and after releases to confirm routes and fates of passed fish, or fish lost to follow-up.

Movement rates (time between release and passage) of eels passing the projects by various routes will also be quantified.

The route selection portion of this study should occur in both study years.

2. Objective 2: Spill, Bypass, and Turbine Mortality/Injury Studies
Spill, bypass, and turbine mortality will be assessed using a radio-telemetric balloon tag method. A minimum number of 50 tagged eels (e.g., 5 separate groups of approximately 10 eels each) will be required at each location (dam bascule gate, dam Tainter gate, Cabot Station spillway, Cabot Station bypass, Station 1 and Cabot Station) to maximize the data return. Turbine mortality studies are not required at NFMPS because it is assumed that all entrained fish (including eels) are lost to the Connecticut River system.

For spill mortality sites (dam bascule gate, dam Tainter gate, Cabot spillway, Cabot Station bypass), tagged eels will be injected or released into spill flow at points where water velocity exceeds 10 ft/sec, to minimize the possibility of eels swimming upstream into the headpond or canal. Passed balloon-tagged eels will be recovered below areas of spill and held for 48 hours in isolated tanks for observation of injury and latent mortality; unrecovered balloon-tagged eels will be censored from the data.

For turbine mortality sites (Station 1 and Cabot Station), tagged eels will be injected into intakes of units operating at or near full generation at points where intake water velocity exceeds 10 ft/sec, to minimize the possibility of eels swimming back upstream through the intakes. Passed balloon-tagged eels will be recovered in the tailrace and held for 48 hours in isolated tanks for observation of injury and latent mortality; unrecovered balloon-tagged eels will be censored from the data.

Mobile tracking (i.e., via boat) in river reaches between release sites and several km downstream of Cabot Station will be performed at regular intervals after releases to confirm routes and fates of passed fish, or fish lost to follow-up.

The turbine mortality component of the study should occur in Study Year 2.

Data analyses of route selection and turbine mortality (instantaneous and latent) will follow standard methodology.

Project operation (flows, levels, gate openings, number of units operating and operation level) and environmental conditions (river flow, temperature, turbidity, air temperature, precipitation) will be monitored regularly (hourly measurements if possible) throughout the duration of the studies.

These methodologies are consistent with accepted practice.

Level of Effort and Cost

The level of cost and effort for the downstream eel passage study would be moderate to high; silver eels would need to be collected, tagged, and released in several locations over the course of the migration season. Antennas and receivers would need to be installed at the intakes to all stations as well as at the Turners Falls dam spillway and Cabot Station bypass, and monitored regularly. Data would need to be retrieved periodically, then analyzed. A multi-site route selection study conducted by the USGS Conte Lab on the Shetucket River in Connecticut cost approximately $75,000 for the first year of study. Cost are estimated at $100,000 per year for the Route Selection studies and $75,000 per year for the Spill, Bypass, and Turbine Mortality/Injury Studies.

In the PAD, the applicant has identified the need to assess issues related to downstream passage for American eels at the project, but indicates that it intends to rely on information from previously conducted studies and ongoing studies. The USFWS is not aware of any previously conducted or ongoing studies related to downstream eel passage.

Literature Cited

Brown, L.S. 2005. Characterizing the downstream passage behavior of silver phase American eels at a small hydroelectric facility. M.Sc. Thesis, Department of Natural Resource Conservation, University of Massachusetts, Amherst, Massachusetts. 110 pp.

Brown, L., A. Haro, and T. Castro-Santos. 2009. Three-dimensional movement of silver-phase American eels in the forebay of a small hydroelectric facility. Pages 277-291in: J. Casselman et al. editors. Eels at the Edge: Science, Status, and Conservation Concerns. American Fisheries Society, Bethesda, MD.

EPRI (Electric Power Research Institute). 2001. Review and documentation of research and technologies on passage and protection of downstream migrating catadromous eels at hydroelectric facilities. EPRI Technical Report No. 1000730, Palo Alto, California 270 pp.

Kart, J., R. Regan, S.R. Darling, C. Alexander, K. Cox, M. Ferguson, S. Parren, K. Royar, B. Popp, editors. 2005. Vermont's Wildlife Action Plan. Vermont Fish & Wildlife Department. Waterbury, Vermont. http://www.vtfishandwildlife.com/swg_cwcs_report.cfm. (Access September 10, 2012).

Vermont Fish and Wildlife Department . 2006. Vermont Fish and Wildlife Strategic Plan. http://www.vtfishandwildlife.com/library/reports_and_documents/Fish_and_wildlife/Strategic_Plan.pdf

Wilder Hydroelectric Project – FERC No. 1892-026
Bellows Falls Hydroelectric Project – FERC No. 1855-045
Vernon Hydroelectric Project – FERC No. 1904-073

Study Request 22: Upstream American eel passage assessment

Goals and Objectives

This study has two objectives:

1. Conduct systematic surveys of eel presence/abundance at tailrace and spillway locations at the Vernon, Bellows Falls, and Wilder projects to identify areas of concentration of eels staging in pools or attempting to ascend wetted structures that would potentially establish the most effective locations to place upstream eel passage facilities.
2. Collect eels with temporary trap/pass devices from areas identified from surveys as potential locations of eel concentration to assess whether eels can be collected/passed in substantial numbers, and whether locations are viable sites for permanent eel trap/pass structures.

Resource Management Goals

The American eel (*Anguilla rostrata*), is also one of New Hampshire and Vermont's Species of Greatest Conservation Need (SGCN). The status for conservation need in Vermont is listed as high priority (Kart et al. 2005), and the species is listed as "vulnerable" in New Hampshire. As identified in Vermont's Wildlife Action Plan (Kart et al. 2005), threats to the species include the construction of large dams on rivers which obstruct juvenile fish access to critical rearing habitats, as well as mortality associated with passing through hydroelectric facilities' turbines during their outmigration to sea.

As outlined in Vermont's Wildlife Action Plan (Kart et al. 2005), research and monitoring needs for this SGCN include determining their distribution and abundance, as the contribution of eels in northern regions to overall stock is unknown. One of the conservation strategies for this species is to support efforts to enhance access of American eels to Vermont waters by eliminating or minimizing impacts of dams and other obstructions along the Richelieu, St. Lawrence, and Connecticut Rivers.

The Atlantic States Marine Fisheries Commission has developed two documents related to the management of American eel:

1. Interstate Fishery Management Plan for American Eel. April 2000. Atlantic States Marine Fisheries Commission.
2. Addendum II to the Fishery Management Plan for American Eel. Atlantic States Marine Fisheries Commission. Approved October 23, 2008. 8 pp.

In addition, the Connecticut River Atlantic Salmon Commission (CRASC) developed the draft document: A Management Plan for American Eel (*Anguilla rostrata*) in the Connecticut River Basin in 2005. The goal of the plan is "to protect and enhance the abundance of the American eel resource to ensure its continued role in the Connecticut River Basin ecosystem…" Management objectives in the plan include the following:

1. Protect and enhance eel populations where they currently exist;
2. Where practical, restore populations to waters where they had historical abundance;
3. Provide effective upstream and downstream fish passage around dams and other barriers within the species' range in the basin; and
4. Comply with all requirements of the Fishery Management Plan of the ASMFC.

Based on these plans, the Agency seeks the accomplishment of a number of resource goals and objectives through the relicensing process for the three projects. General goals include the following:

1. Ensure that protection, mitigation and enhancement measures are commensurate with Project effects and help meet regional fish and wildlife objectives for the basin.
2. Conserve, protect, and enhance the habitats for fish, wildlife, and plants that continue to be affected by the Project.

Specific to upstream passage of American eel, the Agency's goals are:

1. Minimize current and potential negative project operation effects that could hinder management goals and objectives.
2. Minimize project-related sources of upstream passage delay, injury, and stress in order to facilitate access to historical rearing habitat.

Our study requests are intended to facilitate the collection of information necessary to conduct effects analyses and to develop reasonable and prudent conservation measures, and protection, mitigation, and enhancement measures pursuant to the Endangered Species Act of 1973, as amended (16 U.S.C. §1531 *et seq*.), the Fish and Wildlife Coordination Act, as amended (16 U.S.C. §661 *et seq*.), and the Federal Power Act (16 U.S.C. §791a, *et seq*.).

Public Interest Consideration

The requester is a resource agency.

Existing Information

The PAD contains no information relative to areas where eels seeking to move upstream concentrate downstream of the three dams, or annual numbers of eels attempting to ascend past the dams. While eels have been known to ascend the Vernon and Bellows Falls fish ladders, their efficiency for passing eels is unknown, and they are only operated during the American shad passage season (from April 15 through July 15). Eels are currently able to pass Vernon, Bellows Falls, and Wilder dams (as evidenced by documented presence of eels upstream), but the total number of eels attempting to pass all three dams and the proportion successfully passing each project is unknown (but suspected to be low). The downstream Holyoke Project has operated upstream eel passage facilities since 2004. Last year these facilities passed over 40,000 juvenile eels. While the next dam upstream (the Turners Falls Project; FERC No. 1889) has no dedicated upstream eel passage facilities, eels have been known to ascend the Cabot Station fish ladder (A. Haro, U.S. Geological Survey, pers. comm.). Although there is rearing habitat in between the Turners Falls and Vernon dams, some eels will attempt to continue upstream, and passage needs to be provided so these fish can access historical habitat.

These information gaps need to be filled so resource agencies can determine the best locations to site upstream eel passage facilities and assess whether operating the existing anadromous ladders would be an effective mechanism to move juvenile eels upstream past the projects.

We also note that within the past seven years, the USFWS has received two petitions to list the American eel under the Endangered Species Act. The first petition was received on November 18, 2004. On July 6, 2005 the USFWS issued a substantial 90-day finding on the petition and initiated a 12-month status review that concluded on February 2, 2007 with a finding that listing was not warranted. The second petition was filed on April 30, 2010 by the Council for Endangered Species Act Reliability (CEASAR). On September 29, 2011 the USFWS issued a substantial 90-day finding and initiated a 12-month status review. The USFWS is still accepting new American eel information for the ongoing status review. The USFWS also is currently in settlement negotiations with CESAR on their legal complaint that the USFWS failed to complete the 12-month finding within the statutory timeframe. Although the date for completion of the USFWS's 12-month finding on the latest petition is uncertain, it is likely that it will be made before any new licenses are issued for the projects.

Project Nexus

The three projects generate hydropower on the head created by the Vernon, Bellows Falls, and Wilder dams. These dams create barriers to upstream migrating eels. While some eels are able to pass dams, some are not, and the passability of a given dam depends on factors such as its height, hydraulics, presence of climbable surfaces, presence of predators, risk of exposure to heat or drying while climbing a dam, etc. All three dams are high (Vernon: 58 ft. high; Bellows Falls: 30 ft. high; and Wilder: 60 ft. high), and the majority of the dam faces are dry during most of the upstream eel passage season. Design of the dams is not currently amenable to passage of eels by climbing. As mentioned earlier, the existing anadromous passage facilities are not designed to pass eels, and even if some eels are able to ascend the ladders, they may incur delays (in attraction or passage rates), be size-selective (e.g. velocity barrier for small eels presented by ~8 ft/sec flow through weirs and orifices), present a potential predation risk (predators in or near the fishways), and are not operated throughout the upstream eel passage season.

Proposed Methodology

Objective 1: Systematic Surveys

Surveys of eel presence and relative abundance should be conducted at regular intervals throughout the eel upstream migratory season (~1 May to ~15 October, or when river temperatures exceed 10 C). Surveys should consist of visual inspection and trapping in likely areas where eels may concentrate as they attempt to climb structures wetted by significant spill or leakage flow below the dams and associated structures. These locations include: the upstream fish ladders at all three projects (dewatered state) and leakage or overflow points along the downstream faces of all three dams, including spillways. Methods should include visual surveys (on foot, from a boat, or snorkeling) and trapping using small mesh (< 1/8” clear opening) baited eel pots. Visual surveys should be performed once per week, at night, preferentially during precipitation events. Trap sets should be performed once per week, with an overnight soak time. Recorded

data should include location, observation of eels (presence, absence, relative numbers, relative sizes, behaviors, time/date of observation), and survey method.

Objective 2: Trap/Pass Collections

Areas identified from Systematic Surveys as having significant number of eels present should be targeted as potential areas for permanent eel trap/passes, and should be initially assessed using temporary/portable trap passes. At a minimum (regardless of survey results), temporary trap passes should be installed at stilling basins and/or lower sections of fishways supplied with minimal attraction flow (0.5-1.0 cfs) during dewatered conditions at all three projects , as these locations may be supplemented with additional attraction flow and have high potential for being concentration points for upstream migrant eels. Similarly, traps should also be placed at spillway or bypass channel locations where eels have a potential to climb wetted (e.g., via leakage) flow zones, at the highest points where eels are able to climb to, or where otherwise feasible. Temporary trap/passes should be purpose-designed and built for each location, and operated throughout the eel upstream migratory season (~1May to 15 October, or when river temperatures exceed 10° C). Ramp-type traps with supplementary attraction flow are preferred temporary trap/pass designs. Traps should operate daily, with catches quantified every 2-3 days. Recorded data should include location, trapping interval, absolute numbers of eels trapped, relative eel sizes, and hydraulic and environmental conditions during the trapping period.

All collected eels from surveys should be released at their point of capture; those eels collected from trap/pass collections should be transported to and released into the headponds upstream of where they were collected.

These methodologies are consistent with accepted practice.

Level of Effort and Cost

The level of cost and effort for the survey component of the study would be low for each individual project (moderate for all three projects combined); a minimal number of personnel may be able to conduct the weekly surveys. The trap/pass component would require low to moderate cost and effort. We estimate $40,000 per project to conduct this study.

The Agency is not aware of any previously conducted or ongoing studies related to upstream eel passage. The applicant did not propose any studies to meet this need in the PAD.

Literature Cited

Kart, J., R. Regan, S.R. Darling, C. Alexander, K. Cox, M. Ferguson, S. Parren, K. Royar, B. Popp, editors. 2005. Vermont's Wildlife Action Plan. Vermont Fish & Wildlife Department. Waterbury, Vermont. http://www.vtfishandwildlife.com/swg_cwcs_report.cfm. (Accessed September 10, 2012).

Vermont Fish and Wildlife Department . 2006. Vermont Fish and Wildlife Strategic Plan. http://www.vtfishandwildlife.com/library/reports_and_documents/Fish_and_wildlife/Strategic_Plan.pdf

Turners Falls Hydroelectric Project – FERC No. 1889-081

Study Request 22: Upstream American eel passage assessment

Goals and Objectives

This study has two objectives:

1. Conduct systematic surveys of eel presence/abundance at Cabot Station discharge, Station #1 discharge, canal discharges, and Turners Falls Dam to identify areas of concentration of eels staging in pools or attempting to ascend wetted structures that would potentially establish the most effective locations to place upstream eel passage facilities.
2. Collect eels with temporary trap/pass devices from areas identified from surveys as potential locations of eel concentration to assess whether eels can be collected/passed in substantial numbers, and whether locations are viable sites for permanent eel trap/pass structures.

Resource Management Goals

The Agency's goals related to aquatic natural resources are to:

1. Protect, enhance, or restore, diverse high quality habitat necessary to sustain healthy aquatic and riparian plant and animal communities.
2. Provide an instream flow regime that meets the life history requirements of resident fish and wildlife (including invertebrates such as freshwater mussels) throughout the area impacted by Project operations.
3. Minimize the potential negative effects of project operation on water quality and aquatic habitat, and mitigate for loss or degradation.

The Connecticut River is classified by the state of Vermont as Class B cold water fish habitat. Vermont Water Quality Standards state that Class B waters should be managed to achieve and maintain a level of quality that fully supports aquatic biota and habitat. Furthermore, the VTFWD's mission is "the conservation of all species of fish, wildlife, and plants and their habitats for the people of Vermont" (Kart et al. 2005).

Two of the Department's planning goals are:

1. Conserve, enhance, and restore Vermont's natural communities, habitats, and species and the ecological processes that sustain them.
2. Provide a diversity of fish- and wildlife-based activities and opportunities that allow the safe and ethical viewing, regulated harvesting, and utilization of fish, plant and wildlife resources consistent with the North American model of fish and wildlife conservation.

Vermont Fish and Wildlife Department's Strategic Plan (2002 -2010) focuses towards four major areas of concern: resource conservation, fish and wildlife-based recreation and use, human health and safety, efficient operations, and effective management.

The American eel (*Anguilla rostrata*), is listed as one of both New Hampshire's and Vermont's Species of Greatest Conservation Need (SGCN). The status for conservation need in Vermont is listed as

high priority (Kart et al. 2005), and the species is listed as "vulnerable" in New Hampshire. As identified in Vermont's Wildlife Action Plan (Kart et al. 2005), threats to the species include the construction of large dams on rivers which obstruct juvenile fish access to critical rearing habitats, as well as mortality associated with passing through hydroelectric facilities' turbines during their outmigration to sea.

As outlined in Vermont's Wildlife Action Plan (Kart et al. 2005), research and monitoring needs for this SGCN include determining their distribution and abundance, as the contribution of eels in northern regions to overall stock is unknown. One of the conservation strategies for this species is to support efforts to enhance access of American eels to Vermont waters by eliminating or minimizing impacts of dams and other obstructions along the Richelieu, St. Lawrence, and Connecticut Rivers.

The Atlantic States Marine Fisheries Commission has developed two documents related to the management of American eel:

1. Interstate Fishery Management Plan for American Eel. April 2000. Atlantic States Marine Fisheries Commission.
2. Addendum II to the Fishery Management Plan for American Eel. Atlantic States Marine Fisheries Commission. Approved October 23, 2008. 8 pp.

The Connecticut River Atlantic Salmon Commission (CRASC) was established by Congress in 1983 (and reauthorized in 2002 for another 20 years) through the Connecticut River Atlantic Salmon Compact (Public Law 98-138). The Vermont Fish and Wildlife Department is a CRASC member agency, and a senior biologist from the department serves on the Technical Committee. In addition, the Connecticut River Atlantic Salmon Commission (CRASC) developed A Management Plan for American Eel (*Anguilla rostrata*) in the Connecticut River Basin in 2005. The goal of the plan is "to protect and enhance the abundance of the American eel resource to ensure its continued role in the Connecticut River Basin ecosystem…" Management objectives in the plan include the following:

1. Protect and enhance eel populations where they currently exist;
2. Where practical, restore populations to waters where they had historical abundance;
3. Provide effective upstream and downstream fish passage around dams and other barriers within the species' range in the basin; and
4. Comply with all requirements of the Fishery Management Plan of the ASMFC.

Based on these plans, the Agency seeks the accomplishment of a number of resource goals and objectives through the relicensing process for the Project. General goals include the following:

1. Ensure that protection, mitigation and enhancement measures are commensurate with Project effects and help meet regional fish and wildlife objectives for the basin.
2. Conserve, protect, and enhance the habitats for fish, wildlife, and plants that continue to be affected by the Project.

Specific to upstream passage of American eel, the Agency's goals are:

1. Minimize current and potential negative project operation effects that could hinder management goals and objectives.

2. Minimize project-related sources of upstream passage delay, injury, and stress in order to facilitate access to historical rearing habitat.

Our study requests are intended to facilitate the collection of information necessary to conduct effects analyses and to develop reasonable and prudent conservation measures, and protection, mitigation, and enhancement measures pursuant to the Endangered Species Act of 1973, as amended (16 U.S.C. §1531 *et seq*.), the Fish and Wildlife Coordination Act, as amended (16 U.S.C. §661 *et seq*.), and the Federal Power Act (16 U.S.C. §791a, *et seq*.).

Public Interest Consideration

The requester is a resource agency.

Existing Information

The PAD contains no information relative to areas where eels seeking to move upstream concentrate downstream of the dam, or annual numbers of eels attempting to ascend past Turners Falls Dam. While eels have been known to ascend the Cabot Station ladder (A. Haro, U.S. Geological Survey, pers. comm.), its efficiency is unknown, and it is only operated during the American shad passage season (from April 1 through July 15). Eels are currently able to pass the Turners Falls Dam complex (as evidenced by documented presence of eels upstream), but the total number of eels attempting to pass Turners Falls and the proportion successfully passing the project is unknown (but suspected to be low). The downstream Holyoke Project has operated upstream eel passage facilities since 2004. Last year these facilities passed over 40,000 juvenile eels. While there is rearing habitat in between the Holyoke and Turners Falls dams, some eels will attempt to continue upstream, and passage needs to be provided so these fish can access historical habitat.

These information gaps need to be filled so resource agencies can determine the best locations to site upstream eel passage facilities and assess whether operating the existing anadromous ladders would be an effective mechanism to move juvenile eels upstream past the project.

We also note that within the past seven years, the USFWS has received two petitions to list the American eel under the Endangered Species Act. The first petition was received on November 18, 2004. On July 6, 2005 the USFWS issued a substantial 90-day finding on the petition and initiated a 12-month status review that concluded on February 2, 2007 with a finding that listing was not warranted. The second petition was filed on April 30, 2010 by the Council for Endangered Species Act Reliability (CESAR). On September 29, 2011 the USFWS issued a substantial 90-day finding and initiated a 12-month status review. The USFWS is still accepting new American eel information for the ongoing status review. The USFWS also is currently in settlement negotiations with CESAR on their legal complaint that the USFWS failed to complete the 12-month finding within the statutory timeframe. Although the date for completion of the USFWS's 12-month finding on the latest petition is uncertain, it is likely that it will be made before any new licenses are issued for the projects.

Project Nexus

The project generates hydropower on the head created by the Turners Falls dam. This dam creates a barrier to upstream migrating eels. While some eels are able to pass dams, some are not, and the passability of a given dam depends on factors such as its height, hydraulics, presence of climbable surfaces, presence of predators, risk of exposure to heat or drying while climbing a dam, etc. The Turners Falls dam is high (35 feet above bedrock), and the majority of the dam face is dry during most of the upstream eel passage season. Design of the dam is not currently amenable to passage of eels by climbing. While flow is released to the bypass reach via a bascule gate (typically the one closest to the gatehouse), this would not facilitate eel passage, as bascule gates open outward and downward (i.e., requiring the eels to essentially swim nearly upside down to get over the gate). As mentioned earlier, the existing anadromous passage facilities are not designed to pass eels, and even if some eels are able to ascend the ladders, they may incur delays (in attraction or passage rates), be size-selective (e.g. velocity barrier for small eels presented by ~8 ft/sec flow through weirs and orifices), present a potential predation risk (predators in or near the fishways), and are not operated throughout the upstream eel passage season.

Proposed Methodology

Objective 1: Systematic Surveys

Surveys of eel presence and relative abundance should be conducted at regular intervals throughout the eel upstream migratory season (~1 May to ~15 October, or when river temperatures exceed 10 C). Surveys should consist of visual inspection and trapping in likely areas where eels may concentrate as they attempt to climb structures wetted by significant spill or leakage flow in the Turners Falls dam complex area. These locations include: Cabot Station downstream bypass outfall, Cabot Station spillway (including attraction water stilling basin), Cabot Fishway (dewatered state), USGS Conte Lab flume outfall, Number One Station outfall, various small turbine and process water outfalls from the Cabot Canal, Spillway Fishway attraction water stilling basin, and leakage points along the downstream face of Turners Falls Dam (bascule and Tainter gates). Methods should include visual surveys (on foot, from a boat, or snorkeling) and trapping using small mesh (< 1/8” clear opening) baited eel pots. Visual surveys should be performed once per week, at night, preferentially during precipitation events. Trap sets should be performed once per week, with an overnight soak time. Recorded data should include location, observation of eels (presence, absence, relative numbers, relative sizes, behaviors, time/date of observation), and survey method.

Objective 2: Trap/Pass Collections

Areas identified from Systematic Surveys as having significant number of eels present should be targeted as potential areas for permanent eel trap/passes, and should be initially assessed using temporary/portable trap passes. At a minimum (regardless of survey results), temporary trap passes should be installed at the following locations: Cabot Fishway attraction flow stilling basin (during dewatered fishway period), Number One Station outfall, and Spillway Fishway attraction flow stilling basin (during watered and dewatered fishway period), as these locations may be supplemented with additional attraction flow and have high potential for being concentration points for upstream

> migrant eels. Temporary trap/passes should be purpose-designed and built for each location, and operated throughout the eel upstream migratory season (~1May to 15 October, or when river temperatures exceed 10 C). Ramp-type traps with supplementary attraction flow are preferred temporary trap/pass designs. Traps should operate daily, with catches quantified every 2-3 days. Recorded data should include location, trapping interval, absolute numbers of eels trapped, relative eel sizes, and hydraulic and environmental conditions during the trapping period.

All collected eels from surveys should be released at their point of capture; those eels collected from trap/pass collections should be transported to and released above the dam in the Turners Falls Pool.

These methodologies are consistent with accepted practice.

Level of Effort and Cost

The level of cost and effort for the survey component of the study would be low; a minimal number of personnel may be able to conduct the weekly surveys. The trap/pass component would require low to moderate cost (estimated at $40,000) and effort.

In the PAD, the applicant has identified the need to assess issues related to upstream passage for American eels at the project, but indicates that it intends to rely on information from previously conducted studies and ongoing studies. The USFWS is not aware of any previously conducted or ongoing studies related to upstream eel passage.

Wilder Hydroelectric Project – FERC No. 1892-026
Bellows Falls Hydroelectric Project – FERC No. 1855-045
Vernon Hydroelectric Project – FERC No. 1904-073

Study Request 23: Impingement and entrainment of resident fish species at project intakes

Goals and Objectives
The goal of this study is to assess the adequacy of the intakes at Bellows Falls, Wilder, and Vernon projects to minimize fish mortality resulting from impingement and entrainment of fishes residing in the Connecticut River, and to recommend appropriate mitigative measures as necessary.
Specific objectives include:

- Describe the configuration of the intake at each project, including the forebay characteristics, size of the intakes, trashrack spacing and extent of coverage if the intakes, approach velocities and the influence of trashrack debris and cleaning protocols.
- Estimate the mortality rates for resident fish species and life stages that may result from impingement on project trashracks.
- Estimate the mortality rates for resident fish species and life stages that may result from entrainment and passage through the project turbines. Review existing Vermont Fish and Wildlife Department's (VTFWD) fish passage data to increase sample size and gain a better understanding of temporal variability.
- Determine structural and operational measures that could be reduce fish mortality.

Resource Management Goals
Vermont Water Quality Standards (VWQS) seek to provide high quality aquatic habitat necessary to support healthy aquatic communities and the associated uses such as fishing.
The Agency's goals related to aquatic natural resources and pertinent to this study request are to:

1. Provide for healthy, self-sustaining fish communities.
2. Minimize the potential negative effects of project operation on resident fish populations, and mitigate for losses.

Public Interest Consideration
The requestor is a state fish and wildlife agency.

Existing Information
The Connecticut River and the project impoundments support a variety of resident fish species as well as angling. However, there is no information about fish mortality and the population effects resulting from project impingement and entrainment. The project PADs contain almost no information about the project trashracks. During the ILP site visits held in October 2012 the Agency was informed that the rack spacing was in most cases four inches (on center) and as much as six inches in some cases. Further, these trashracks do not cover the entire intake area in all cases. No information on approach velocities has been provided. Mortality rates of fish passing through the turbines are not known.

Project Nexus

The Bellows Falls, Wilder and Vernon dams span across the Connecticut River, acting as a physical impediment to fish passage. Fishes living in the impoundments will at times enter project forebays and come in close proximity to project intakes. Impingement or entrainment is certainly occurring but the extent of this impact is unknown. The wide rack spacing is likely to result in entrainment.

The projects include downstream fish passage facilities but their use and effectiveness for resident fish species is unknown. These facilities are operated seasonally and therefore will not mitigate impingement and entrainment at all times.

Proposed Methodology

Impingement, entrainment and turbine mortality studies have been conducted at numerous other hydropower projects and can be used to assess potential fish mortality based on results from other projects with similar configurations.

Approach velocities can be calculated and actual measurements can be taken to quantify variability by location and verify calculated results.

Turbine mortality should be assessed by releasing tagged fish for downstream recovery. The details of this type of study should be addressed during the study plan stage.

The contribution of existing fish passage facilities to reducing impingement and entrainment of resident fishes should also be assessed.

Level of Effort and Cost

The expected level of effort and anticipated costs will be comparable or less than those experienced on similar FERC projects of this size.

Wilder Hydroelectric Project – FERC No. 1892-026
Bellows Falls Hydroelectric Project – FERC No. 1855-045
Vernon Hydroelectric Project – FERC No. 1904-073

Study Request 24: Determine upstream passage needs for riverine fish species at project fishways

Goals and Objectives
The goal of this study is to determine the adequacy of the existing Bellows Falls, Wilder, and Vernon fish ladders in passing riverine species and determine the appropriate operation period for these fishways to pass riverine and diadromous fish.
Specific objectives include:

- Identify the utilization and temporal distribution, of passage through the Bellows Falls, Wilder, and Vernon fishways by riverine and diadromous fish species
- Review existing Vermont Fish and Wildlife Department's (VTFWD) fish passage data to increase sample size and gain a better understanding of temporal variability.
- Operate and monitor the fishways year-round (or until otherwise infeasible) to assess fishway use over a longer period than the fishways have traditionally been operated to:

    1. Determine the appropriate operating windows of the fishways for riverine species

    2. Determine the appropriate operating windows of the fishways for diadromous species such as American eel and sea lamprey.

Resource Management Goals
The Connecticut River is classified by the state of Vermont as Class B cold water fish habitat. Vermont Water Quality Standards state that Class B waters should be managed to achieve and maintain a level of quality that fully supports aquatic biota and habitat. Furthermore, the VTFWD's mission is "the conservation of all species of fish, wildlife, and plants and their habitats for the people of Vermont" (Kart et al. 2005).

Two of the Department's planning goals are:
1. Conserve, enhance, and restore Vermont's natural communities, habitats, and species and the ecological processes that sustain them.
2. Provide a diversity of fish- and wildlife-based activities and opportunities that allow the safe and ethical viewing, regulated harvesting, and utilization of fish, plant and wildlife resources consistent with the North American model of fish and wildlife conservation.

Vermont Fish and Wildlife Department's Strategic Plan (2002 -2010) focuses towards four major areas of concern: resource conservation, fish and wildlife-based recreation and use, human health and safety, efficient operations, and effective management.

A mission of the New Hampshire Fish and Game Department (NHFGD) is to conserve, manage and protect the state's fish, wildlife and marine resources and their habitats.

Three of the NHFGD's goals are to ensure:

1. New Hampshire has a wide range of naturally occurring habitats and health, functioning ecosystems.
2. New Hampshire has abundant and varied fish, wildlife, and marine species at levels that ensure sustainable, healthy populations.
3. New Hampshire has fish, wildlife, and marine populations that support desirable levels of hunting, trapping, fishing, and wildlife viewing.

In order to be consistent with both Department's missions and goals, and to promote healthy fish populations, connectivity within a river system is important. By allowing fish to move through the fishway during different times of the year, and during different life history stages, access to available riverine aquatic habitat is increased. Fish are able to seek the best available habitat and food resources, as well as avoid predator interactions. Furthermore, movement within a river system promotes genetic diversity. Currently upstream resident fish passage at the Bellows Falls, Wilder, and Vernon dams is precluded most of the year due to fishway closure.

Public Interest Consideration

The requestor is a state natural resource agency.

Existing Information

No such information exists that will allow for a comprehensive assessment of existing year round fishway utilization by resident species. The VTFWD has several years (2007-2012) of seasonal passage data that have not yet been analyzed. These data are in the form of .avi files, but only include the spring and summer months (typically May- July).
The PAD acknowledges that "Resident species have also been recorded using the Bellows Falls and Wilder fish ladder". Those data are available from the Vermont Fish & Wildlife Department. Fish passage video data that have been processed should be available for distribution in the future (Lael Will, Vermont Fish & Wildlife, personal communication)". Although not comprehensive, analysis of these data would assist in filling this data gap.

In 2012, VTFWD staff documented resident species passage at the Vernon fishway. Species observed utilizing the fishway included bluegill (N = 555), common carp (N = 209), channel catfish (N = 37), trout sp. (N = 2), walleye (N = 54), white sucker (N = 102), and American eel (N =262). However, these analyses were conducted during one year and did not include any monitoring outside of the spring spawning run.

Project Nexus

The Bellows Falls, Wilder and Vernon dams span across the Connecticut River, acting as a physical impediment to fish passage. Therefore, the project has a direct impact on fish passage and limits fish from accessing available aquatic habitat located upstream of the dam.
The PAD acknowledges that "river fragmentation can reduce or obstruct fish and aquatic community connectivity and therefore genetic diversity and stock structure. However, those impacts are reduced by the provision of fish passage and the length of the impoundment. Upstream and downstream fish passages, designed for Atlantic salmon, are likely used by other migratory and resident species, providing connectivity; however, fish counts are limited,

unknown or unavailable for resident species". In fact, it is known that riverine and diadromous species use the fishways, but there has been limited analysis of this data and fishway monitoring was limited to spring period.

Therefore, in order to determine the level of riverine fish passage through the existing fishways, and the appropriate operation period for the fishway , review of existing data and , further monitoring of the fishways is warranted.

Proposed Methodology

Fishway monitoring has been conducted annually by VTFWD dating back to 1985. Monitoring was focused on Atlantic salmon, American shad and American eel. Resident species were recorded periodically, but were not monitored outside the spring anadromous fish migration period

Fishway monitoring has been used to assess existing and proposed project operations, and to develop appropriate operating windows for fisheries resources.

In addition to fish window count data, monitoring should include monitoring of the hydraulic conditions in the fishways and fishway entrances, and periodic fish observations should be made over the length of the fishways. If count data or observations of the fishways indicate the need for fishway operation changes or for more specific information on fish movement through the fishways, changes to the monitoring plan for year 2 monitoring would need to be implemented.

Level of Effort and Cost

This study will require video monitoring equipment, appropriate software (e.g. salmon soft), and personal to read to files, and manage the equipment. Some information already exists in the form of .avi files and past count data and are readily available from VTFWD. No other tool (e.g. radio telemetry) is more appropriate or cost effective for these types of assessments. Cost is relatively low.

Literature Cited

Kart, J., R. Regan, S.R. Darling, C. Alexander, K. Cox, M. Ferguson, S. Parren, K. Royar, B. Popp, editors. 2005. Vermont's Wildlife Action Plan. Vermont Fish & Wildlife Department. Waterbury, Vermont. http://www.vtfishandwildlife.com/swg_cwcs_report.cfm. (Accessed September 10, 2012).

Vermont Fish and Wildlife Department . 2006. Vermont Fish and Wildlife Strategic Plan. http://www.vtfishandwildlife.com/library/reports_and_documents/Fish_and_wildlife/Strategic_Plan.pdf

Wilder Hydroelectric Project – FERC No. 1892-026

Study Request 25: Impact of impoundment water level fluctuations on wetlands

Goals and Objectives

The goal of this study is to determine the impacts to wetlands from daily and seasonal water level fluctuation in the impoundment and downstream from the Wilder Hydroelectric Project to the head of the Bellows Falls impoundment.

The objectives of this study are to:

1. Identify all wetlands types, natural communities, and invasive species within the impoundment and downstream, and determine the proportion of wetlands and wetland type (i.e. emergent, shrub, forested) that are impacted by daily and seasonal water level fluctuations from project operations.
2. Determine the ratios of wetland types in the project area should be compared to previous national wetland inventory maps, and/or to reference conditions to determine if wetland types or natural communities within the project impoundment or downstream are being altered by project operations.
3. Determine how project operations are affecting the wetland plant community composition, including promoting the spread of invasive species or affecting rare, threaten, and endangered species.

Resource Management Goals

The Agency's goals related to aquatic natural resources are to:

1. Protect, enhance, or restore, diverse high quality habitat necessary to sustain healthy aquatic and riparian plant and animal communities.
2. Provide an instream flow regime that meets the life history requirements of resident fish and wildlife (including invertebrates such as freshwater mussels) throughout the area impacted by Project operations.
3. Minimize the potential negative effects of project operation on water quality and aquatic habitat, and mitigate for loss or degradation.

The Connecticut River is classified by the state of Vermont as Class B cold water fish habitat. Vermont Water Quality Standards state that Class B waters should be managed to achieve and maintain a level of quality that fully supports aquatic biota and habitat. Furthermore, the VTFWD's mission is "the conservation of all species of fish, wildlife, and plants and their habitats for the people of Vermont" (Kart et al. 2005).

Two of the Department's planning goals are:

1. Conserve, enhance, and restore Vermont's natural communities, habitats, and species and the ecological processes that sustain them.
2. Provide a diversity of fish- and wildlife-based activities and opportunities that allow the safe and ethical viewing, regulated harvesting, and utilization of fish, plant and wildlife resources consistent with the North American model of fish and wildlife conservation.

The goal of the Vermont Agency of Natural Resources is to identify and protect significant wetlands and the values and function which they ensure that there is no net loss of such wetlands and their function are achieved. Vermont classifies wetlands that are adjacent to streams, rivers, and open water that contain woody or persistent non-woody vegetation as Class II significant wetlands.

Public Interest Consideration
The requestor is a state natural resource agency.

Existing Information
The PAD does not address how wetlands type or wetland community composition that could be impacted by daily and seasonal water level fluctuations within the impoundment.

Project Nexus
The project impoundment extends 45 miles upstream from the dam. The project currently operates in a peaking mode, with allowable impoundment fluctuations of up to 5 feet, with proposals to continue as such. Wetlands can be affected by the operations of the hydropower project depending on frequency, timing, amplitude and duration of impoundment fluctuations. The PAD provides limited information on how project operations affect wetlands and the plant community composition within the project impoundment and downstream. Operations of the project must conform to Vermont goal of protecting significant wetlands and the values and function which they ensure that there is no net loss of such wetlands. The Agency requests a study to determine the impacted by normal daily and seasonal operations of the project on wetland communities.

Proposed Methodology
The widely accepted methodology in the Federal Manual for Identifying and Delineating Jurisdictional Wetlands, as amended and supplemental guidance documents issued by the U.S. Army Corps of Engineers is recommended for identifying wetlands. The Vermont classification system for natural communities should be used to classify community type (See Appendix A). The general community composition should be recorded as well as any rare, threaten or endangered plant species or invasive species. The proportion of wetlands that are impacted by project operations should be compared to reference wetlands communities to evaluate how plant species composition has been altered by project operations. The frequency, timing, amplitude, and duration of reservoir fluctuations on impacted wetlands and natural communities should be recorded throughout the year. The ratio of wetland types presently identified in the project boundaries should be compared to national wetland inventory maps to address if project operations have altered wetlands.

Level of Effort and Cost
The cost and effort of this study will be moderate, but is important to document the potential impact operations have on wetlands within the vicinity of the project to determine if Vermont's wetland management goals are being met.

Bellows Falls Hydroelectric Project – FERC No. 1855-045

Study Request 25: Impact of impoundment water level fluctuations on wetlands

Goals and Objectives

The goal of this study is to determine the impacts to wetlands from daily and seasonal water level fluctuation in the impoundment and downstream from the Bellows Falls Hydroelectric Project to the head of the Vernon impoundment.

The objectives of this study are to:

1. Identify all wetlands types, natural communities, and invasive species within the impoundment and downstream, and determine the proportion of wetlands and wetland type (i.e. emergent, shrub, forested) that are impacted by daily and seasonal water level fluctuations from project operations.
2. Determine the ratios of wetland types in the project area should be compared to previous national wetland inventory maps, and/or to reference conditions to determine if wetland types or natural communities within the project impoundment or downstream are being altered by project operations.
3. Determine how project operations are affecting the wetland plant community composition, including promoting the spread of invasive species or affecting rare, threaten, and endangered species.

Resource Management Goals

The Agency's goals related to aquatic natural resources are to:

1. Protect, enhance, or restore, diverse high quality habitat necessary to sustain healthy aquatic and riparian plant and animal communities.
2. Provide an instream flow regime that meets the life history requirements of resident fish and wildlife (including invertebrates such as freshwater mussels) throughout the area impacted by Project operations.
3. Minimize the potential negative effects of project operation on water quality and aquatic habitat, and mitigate for loss or degradation.

The Connecticut River is classified by the state of Vermont as Class B cold water fish habitat. Vermont Water Quality Standards state that Class B waters should be managed to achieve and maintain a level of quality that fully supports aquatic biota and habitat. Furthermore, the VTFWD's mission is "the conservation of all species of fish, wildlife, and plants and their habitats for the people of Vermont" (Kart et al. 2005).

Two of the Department's planning goals are:

1. Conserve, enhance, and restore Vermont's natural communities, habitats, and species and the ecological processes that sustain them.
2. Provide a diversity of fish- and wildlife-based activities and opportunities that allow the safe and ethical viewing, regulated harvesting, and utilization of fish, plant and wildlife resources consistent with the North American model of fish and wildlife conservation.

The goal of the Vermont Agency of Natural Resources is to identify and protect significant wetlands and the values and function which they ensure that there is no net loss of such wetlands and their function are achieved. Vermont classifies wetlands that are adjacent to streams, rivers, and open water that contain woody or persistent non-woody vegetation as Class II significant wetlands.

Public Interest Consideration
The requestor is a state natural resource agency.

Existing Information
The PAD does not address how wetlands type or wetland community composition that could be impacted by daily and seasonal water level fluctuations within the impoundment.

Project Nexus
The project impoundment extends 26 miles upstream from the dam. The project currently operates in a peaking mode, with allowable impoundment fluctuations of up to 3 feet, with proposals to continue as such. Wetlands can be affected by the operations of the hydropower project depending on frequency, timing, amplitude and duration of impoundment fluctuations. The PAD provides limited information on how project operations affect wetlands and the plant community composition within the project impoundment and downstream. Operations of the project must conform to Vermont goal of protecting significant wetlands and the values and function which they ensure that there is no net loss of such wetlands. The Agency requests a study to determine the impacted by normal daily and seasonal operations of the project on wetland communities.

Proposed Methodology
The widely accepted methodology in the Federal Manual for Identifying and Delineating Jurisdictional Wetlands, as amended and supplemental guidance documents issued by the U.S. Army Corps of Engineers is recommended for identifying wetlands. The Vermont classification system for natural communities should be used to classify community type (See Appendix A). The general community composition should be recorded as well as any rare, threaten or endangered plant species or invasive species. The proportion of wetlands that are impacted by project operations should be compared to reference wetlands communities to evaluate how plant species composition has been altered by project operations. The frequency, timing, amplitude, and duration of reservoir fluctuations on impacted wetlands and natural communities should be recorded throughout the year. The ratio of wetland types presently identified in the project boundaries should be compared to national wetland inventory maps to address if project operations have altered wetlands.

Level of Effort and Cost
The cost and effort of this study will be moderate, but is important to document the potential impact operations have on wetlands within the vicinity of the project to determine if Vermont's wetland management goals are being met.

Vernon Hydroelectric Project – FERC No. 1904-073

Study Request 25: Impact of impoundment water level fluctuations on wetlands

Goals and Objectives

The goal of this study is to determine the impacts to wetlands from daily and seasonal water level fluctuation in the impoundment and downstream from the Vernon Hydroelectric Project to the head of the Turner Falls impoundment.

The objectives of this study are to:

1. Identify all wetlands types, natural communities, and invasive species within the impoundment and downstream, and determine the proportion of wetlands and wetland type (i.e. emergent, shrub, forested) that are impacted by daily and seasonal water level fluctuations from project operations.
2. Determine the ratios of wetland types in the project area should be compared to previous national wetland inventory maps, and/or to reference conditions to determine if wetland types or natural communities within the project impoundment or downstream are being altered by project operations.
3. Determine how project operations are affecting the wetland plant community composition, including promoting the spread of invasive species or affecting rare, threaten, and endangered species.

Resource Management Goals

The Agency's goals related to aquatic natural resources are to:

1. Protect, enhance, or restore, diverse high quality habitat necessary to sustain healthy aquatic and riparian plant and animal communities.
2. Provide an instream flow regime that meets the life history requirements of resident fish and wildlife (including invertebrates such as freshwater mussels) throughout the area impacted by Project operations.
3. Minimize the potential negative effects of project operation on water quality and aquatic habitat, and mitigate for loss or degradation.
4.

The Connecticut River is classified by the state of Vermont as Class B cold water fish habitat. Vermont Water Quality Standards state that Class B waters should be managed to achieve and maintain a level of quality that fully supports aquatic biota and habitat. Furthermore, the VTFWD's mission is "the conservation of all species of fish, wildlife, and plants and their habitats for the people of Vermont" (Kart et al. 2005).

Two of the Department's planning goals are:

1. Conserve, enhance, and restore Vermont's natural communities, habitats, and species and the ecological processes that sustain them.
2. Provide a diversity of fish- and wildlife-based activities and opportunities that allow the safe and ethical viewing, regulated harvesting, and utilization of fish, plant and wildlife resources consistent with the North American model of fish and wildlife conservation.

The goal of the Vermont Agency of Natural Resources is to identify and protect significant wetlands and the values and function which they ensure that there is no net loss of such wetlands and their function are achieved. Vermont classifies wetlands that are adjacent to streams, rivers, and open water that contain woody or persistent non-woody vegetation as Class II significant wetlands.

Public Interest Consideration
The requestor is a state natural resource agency.

Existing Information
The PAD does not address how wetlands type or wetland community composition that could be impacted by daily and seasonal water level fluctuations within the impoundment.

Project Nexus
The project impoundment extends 26 miles upstream from the dam. The project currently operates in a peaking mode, with allowable impoundment fluctuations of up to 8 feet, with proposals to continue as such. Wetlands can be affected by the operations of the hydropower project depending on frequency, timing, amplitude and duration of impoundment fluctuations. The PAD provides limited information on how project operations affect wetlands and the plant community composition within the project impoundment and downstream. Operations of the project must conform to Vermont goal of protecting significant wetlands and the values and function which they ensure that there is no net loss of such wetlands. The Agency requests a study to determine the impacted by normal daily and seasonal operations of the project on wetland communities.

Proposed Methodology
The widely accepted methodology in the Federal Manual for Identifying and Delineating Jurisdictional Wetlands, as amended and supplemental guidance documents issued by the U.S. Army Corps of Engineers is recommended for identifying wetlands. The Vermont classification system for natural communities should be used to classify community type (See Appendix A). The general community composition should be recorded as well as any rare, threaten or endangered plant species or invasive species. The proportion of wetlands that are impacted by project operations should be compared to reference wetlands communities to evaluate how plant species composition has been altered by project operations. The frequency, timing, amplitude, and duration of reservoir fluctuations on impacted wetlands and natural communities should be recorded throughout the year. The ratio of wetland types presently identified in the project boundaries should be compared to national wetland inventory maps to address if project operations have altered wetlands.

Level of Effort and Cost
The cost and effort of this study will be moderate, but is important to document the potential impact operations have on wetlands within the vicinity of the project to determine if Vermont's wetland management goals are being met.

Wilder Hydroelectric Project – FERC No. 1892-026
Bellows Falls Hydroelectric Project – FERC No. 1855-045
Vernon Hydroelectric Project – FERC No. 1904-073

Study Request 26: Impacts of water level fluctuations on aquatic vegetation, including invasive species, in project impoundments

Goals and Objectives

The goal of this study is to determine if the full range of water level fluctuations from the Vernon, Bellows Falls and Wilder Hydroelectric Projects negatively impact emergent aquatic vegetation (EAV) and submerged aquatic vegetation (SAV) and their habitats in the impoundments and riverine reaches below the dams.

The objective is to conduct field studies in mainstem littoral zones, tributaries and backwaters to determine if EAV and SAV species distribution and abundance, and their habitats, are impacted by current water level fluctuations permitted under the TransCanada Projects' licenses and whether aquatic vegetation and its habitats can be enhanced by modifications to project operations or other mitigation measures and whether there is any unique or important shoreline or aquatic habitats that should be protected. Results of this study may also be used to help determine the adequacy of existing downstream minimum flow requirements.

The specific objectives of the field study, at a minimum, include:

- Quantitatively describe and map wetland types within 200 feet of the shoreline, and describe associated wildlife;
- Delineate, quantitatively describe, and map all wetland types including invasive species and wildlife observed (e.g., bald eagle nesting, water fowl nesting) within 200 feet of the shoreline, and the extent of this habitat if it extends beyond 200 feet; and
- Quantitatively describe (e.g., substrate composition, vegetation type and abundance) and map shallow water aquatic habitat types subject to project operation inundation and exposure, noting and describing additional areas where water depths at lowest operational range are wetted to a depth less than one foot (flats, near shore areas, gravel bars, with very slight bathymetric change);

A second year of study may be required should river discharge in the first year prove to be atypical (outside of 25-75th percentile of average weekly flow values) during the study period.

The field study should produce a habitat inventory report that includes:

- The results of the field study in the form of maps and descriptions;
- An assessment of project effects on wetland, riparian, littoral zone vegetation and shallow water habitats, invasive plant species, and wildlife habitat at the project; and
- Recommendations for any necessary plant, habitat type, or wildlife, protection and/or invasive species control measures.

Resource Management Goals

The Agency's goals related to aquatic natural resources are to:

1. Protect, enhance, or restore, diverse high quality habitat necessary to sustain healthy aquatic and riparian plant and animal communities.
2. Provide an instream flow regime that meets the life history requirements of resident fish and wildlife (including invertebrates such as freshwater mussels) throughout the area impacted by Project operations.
3. Minimize the potential negative effects of project operation on water quality and aquatic habitat, and mitigate for loss or degradation.

The Connecticut River is classified by the state of Vermont as Class B cold water fish habitat. Vermont Water Quality Standards state that Class B waters should be managed to achieve and maintain a level of quality that fully supports aquatic biota and habitat. Furthermore, the VTFWD's mission is "the conservation of all species of fish, wildlife, and plants and their habitats for the people of Vermont" (Kart et al. 2005).

Two of the Department's planning goals are:

1. Conserve, enhance, and restore Vermont's natural communities, habitats, and species and the ecological processes that sustain them.
2. Provide a diversity of fish- and wildlife-based activities and opportunities that allow the safe and ethical viewing, regulated harvesting, and utilization of fish, plant and wildlife resources consistent with the North American model of fish and wildlife conservation.

Vermont Fish and Wildlife Department's Strategic Plan (2002 -2010) focuses towards four major areas of concern: resource conservation, fish and wildlife-based recreation and use, human health and safety, efficient operations, and effective management.

Riverine fish species are an important component of the river's ecology and in some cases are the basis for a sport fishery. Aquatic vegetation is crucial fish habitat as the majority of fish in the project impoundments utilize EAV and SAV at some point during their life history. This requested study will help enhance EAV and SAV in the project impoundments.

Public Interest Consideration

The New Hampshire Fish and Game Department, the Vermont Fish and Wildlife Department, and the New Hampshire Department of Environmental Services are requesting this study. The requestors are state natural resource agencies.

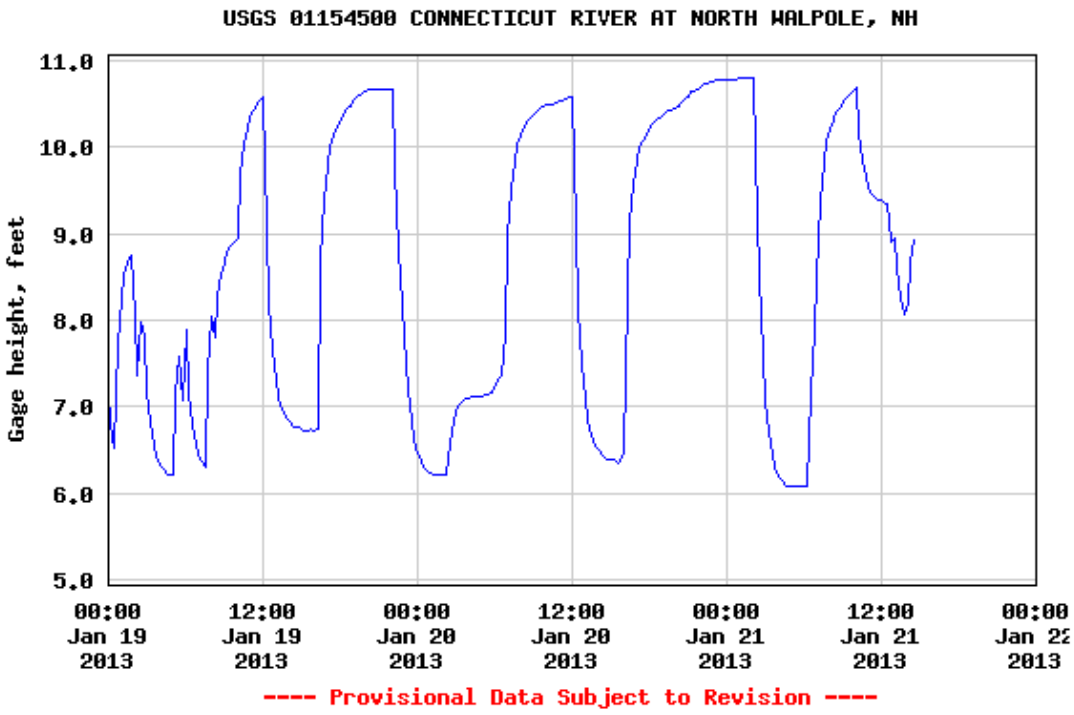
Existing Information

Existing information in the PADs does not quantify EAV and SAV. However, the applicant acknowledges that water level fluctuations caused by the project have the potential to affect fringing wetland and littoral areas:

> "*The average daily water level fluctuation of 2.5 vertical feet has resulted in a zone of sparse vegetation along most of the shorelines of the impoundment. Wetland and littoral resources in this zone are limited by the frequent wetting and drying.*" (Wilder PAD, p.3-

104, see also similar language in the Bellows Falls PAD p. 3-115 and the Vernon PAD p. 3-143)

An example of the water level fluctuations that occur in the Lower Connecticut River due to hydropower generation is shown below.



Project Nexus

Water level fluctuations due to project operations have the potential to influence fish species life history requirements, biological interactions, and habitat quantity and quality by impacting EAV and SAV. For example, water level changes due to project operations could create conditions where EAV and SAV abundance is diminished, thus negatively impacting a habitat used by riverine fish for spawning, rearing, feeding, and cover. Additionally, water level fluctuations due to project operations could influence EAV and SAV habitat in the project impoundments and promote invasive plants over native species. This study needs to take into account existing and potential future limits on impoundment level fluctuations intended to limit recreation impacts, and the interactions of any changes in pond level fluctuation range or frequency and discharge changes.

Proposed Methodology

Vegetation mapping and mapping of littoral zones in relation to water level fluctuations are common tools for identifying EAV and SAV that may be impacted by changes in water levels. The study should include field surveys designed to describe the characteristics of each mapped wetland, riparian, littoral and shallow water habitat including plant species composition, relative abundance/density, habitat quality, and land use. These surveys should be conducted to describe

these habitats at the lowest water level operational range permitted on a daily operation schedule, under low flow conditions. Information collected should include:

- Plant species composition, and their relative abundance/density and condition/structure (e.g., seedlings)
- Surveying for the federally Endangered Northeastern bulrush (*Scirpus ancistrochaetus*);
- Structured data, including estimates of average heights and aerial cover of each vegetation layer (specifically denoting invasive species);
- Aquatic habitat substrate composition, quantity (i.e., percent types and area), wood structure (relative abundance measure applied by area), water depths (inundated, exposed, and water less than one foot);
- Predominate land use(s) associated with each cover type;
- Wildlife sightings should be noted;
- Field verified wetland, riparian, and littoral and shallow water habitats and invasive species occurrences, should be geo-referenced as polygons and overlain on orthophoto at a suitable scale.

Bathymetric mapping of the littoral zone will be needed to model the extent of this zone that will be affected by different water fluctuation scenarios.

The study area is from the most upstream area influenced by the Wilder Dam to the most downstream area influenced by the Vernon Dam. Water level fluctuations caused by the projects may affect not only the impoundments, but also the downstream river reaches below the dams. Studies would occur in the main river littoral zone and in backwater areas during spring, summer and fall. A second year of study may be required if first year data collection is limited due to environmental or other conditions, or if river discharge in the first year prove to be atypical (outside of 25-75th percentile of average weekly flow values) during the study period.

Level of Effort and Cost

Although the PAD's acknowledge that project operations have the potential to impact littoral resources, TransCanada did not propose any studies concerning aquatic vegetation. Analysis as described above is needed to understand potential impacts of the projects on these resources. Estimated cost for the study is moderate due to the need for field assessment.

Literature Cited

Kart, J., R. Regan, S.R. Darling, C. Alexander, K. Cox, M. Ferguson, S. Parren, K. Royar, B. Popp, editors. 2005. Vermont's Wildlife Action Plan. Vermont Fish & Wildlife Department. Waterbury, Vermont. http://www.vtfishandwildlife.com/swg_cwcs_report.cfm. (Access September 10, 2012).

Vermont Fish and Wildlife Department . 2006. Vermont Fish and Wildlife Strategic Plan. http://www.vtfishandwildlife.com/library/reports_and_documents/Fish_and_wildlife/Strategic_Plan.pdf

Turners Falls Hydroelectric Project – FERC No. 1889-081
Northfield Mountain Pumped Storage Project – FERC No. 2485-063

Study Request 26: Impacts of water level fluctuations on aquatic vegetation, including invasive species, in project impoundment

Goals and Objectives

The goal of this study is to obtain baseline information on riparian, wetland, Emergent Aquatic Vegetation (EAV), Submerged Aquatic Vegetation (SAV), littoral zone and shallow water aquatic habitats (subject to operational inundation and exposure to near exposure) known to occur in the project area. Information would be used to determine whether riparian, wetland, EAV and SAV, littoral, and shallow water (e.g., mid river bars and shoals) habitats are impacted by current water level fluctuations permitted under the Turners Falls and Northfield projects' licenses and whether these vegetation types and shallow water habitats can be protected and restored by modifications to project operations or other mitigation measures. This analysis needs to take into account existing and potential future limits on pond level fluctuations intended to limit recreation impacts, and the interactions of any changes in pond level fluctuation range or frequency and discharge changes under a new licenses of the Turners Falls and upstream projects. This information is needed to determine whether the projects operation affects plants, habitat, and wildlife in the project area, whether aquatic vegetation and its habitats can be enhanced by modifications to project operations or other mitigative measures, and whether there is any unique or important shoreline or aquatic habitats that should be protected.

The specific objectives of the field study, at a minimum, include:

- Quantitatively describe and map wetland types within 200 feet of the shoreline, and describe associated wildlife;
- Delineate, quantitatively describe, and map all wetland types including invasive species and wildlife observed (e.g., bald eagle nesting, water fowl nesting) within 200 feet of the shoreline, and the extent of this habitat if it extends beyond 200 feet; and
- Quantitatively describe (e.g., substrate composition, vegetation type and abundance) and map shallow water aquatic habitat types subject to project operation inundation and exposure, noting and describing additional areas where water depths at lowest operational range are wetted to a depth less than one foot (flats, near shore areas, gravel bars, with very slight bathymetric change);

A second year of study may be required should river discharge in the first year prove to be atypical (outside of 25-75th percentile of average weekly flow values) during the study period.

The field study should produce a habitat inventory report that includes:

- The results of the field study in the form of maps and descriptions;
- An assessment of project effects on wetland, riparian, littoral zone vegetation and shallow water habitats, invasive plant species, and wildlife habitat at the project; and
- Recommendations for any necessary plant, habitat type, or wildlife, protection and/or invasive species control measures.

Resource Management Goals

The Agency's goals related to aquatic natural resources are to:

1. Protect, enhance, or restore, diverse high quality habitat necessary to sustain healthy aquatic and riparian plant and animal communities.
2. Provide an instream flow regime that meets the life history requirements of resident fish and wildlife (including invertebrates such as freshwater mussels) throughout the area impacted by Project operations.
3. Minimize the potential negative effects of project operation on water quality and aquatic habitat, and mitigate for loss or degradation.

The Connecticut River is classified by the state of Vermont as Class B cold water fish habitat. Vermont Water Quality Standards state that Class B waters should be managed to achieve and maintain a level of quality that fully supports aquatic biota and habitat. Furthermore, the VTFWD's mission is "the conservation of all species of fish, wildlife, and plants and their habitats for the people of Vermont" (Kart et al. 2005).

Two of the Department's planning goals are:

1. Conserve, enhance, and restore Vermont's natural communities, habitats, and species and the ecological processes that sustain them.
2. Provide a diversity of fish- and wildlife-based activities and opportunities that allow the safe and ethical viewing, regulated harvesting, and utilization of fish, plant and wildlife resources consistent with the North American model of fish and wildlife conservation.

Vermont Fish and Wildlife Department's Strategic Plan (2002 -2010) focuses towards four major areas of concern: resource conservation, fish and wildlife-based recreation and use, human health and safety, efficient operations, and effective management. The Agency aims to protect and restore native riparian, wetland, EAV, SAV, littoral and shallow water habitat (i.e., spawning and or nursery areas for aquatic organisms) in the project reservoir.

Public Interest Consideration

The requestor is a resource agency.

Existing Information

Existing information in the PAD does not quantify EAV and SAV in this area, or other shallow aquatic habitat types and physical features (e.g., depths, substrates, wood structure) that are the environment for aquatic biota in the project area. The PAD does provide some limited monitoring data for 2012 (2 locations) on water surface elevations that show daily fluctuations, in the upper third of this impoundment, that varied over 4 feet on a daily cycling frequency, with fluctuations generally in the 2 foot range in low flow months for the data provided in the PAD. The current license does permit a greater pool elevation operational fluctuation, up to a 9 foot change in elevation, based on the Turners Falls Dam water elevation. In the PAD it is noted these operational fluctuations under most circumstances at the Turners Falls Dam are within 3.5 feet.

In the PAD it is noted that FLP would like to expand its NMPS upper reservoir capacity (by up to 24%), how this may affect project operations and the habitats noted in this request is unknown. It is also noted that water is typically pumped to the upper reservoir in evening and generation back to the river occurs once to twice daily, in daytime hours, based upon power needs and power value. Under current license conditions, provided set thresholds for minimum flow and Turners Dam current license elevations are met, the NMPS may operate with no restriction in timing, frequency, or magnitude for pumping or generation. No data were provided on the operation of the NMPS plant over time relative to data on pumping and generation on an hourly basis, averaged values were provided over monthly periods. It is unclear what the actual timing, frequency and magnitude of these NMPS operations are over the course of a year and how that relates to; aquatic plant species establishment, growth, survival, littoral zone or other shallow water habitat fish spawning periods and their effects on these fishes (reproduction success and subsequent recruitment, e.g., bass and fall fish nests) in available and utilized habitat, and how the quantity and quality of these shallow water habitats are effected by project operational manipulation/alteration, as currently permitted or proposed.

The PAD provides lists of plant and wildlife species whose native ranges overlap with the project area, but it does not provide any baseline information on known occurrences of these species in the wetlands, riparian, littoral and shallow water habitats, within or adjacent to, the project area. Plant and wildlife occurring in these habitats may benefit from protection, mitigation, and enhancement (PMEs) measures, given the potential effects of continuing the current semiautomatic peaking operating regime. In addition, a large scale sediment discharge from NMPS resulted in regulatory actions by FERC, the EPA and MADEP in 2010. Continuing and as yet unresolved management plan measures relative to sediment and NMPS project operations, are further concerns for shallow water, littoral zone, and wetland habitats.

The Atlantic States Marine Fisheries Commission, Atlantic Coast Diadromous Fish Habitat: A Review of utilization, threats, recommendations for conservation, and research needs (ASMFC 2009), contains a review of habitat information for these species. Recommendations in this report include: Maintain water quality and suitable habitat for all life stages of diadromous species in all rivers with populations of diadromous species.

Project Nexus

Water level fluctuations due to project operations could affect EAV and SAV habitat as well as the quantity and quality littoral and shallow water habitat. These operational water level fluctuation effects are expected to impact fish species use of these habitats and may affect spawning fishes reproductive success and subsequent population recruitment including but not limited to American shad, blueback herring, sea lamprey, fall fish, and bluegill, which spawn in mid to late spring through early summer in areas subject to daily or more frequent water level fluctuations.

The current operating mode, as well as the unknowns with proposed upper reservoir expansion, may affect wetland riparian, littoral and other shallow water habitats and promote the introduction and expansion of invasive plant species through fluctuating water levels. A study that explains the relationship between the proposed mode of operation and the type and quantity

or wetland, riparian, littoral, shallow water habitats, and invasive species affected would help inform a decision on the need for protection and/or control of these resources in the license.

Proposed Methodology

The PAD currently contains maps portraying general wetland types from the Cabot Station tailrace upstream to the Vernon Dam. In addition, the Service understands that the detailed bathymetry exists for the Turners Falls impoundment. The proposed study should utilize this existing information in conjunction with field surveys designed to describe the characteristics of each mapped wetland, riparian, littoral and shallow water habitat including plant species composition, relative abundance/density, habitat quality, and land use. These surveys should be conducted to describe these habitats at the lowest water level operational range permitted on a daily operation schedule, under low flow conditions. Information collected should include:

- Plant species composition, and their relative abundance/density and condition/structure (e.g., seedlings);
- Structured data, including estimates of average heights and aerial cover of each vegetation layer (specifically denoting invasive species);
- Aquatic habitat substrate composition, quantity (i.e., percent types and area), wood structure (relative abundance measure applied by area), water depths (inundated, exposed, and water less than one foot);
- Predominate land use(s) associated with each cover type;
- Wildlife sightings should be noted;
- Field verified wetland, riparian, and littoral and shallow water habitats and invasive species occurrences, should be geo-referenced as polygons and overlain on orthophoto at a suitable scale.

Level of Effort and Cost

In the PAD, First Light identified impacts of the project operations on wetlands, riparian and littoral zone habitat as a potential issue to be addressed in relicensing, and proposed wetland vegetation mapping. However, additional analysis as described above is needed to understand the impacts of the project on these resources and habitats.

A wetlands, riparian, littoral/shallow water, invasive species inventory, of the scope envisioned, would likely require 6-8 months to complete and cost $40,000 to $50,000.

Literature Cited

Atlantic States Marine Fisheries Commission. 2009. Atlantic coast diadromous fish habitat: A review of utilization, threats, recommendations, for conservation, and research needs. Habitat Management Series #9. Washington, D.C.

Kart, J., R. Regan, S.R. Darling, C. Alexander, K. Cox, M. Ferguson, S. Parren, K. Royar, B. Popp, editors. 2005. Vermont's Wildlife Action Plan. Vermont Fish & Wildlife Department. Waterbury, Vermont. http://www.vtfishandwildlife.com/swg_cwcs_report.cfm. (Access September 10, 2012).

Vermont Fish and Wildlife Department . 2006. Vermont Fish and Wildlife Strategic Plan. http://www.vtfishandwildlife.com/library/reports_and_documents/Fish_and_wildlife/Strategic_Plan.pdf

Wilder Hydroelectric Project – FERC No. 1892-026
Bellows Falls Hydroelectric Project – FERC No. 1855-045

Study Request 27: Project effects on the dwarf wedgemussel (*Alasmidonta heterodon*)

Goals and Objectives

It has been well documented that the damming of rivers can have detrimental impacts on the mussel communities that inhabit areas both upstream and downstream of dams (Watters 1999, Layzer et. al. 1993, Moog 1993). The goal of this study is to evaluate the effects that the Wilder, and Bellows Falls hydroelectric projects have on populations of the federally-endangered dwarf wedgemussel (*Alasmidonta heterodon*). In addition, the results of the study can be used to develop measures to minimize adverse impacts to the dwarf wedgemussel in the future.

The specific objectives of the study are as follows:

1. Conduct an initial survey of the free flowing stretch of the Connecticut River from the Wilder Dam to the upstream end of the Bellows Falls impoundment to determine the distribution of the dwarf wedgemussel in this reach.
2. Determine the best sites for intensive quantitative sampling of mussel communities, with emphasis on the dwarf wedgemussel. Data will be collected to estimate density (mussels per unit area) and age class structure for all species.
3. Lay the groundwork for a long-term monitoring program.
4. Document instream behavior of mussels during varying flow conditions.
5. Determine how availability and persistence of dwarf wedgemussel habitat changes with water level and flow fluctuations.

Resource Management Goals

The dwarf wedgemussel is a federally- and state-endangered species. As such, this study request is intended to facilitate the collection of information necessary to conduct effects analyses and to develop reasonable and prudent conservation measures and protection, mitigation, and enhancement measures for the species pursuant to the Endangered Species Act of 1973, as amended (16 U.S.C. §1531 *et seq*.), and Vermont's Endangered Species Law (10 V.S.A. section 5401 et. seq.).

The Agency of Natural Resources conservation goals for endangered species are:

1. Maintain or increase populations of rare, threatened, and endangered species in the town or area of interest.
2. Maintain, restore, provide stewardship for, and conserve habitats and natural communities that support rare, threatened, and endangered species.

The Connecticut River dwarf wedgemussel population is one that must be demonstrated to be viable in order before the species can be down listed to threaten. The Upper Connecticut metapopulation is likely the largest remaining population in the world (USFWS 2007), and so its protection is essential to the recovery of the species as a whole.

Public Interest Consideration
The requestor is a state natural resource agency

Existing Information
In 2011, Biodrawversity, LLC conducted a freshwater mussel survey throughout the Vernon, Bellows Falls, and Wilder project areas (Biodrawversity and LBG 2012). This survey was semi-quantitative (i.e. timed searches were used) and the main goal was to assess the distribution, abundance, demographics, and habitat of the dwarf wedgemussel in the project areas. Dwarf wedgemussel were found in the Wilder impoundment (all within a 14-mile stretch of the river beginning 27 miles upstream of the Wilder Dam) and Bellows Falls impoundment (located sporadically in the upper 17 miles of the impoundment); none were found in the Vernon project-affected area. These results corroborate the results of other studies performed in the past in these areas (Nedeau 2006a, Nedeau 2006b).

The 2011 survey did not include the 17-mile free flowing stretch of the Connecticut River downstream of Wilder Dam. The dwarf wedgemussel has, in the past, been found within this river reach, although overall there has been limited survey work in the area. A better understanding of the distribution and abundance of the dwarf wedgemussel in this stretch of the river is required before an evaluation of how the dam affects this species can be made. **This need is represented in Objective 1**.

Since the 2011 survey was semi-quantitative, it cannot be used as a basis for determining population estimates or trends (Wicklow 2005). In fact, few if any of the past surveys performed in the project-affected areas have employed quantitative methodology. In addition, there is little quantitative information regarding the age class structure, and therefore recruitment, of the mussel communities in the area. In order to demonstrate that a dwarf wedgemussel population is viable according to the Dwarf Wedgemussel Recovery Plan (USFWS 1993), it must have a large and dense enough population to maintain genetic variability and annual recruitment must be adequate to maintain a stable population. Thus, knowledge of population size and density as well as a better understanding of age class structure is a necessary step in determining the baseline status of dwarf wedgemussel populations. The 2011 survey and other surveys can be used to determine the best sites for implementing a monitoring program. **This need is represented in Objective 2**.

Once this baseline is established, it will be important to monitor the sites so that biologists can estimate and track changes to dwarf wedgemussel populations and/or evaluate any project-related population impacts. Therefore, there is a need to develop long-term monitoring plots that will be surveyed at regular intervals using methodology that is repeatable and yields quantitative, statistically valid results. **This need is represented in Objective 3**.

Flow conditions that result from dam operations may alter the behavior of individual dwarf wedgemussels or individuals of other species. Dam operations affect streamflow, temperature, and dissolved oxygen, and changes to these variables can often be rapid. It is not known how these rapid changes affect various aspects of a mussel's biology, including lure display, shell position (open/closed), siphoning rate, and vertical migration. **This need is represented in Objective 4**.

Dam operations can also affect the availability of habitat for mussels, and this availability can change quickly as water levels fluctuate under peaking operations. The persistence of habitat is a key element to the long-term success of sedentary lotic organisms such as the dwarf wedgemussel (Maloney et. al. 2012), which is unable to quickly move in response to rapid changes in its environment and can thus become stranded in areas of unsuitable habitat; however, there is currently no information concerning the relation of project operations to habitat persistence within the Wilder and Bellows project-affected areas. **This need is represented in Objective 5**.

Project Nexus

The dwarf wedgemussel is known to occur within the Wilder and Bellows Falls project areas and operations of these two dams may affect the viability of this species in the Connecticut River. This study plan will allow for a better understanding of how sub-daily flow and water level fluctuations influence dwarf wedgemussel abundance, available habitat, and behavior. This information can be used to inform the development of license requirements that can ensure the continued existence of this species within the project-affected areas.

Additionally, a long-term monitoring program of important dwarf wedgemussel sites within the project areas is necessary to evaluate any project-related population and/or behavioral impacts that may occur. This information can be used to inform decision makers in the future.

Proposed Methodology

A survey of the 17-mile reach between the Bellows Falls impoundment and the Wilder Dam is the logical first step of the study plan, and this can be done in well less than one field season. This may be treated as an extension of the Biodrawversity and LBG (2012) survey and the same semi-quantitative methodology may be used. Once completed, this survey will help fill in the knowledge gap that exists in the distribution of the dwarf wedgemussel within this reach of the Connecticut River. **This proposed methodology corresponds to Objective 1**.

Next, quantitative study plots should be established at sites throughout the two project-affected areas that are known to support the dwarf wedgemussel. Plots should be set up and surveyed using methodology that will allow for the estimation of population density and size. Smith et. al. (2001) have developed such a methodology, which is also outlined in Strayer and Smith (2003). It is based on a double-sampling design (visual inspection of the substrate surface plus excavation of a random subset of quadrats) using 0.25 m^2 quadrats that are placed systematically with multiple random starts. This protocol has been used to monitor dwarf wedgemussel populations at two sites on the Ashuelot River in Keene, NH (Nedeau 2004). A number of other recent studies have also made use of this protocol for different species of mussels (Fulton et. al. 2010, Crabtree & Smith 2009, Bradburn 2009).

Data to determine age class structure should also be collected at these selected sites. This would involve measuring the length and estimating the age (through external annuli counts) of each mussel sampled within a quadrat. Based on this information, an analysis of recruitment can be made. This field work and analysis was performed on the mussel community inhabiting the lower Osage River in Missouri as part of the relicensing process of the Osage Hydroelectric

Project (FERC no. 459) (ESI 2003). The work done on the Osage can be used as a template for this study. Depending on how many plots are chosen, this phase of the study could take one or two field seasons. **This proposed methodology corresponds to Objective 2**.

The sites surveyed to meet Objective 2 should be resurveyed using the same methodology at regular intervals in the future so that any changes over time and/or over varied flow regimes can be evaluated. In addition, a mark-recapture pilot study should be initiated to evaluate the potential for using this methodology for long-term monitoring of dwarf wedgemussel abundance and survival. Mark-recapture methods provide statistically robust estimates of population parameters that are superior to simple count estimates in cases where it is not practicable to count all individuals in a population. Methods should be similar to those in Peterson et al. (2011), Meador et al. (2011), and Villella et al. (2004), but should focus on differences among sampled sites. Sites should be selected based on those sampled to meet Objective 2, but should also include sites outside of the project area to fully evaluate project effect and to account for any natural variability that may be independent of project effect.

A long-term mussel monitoring program was devised as part of the study plan for the relicensing of the Lake Blackshear Hydroelectric Project (FERC no. 659) on the Flint River in Georgia. According to the monitoring plan (Lake Blackshear Project 2009), three surveys will be conducted five years apart, beginning five years after issuance of the FERC license. Surveys will be quantitative (there is a qualitative aspect to the Lake Blackshear mussel monitoring plan that can be ignored) and will focus on evaluating changes in recruitment and population size of the purple bankclimber (*Elliptoideus sloatianus*), a federally-listed species. A similar protocol should be used to monitor dwarf wedgemussel populations in the project-affected areas of the Connecticut River post-license, although the number of surveys and the time between surveys may require some research and discussion. **This proposed methodology corresponds to Objective 3**.

In order to investigate the effects that the hydropower projects have on mussel behavior, individual mussels should be observed as flow fluctuates as a result of dam operations. Researchers should measure changes in shell position (open/closed), siphoning rate, lure display, horizontal migration (movement across the substrate), and vertical migration (burrowing). Past studies have quantified changes in vertical migration due to flow fluctuations (Saha & Layzer 2008, DiMaio & Corkum 1997). This phase of the study will likely take two field seasons in order to maximize the number of behavioral observations so that any trends can be identified and evaluated. **This proposed methodology corresponds to Objective 4**.

At these same sites, an evaluation of flow fluctuations on dwarf wedgemussel habitat persistence should be conducted following methods similar to those of Maloney et. al. (2012). This will include the development of a two-dimensional hydrodynamic model based on modeled depth, velocity, Froude number, shear velocity, and shear stress. This model will be used to quantify suitable dwarf wedgemussel habitat and its persistence over a range of flows, including flows typically experienced under peaking operations. These methods are being employed to evaluate persistence of dwarf wedgemussel habitat on the Delaware (Maloney et. al. 2012) and Susquehanna (T. Moburg, The Nature Conservancy, personal communication) rivers. Depending

on how many plots are chosen, this phase of the study could take one or two field seasons. **This proposed methodology corresponds to Objective 5**.

Level of Effort and Cost

The cost for collecting the data for this study is entirely dependent on the number of study sites selected, as well as how frequently surveys will be conducted as part of the long-term monitoring plan. The expected level of effort and anticipated costs will be comparable to that of similar FERC relicensing projects of this size.

Literature Cited

Biodrawversity and LBG (Biodrawversity, LLC and the Louis Berger Group, Inc.). 2012.Freshwater mussel survey in the Connecticut River for the Vernon, Bellows Falls, and Wilder Hydroelectric Projects. Prepared for TransCanada Hydro Northeast Inc.

Bradburn, Megan. 2009. A study of the abundance, diversity, and recruitment status of freshwater mussels in the Marais des Cygnes River, Kansas. Diss. University of Missouri.

Crabtree, D.L. & T.A. Smith. 2009. Population attributes of an endangered mussel, *Epioblasma torulosa rangiana* (Northern Riffleshell), in French Creek and implications for its recovery. *Northeastern Naturalist*, 16(3): 339-354.

DiMaio, J. and L. D. Corkum. 1997. Patterns of orientation in unionids as a function of rivers with differing hydrological variability. *Journal of Molluscan Studies* 63 (4): 531-539.

Ecological Specialists, Inc. (ESI) 2003. Naiad Population Assessment--Osage Hydroelectric Project (FERC No. 459) Submitted to AmerenUE, St. Louis, Missouri.

Fulton, J.W., C.R. Wagner, M.E. Rogers, & G.F. Zimmerman. 2010. Hydraulic modeling of mussel habitat at a bridge-replacement site, Allegheny River, Pennsylvania, USA. *Ecological Modelling* 221(3): 540-554.

Lake Blackshear Project (FERC No. 659). 2009. Post-license Freshwater Monitoring Plan. Available on FERC eLibrary.

Layzer, J. B., M. E. Gordon, and R. M. Anderson. 1993. Mussels: the forgotten fauna of regulated rivers. A case study of the Caney Fork River. *Regulated Rivers: Research and Management* 8: 63–71.

Meador, J.R., J.T. Peterson, and J.M. Wisniewski. 2011. An evaluation of the factors influencing freshwater mussel capture probability, survival, and temporary emigration in a large lowland river. Journal of the North American Benthological Society 30:507-521.

Moog, O. 1993. Quantification of daily peak hydropower effects on aquatic fauna and management to minimize environmental impacts. *Regulated Rivers: Research and Management* 8: 5-14.

Nedeau, E. 2006a. Freshwater mussels of the upper Connecticut River, with emphasis on the federally endangered dwarf wedgemussel (*Alasmidonta heterodon*). Report prepared for the Vermont Fish and Wildlife Department, Waterbury, VT. 25 pp.

Nedeau, E. 2006b. Characterizing the range and habitat of dwarf wedgemussels (Alasmidonta heterodon) in the “Middle Macrosite” of the upper Connecticut River. Report submitted to the U.S. Fish and Wildlife Service, Concord, NH. 6 pp.

Nedeau, E. 2004. Quantitative survey of dwarf wedgemussel (*Alasmidonta heterodon*) Populations downstream of the Surry Mountain Flood Control Dam on the Ashuelot River. Report Prepared for the United State Fish and Wildlife Service, Concord, NH. 10 pp.

Maloney, K.O., W.A. Lellis, R.M. Bennett, & T.J. Waddle. 2012. Habitat persistence for sedentary organisms in managed rivers: the case for the federally endangered dwarf wedgemussel (*Alasimodonta heterodon*) in the Delaware River. *Freshwater Biology* 57 (6): 1315–1327.

Peterson, J.T., J.M. Wisniewski, C.P. Shea, and C.R. Jackson. 2011. Estimation of mussel population response to hydrologic alteration in a southeastern U.S. stream. Environmental Management 48:109-122.

Saha, S. and J. Layzer. 2008. Behavioral and physiological responses of freshwater mussels (bivalvia: unionoida) to variations in stream discharge. Paper presented at the annual meeting of the International Congress for Conservation Biology, Convention Center, Chattanooga, TN, July 10, 2008. <http://www.allacademic.com/meta/p244055_index.html>

Smith, D.R., R.F. Villella, & D.P. Lemarie. 2001. Survey protocol for assessment of endangered freshwater mussels in the Allegheny River, Pennsylvania. *Journal of the North American Benthological* Society 20(1): 118-132.

Strayer, D.L., and D.R. Smith. 2003. A Guide to Sampling Freshwater Mussel Populations. American Fisheries Society, Monograph 8, Bethesda, Maryland.

U.S. Fish and Wildlife Service. 2007. Dwarf Wedgemussel *Alasmidonta heterodon* 5 year review: Summary and Evaluation. Concord, New Hampshire.

U.S. Fish and Wildlife Service. 1993. Dwarf Wedge Mussel *Alasmidonta heterodon* Recovery Plan. Hadley, Massachusetts. 52 pp.

Villella, R.F., D.R. Smith, and D.P. LeMarié. 2004. Estimating survival and recruitment in a freshwater mussel population using mark-recapture techniques. American Midland Naturalist 151:114-133.

Watters, T. G. 199. Freshwater mussels and water quality: a review of the effects of hydrologic and instream habitat alterations. *Proceedings of the First Freshwater Mollusk Conservation Society Symposium: Ohio Biological Survey:* 261-274.

Wicklow, B. 2005. *in* New Hampshire Wildlife Action Plan. New Hampshire Fish and Game Department, 11 Hazen Dr., Concord, NH, 03301. pp. A26-A35.

Wilder Hydroelectric Project – FERC No. 1892-026

Study Request 28: Assess the impact of project operations on state-listed rare, threatened and endangered plant species and significant natural communities

Goals and Objectives

The goal of this study is to determine the potential impact of water fluctuations downstream and within the impoundment from project operations on state listed rare, threaten, and endangered plant species (S1 & S2) and significant natural communities. The survey should encompass all areas from the head of the impoundment, downstream to the start of the next projects impoundment.

The objectives of this study are:

- Identify rare and state listed plants and significant natural communities that might be affected by an altered hydrological regime.
- Determine mitigation in operations that might be appropriate to ameliorate any adverse impacts.

Resource Management Goals

Vermont threatened and endangered species are protected by Vermont's Endangered Species Law (10 V.S.A. section 5401 et. seq.). The Agency of Natural Resources conservation goals for endangered species are:

1. Maintain or increase populations of rare, threatened, and endangered species in the town or area of interest.
2. Maintain, restore, provide stewardship for, and conserve habitats and natural communities that support rare, threatened, and endangered species.

The Connecticut River is classified by the state of Vermont as Class B cold water fish habitat. Vermont Water Quality Standards state that Class B waters should be managed to achieve and maintain a level of quality that fully supports aquatic biota and habitat. Furthermore, the Vermont Fish and Wildlife Department mission is "the conservation of all species of fish, wildlife, and plants and their habitats for the people of Vermont" (Kart et al. 2005).

Two of the Department's planning goals are:

1. Conserve, enhance, and restore Vermont's natural communities, habitats, and species and the ecological processes that sustain them.
2. Provide a diversity of fish- and wildlife-based activities and opportunities that allow the safe and ethical viewing, regulated harvesting, and utilization of fish, plant and wildlife resources consistent with the North American model of fish and wildlife conservation.

Public Interest Consideration

The requestor is a state natural resource agency.

Existing Information

The PAD indicates that there are many state listed rare, threaten, and endangered plant species occur within project area. A rare plant and community survey was conducted in summer 2012 to document the presence or absence of rare species, identify additional locations of rare species, and to evaluate the potential for project impacts on rare species. The PAD indicates that the detailed results of this survey would be available in late 2012, but at the time of filing this study request, the report was not available for Agency review to confirm the appropriate methodology was used and conclusions in the PAD.

Project Nexus

The project impoundment extends 45 miles upstream from the dam. The project currently operates in a peaking mode, with allowable impoundment fluctuations of up to 5 feet, with proposals to continue as such. The below-project flow requirement is equal to 0.20 csm (675 cfs), but can increase rapidly during times of power generation. Rare plants and natural communities can be affected by the operations of the hydropower project depending on frequency, timing, amplitude and duration of impoundment fluctuations. The PAD provides limited information on how project operations affect the rare plant communities' composition within the project impoundment. Operations of the project must conform to protect state listed plant species and natural communities. The Agency requests a study to determine the impacted by normal daily and seasonal operations of the project on state listed rare, threaten, and endangered plant species (S1 & S2) and significant natural communities.

Proposed Methodology

To assess the adverse impact of project operations on state listed plants and natural communities a survey of the impoundment and downstream of the project should be conducted. The survey should survey all that could potentially be affected by project operations. This survey should extend to cover the 100 year floodplain. A precise elevation should be recorded with a GPS unit to determine the proximity to project operations. An assessment of the plants and natural community overall health and condition should be determined to assess whether project operations are negatively impacting the community. State listed or natural communities deemed to be impacted by project operations; mitigation in operational procedures should be explored. Mitigation of the project operations on plants and natural communities should take into account the physical and biological requirements and whether there are certain times that the plants and/or community are more sensitive to project operations.

Level of Effort and Cost

The cost and effort of this study will be moderate, but is important to document the potential impact operations have on state listed plants and significant natural communities within the vicinity of the project to determine if Vermont's natural resource management goals are being met.

Bellows Falls Hydroelectric Project – FERC No. 1855-045

Study Request 28: Assess the impact of project operations on state-listed rare, threatened and endangered plant species and significant natural communities

Goals and Objectives

The goal of this study is to determine the potential impact of water fluctuations downstream and within the impoundment from project operations on state listed rare, threaten, and endangered plant species (S1 & S2) and significant natural communities. The survey should encompass all areas from the head of the impoundment, downstream to the start of the next projects impoundment.

The objectives of this study are:

- Identify rare and state listed plants and significant natural communities that might be affected by an altered hydrological regime.
- Determine mitigation in operations that might be appropriate to ameliorate any adverse impacts.

Resource Management Goals

Vermont threatened and endangered species are protected by Vermont's Endangered Species Law (10 V.S.A. section 5401 et. seq.). The Agency of Natural Resources conservation goals for endangered species are:

1. Maintain or increase populations of rare, threatened, and endangered species in the town or area of interest.
2. Maintain, restore, provide stewardship for, and conserve habitats and natural communities that support rare, threatened, and endangered species.

The Connecticut River is classified by the state of Vermont as Class B cold water fish habitat. Vermont Water Quality Standards state that Class B waters should be managed to achieve and maintain a level of quality that fully supports aquatic biota and habitat. Furthermore, the Vermont Fish and Wildlife Department mission is "the conservation of all species of fish, wildlife, and plants and their habitats for the people of Vermont" (Kart et al. 2005).

Two of the Department's planning goals are:

1. Conserve, enhance, and restore Vermont's natural communities, habitats, and species and the ecological processes that sustain them.
2. Provide a diversity of fish- and wildlife-based activities and opportunities that allow the safe and ethical viewing, regulated harvesting, and utilization of fish, plant and wildlife resources consistent with the North American model of fish and wildlife conservation.

Public Interest Consideration

The requestor is a state natural resource agency.

Existing Information

The PAD indicates that there are many state listed rare, threaten, and endangered plant species occur within project area. A rare plant and community survey was conducted in summer 2012 to document the presence or absence of rare species, identify additional locations of rare species, and to evaluate the potential for project impacts on rare species. The PAD indicates that the detailed results of this survey would be available in late 2012, but at the time of filing this study request, the report was not available for Agency review to confirm the appropriate methodology was used and conclusions in the PAD.

Project Nexus

The project impoundment extends 26 miles upstream from the dam. The project currently operates in a peaking mode, with allowable impoundment fluctuations of up to 3 feet, with proposals to continue as such. The below-project flow requirement is equal to 0.20 csm (1080 cfs), but can increase rapidly during times of power generation. Rare plants and natural communities can be affected by the operations of the hydropower project depending on frequency, timing, amplitude and duration of impoundment fluctuations. The PAD provides limited information on how project operations affect the rare plant communities' composition within the project impoundment. Operations of the project must conform to protect state listed plant species and natural communities. The Agency requests a study to determine the impacted by normal daily and seasonal operations of the project on state listed rare, threaten, and endangered plant species (S1 & S2) and significant natural communities.

Proposed Methodology

To assess the adverse impact of project operations on state listed plants and natural communities a survey of the impoundment and downstream of the project should be conducted. The survey should survey all that could potentially be affected by project operations. This survey should extend to cover the 100 year floodplain. A precise elevation should be recorded with a GPS unit to determine the proximity to project operations. An assessment of the plants and natural community overall health and condition should be determined to assess whether project operations are negatively impacting the community. State listed or natural communities deemed to be impacted by project operations; mitigation in operational procedures should be explored. Mitigation of the project operations on plants and natural communities should take into account the physical and biological requirements and whether there are certain times that the plants and/or community are more sensitive to project operations.

Level of Effort and Cost

The cost and effort of this study will be moderate, but is important to document the potential impact operations have on state listed plants and significant natural communities within the vicinity of the project to determine if Vermont's natural resource management goals are being met.

Vernon Hydroelectric Project – FERC No. 1904-073

Study Request 28: Assess the impact of project operations on state-listed rare, threatened and endangered plant species and significant natural communities

Goals and Objectives

The goal of this study is to determine the potential impact of water fluctuations downstream and within the impoundment from project operations on state listed rare, threaten, and endangered plant species (S1 & S2) and significant natural communities. The survey should encompass all areas from the head of the impoundment, downstream to the start of the next projects impoundment.

The objectives of this study are:

- Identify rare and state listed plants and significant natural communities that might be affected by an altered hydrological regime.
- Determine mitigation in operations that might be appropriate to ameliorate any adverse impacts.

Resource Management Goals

Vermont threatened and endangered species are protected by Vermont's Endangered Species Law (10 V.S.A. section 5401 et. seq.). The Agency of Natural Resources conservation goals for endangered species are:

1. Maintain or increase populations of rare, threatened, and endangered species in the town or area of interest.
2. Maintain, restore, provide stewardship for, and conserve habitats and natural communities that support rare, threatened, and endangered species.

The Connecticut River is classified by the state of Vermont as Class B cold water fish habitat. Vermont Water Quality Standards state that Class B waters should be managed to achieve and maintain a level of quality that fully supports aquatic biota and habitat. Furthermore, the Vermont Fish and Wildlife Department mission is "the conservation of all species of fish, wildlife, and plants and their habitats for the people of Vermont" (Kart et al. 2005).

Two of the Department's planning goals are:

1. Conserve, enhance, and restore Vermont's natural communities, habitats, and species and the ecological processes that sustain them.
2. Provide a diversity of fish- and wildlife-based activities and opportunities that allow the safe and ethical viewing, regulated harvesting, and utilization of fish, plant and wildlife resources consistent with the North American model of fish and wildlife conservation.

Public Interest Consideration

The requestor is a state natural resource agency.

Existing Information

The PAD indicates that there are many state listed rare, threaten, and endangered plant species occur within project area. A rare plant and community survey was conducted in summer 2012 to document the presence or absence of rare species, identify additional locations of rare species, and to evaluate the potential for project impacts on rare species. The PAD indicates that the detailed results of this survey would be available in late 2012, but at the time of filing this study request, the report was not available for Agency review to confirm the appropriate methodology was used and conclusions in the PAD.

Project Nexus

The project impoundment extends 26 miles upstream from the dam. The project currently operates in a peaking mode, with allowable impoundment fluctuations of up to 8 feet, with proposals to continue as such. The below-project flow requirement is equal to 0.20 csm (1250 cfs), but can increase rapidly during times of power generation. Rare plants and natural communities can be affected by the operations of the hydropower project depending on frequency, timing, amplitude and duration of impoundment fluctuations. The PAD provides limited information on how project operations affect the rare plant communities' composition within the project impoundment. Operations of the project must conform to protect state listed plant species and natural communities. The Agency requests a study to determine the impacted by normal daily and seasonal operations of the project on state listed rare, threaten, and endangered plant species (S1 & S2) and significant natural communities.

Proposed Methodology

To assess the adverse impact of project operations on state listed plants and natural communities a survey of the impoundment and downstream of the project should be conducted. The survey should survey all that could potentially be affected by project operations. This survey should extend to cover the 100 year floodplain. A precise elevation should be recorded with a GPS unit to determine the proximity to project operations. An assessment of the plants and natural community overall health and condition should be determined to assess whether project operations are negatively impacting the community. State listed or natural communities deemed to be impacted by project operations; mitigation in operational procedures should be explored. Mitigation of the project operations on plants and natural communities should take into account the physical and biological requirements and whether there are certain times that the plants and/or community are more sensitive to project operations.

Level of Effort and Cost

The cost and effort of this study will be moderate, but is important to document the potential impact operations have on state listed plants and significant natural communities within the vicinity of the project to determine if Vermont's natural resource management goals are being met.

Wilder Hydroelectric Project – FERC No. 1892-026
Bellows Falls Hydroelectric Project – FERC No. 1855-045
Vernon Hydroelectric Project – FERC No. 1904-073

Study Request 29: Survey the number, species and behavior of adult dragonflies and emerging nymphs within the project areas

Goals and Objectives

The goal of this study is to conduct an inventory to detect and gather information on known and new odonate populations classified as Species of Greatest Conservation Need (SGCN) along the Connecticut River throughout the project area to assess the potential impact of project operations on dragonflies species habitat and survival.

The objectives of this study are:

Obtain information on the habitats of each species collected, in particular the riparian zone vegetation cover, river substrate and water quality.

Obtain information on the life cycle of each species present and most importantly, the hatching period and number per year of nymphs.

Obtain baseline distributional and relative abundance data for all odonate species by conducting surveys throughout the project areas.

Assess the vulnerability of nymphs of each species to disturbances such as water level fluctuation during nymph hatching, flow fluctuations, changes in vegetation or exposed hard substrate in the riparian area.

Determine if Project operations are adversely affecting the survival success of emerging nymphs (i.e. if flow alterations are causing mortality prior to hardening off).

If it is determined that the Project operations are adversely affecting survival, identify operational regimes that will reduce and minimize impacts odonates and odonate habitat within the project area.

Resource Management Goals

The Agency's goals related to aquatic natural resources are to:

1. Protect, enhance, or restore, diverse high quality habitat necessary to sustain healthy aquatic and riparian plant and animal communities.
2. Provide an instream flow regime that meets the life history requirements of resident fish and wildlife (including invertebrates such as freshwater mussels) throughout the area impacted by Project operations.
3. Minimize the potential negative effects of project operation on water quality and aquatic habitat, and mitigate for loss or degradation.

The Connecticut River is classified by the state of Vermont as Class B cold water fish habitat. Vermont Water Quality Standards state that Class B waters should be managed to achieve and maintain a level of quality that fully supports aquatic biota and habitat. Furthermore, the VTFWD's mission is "the conservation of all species of fish, wildlife, and plants and their habitats for the people of Vermont" (Kart et al. 2005).

Two of the Department's planning goals are:

1. Conserve, enhance, and restore Vermont's natural communities, habitats, and species and the ecological processes that sustain them.

2. Provide a diversity of fish- and wildlife-based activities and opportunities that allow the safe and ethical viewing, regulated harvesting, and utilization of fish, plant and wildlife resources consistent with the North American model of fish and wildlife conservation.

Three odonate species within the lower Connecticut River drainage are listed as Vermont Species of Greatest Conservation Need (SGCN) within the River/Stream odonates group.

Conversion of habitat, habitat alteration and sedimentation are all identified in the Vermont Wildlife Action Plan (VWAP) as current problems facing odonates.

A high priority strategy in the VWAP for odonate management is the acquisition or easements on high priority SGCN odonate riverine sites.

Protecting and restoring aquatic and riparian habitats through improved water quality; flow, water level and temperature regimes; sediment reduction; establishment of streamside buffers; and suitable aquatic habitat structure, diversity and complexity is a conservation strategy identified in the VWAP for aquatic species.

Results of the survey will be used to develop flow-related license requirements and/or other mitigation measures that will optimize habitat for these Vermont SGCN.

Public Interest Consideration

The requestor is a state resource agency.

Existing Information

At least nine odonate species are known to inhabit the Connecticut River valley in Vermont, the habitat requirements of which vary within the general rivers/streams category. Most species have not been assigned state status ranks, due to incomplete distribution and abundance information.[2]

A total of 18 dragonfly species have been documented in the Connecticut River valley in Massachusetts just south of the Vernon project area, including 8 that are listed by the state of Massachusetts as Species of Special Concern, Threatened, or Endangered, including some known Vermont species. [1]. However, their existence above the Vernon dam is unknown.

Odonates emerge from the water as nymphs and shed their pupal skins at or very close to the first vertical surface they encounter. Dragonflies are soft for the first half-hour after emerging from their skins and are at risk of being injured or killed by waves from passing boats and rapidly fluctuating water levels. Until their bodies harden and their wings dry, they cannot move further up the bank. Dragonflies that emerge at or very close to the waterline are therefore at significantly higher risk of injury or death. [1]

To date no studies have been conducted above the Vernon Dam to identify odonate populations within the three project areas and whether project operations are affecting these populations.

Project Nexus

The Wilder Project impounds 45 miles of river that would otherwise be free flowing. The project currently operates in a peaking mode, with allowable impoundment fluctuations of up to 5 feet, with proposals to continue as such. The below-project flow requirement is equal to 0.20 csm (675 cfs), but can increase rapidly during times of power generation.

The Bellows Falls Project impounds 26 miles of river that would otherwise be free flowing. The project currently operates in a peaking mode, with allowable impoundment fluctuations of up to 3 feet, with proposals to continue as such. The below-project flow requirement is equal to 0.20 csm (1083 cfs), but can increase rapidly during times of power generation.

The Vernon Project impounds 26 miles of river that would otherwise be free flowing. The project currently operates in a peaking mode, with allowable impoundment fluctuations of up to 8 feet, with proposals to continue as such. The below-project flow requirement is equal to 0.20 csm (1250 cfs), but can increase rapidly during times of power generation.

Operations at the three projects have the potential to cause direct adverse effects to odonate habitat within the project area, and effect survival of during emergence. The Agency requests a study assess whether project operations are having any adverse effects to these populations.

Proposed Methodology

Study methods similar to those from Morrison, F., McLain, D., and Sanders, L. 2006. *A Survey of Dragonfly Emergence Patterns Based on Exuvia Counts and the Results of River Bottom Transects at Selected Sites in the Turners Falls Pool of the Connecticut River, 2006 Field Season* This would provide valley wide consistency in methodology.

Level of Effort and Cost

The estimated level of effort and costs for this recommended study is expected to be moderate. The applicant did not propose any alternative studies in its PAD to address this specific issue.

Literature Cited

[1]Dragonfly Studies
http://www.restoreconnriver.org/dragonfly_studies.php
© 2007 Franklin Regional Council of Governments, 425 Main Street, Suite 20, Greenfield, MA 01301-3313 Ph: 413-774-3167 | Email: info@frcog.org

[2]Vermont's Wildlife Action Plan. 2005. Vermont Fish & Wildlife Department. Waterbury, Vermont. http://www.vtfishandwildlife.com/swg_cwcs_report.cfm.

Wilder Hydroelectric Project – FERC No. 1892-026
Bellows Falls Hydroelectric Project – FERC No. 1855-045
Vernon Hydroelectric Project – FERC No. 1904-073

Study Request 30: Survey for new and existing populations of adult Cobblestone and Puritan tiger beetle populations within the project areas

Goals and Objectives

The goal of this study is to conduct a survey to detect and gather information on known and new Cobblestone and Puritan tiger beetle populations along the Connecticut River throughout the project area (including the impoundments and downstream in the free flowing reaches), and to determine the potential impact from project operations on tiger beetles.

The objectives of this study are:

- Obtain baseline distributional and abundance data and map occurrences of Cobblestone and Puritan tiger beetle populations along the Connecticut River throughout the three project areas.
- Define the particular habitat requirements of each species.
- Assess the vulnerability of each species to disturbances such as siltation, flow fluctuations, and changes in shoreline composition and vegetation.
- Identify areas within the project areas where suitable habitat may exist for tiger beetles and the portion affected by project operations.
- Determine if project operations are adversely affecting the survival success of tiger beetle and beetle larva.
- If it is determined that the project operations are adversely affecting survival, identify operational regimes that will reduce and minimize impacts to tiger beetle and tiger beetle habitat within the project area.

Resource Management Goals

Vermont threatened and endangered species are protected by Vermont's Endangered Species Law (10 V.S.A. section 5401 et. seq.). The Agency of Natural Resources conservation goals for endangered species are:

1. Maintain or increase populations of rare, threatened, and endangered species in the town or area of interest.
2. Maintain, restore, provide stewardship for, and conserve habitats and natural communities that support rare, threatened, and endangered species.

The Connecticut River is classified by the state of Vermont as Class B cold water fish habitat. Vermont Water Quality Standards state that Class B waters should be managed to achieve and maintain a level of quality that fully supports aquatic biota and habitat. Furthermore, the VTFWD's mission is "the conservation of all species of fish, wildlife, and plants and their habitats for the people of Vermont" (Kart et al. 2005).

Two of the Department's planning goals are:

1. Conserve, enhance, and restore Vermont's natural communities, habitats, and species and the ecological processes that sustain them.
2. Provide a diversity of fish- and wildlife-based activities and opportunities that allow the safe and ethical viewing, regulated harvesting, and utilization of fish, plant and wildlife resources consistent with the North American model of fish and wildlife conservation.

Two tiger beetle species within the Connecticut River drainage are listed as Vermont's Species of Greatest Conservation Need (SGCN), the Cobblestone tiger beetle (state-threatened species) and the Puritan tiger beetle (federally-threatened species). [1]

Conversion of habitat, habitat alteration, habitat succession, inadequate disturbance regime and sedimentation are all identified in the Vermont Wildlife Action Plan (VWAP) as current problems facing tiger beetles. [1]

A high priority strategy in the VWAP for tiger beetle management is easement acquisition of high priority SGCN tiger beetle riverine sites. [1]

Protecting and restoring aquatic and riparian habitats through improved water quality; flow, water level and temperature regimes; sediment reduction; establishment of streamside buffers; and suitable aquatic habitat structure, diversity and complexity is a conservation strategy identified in the VWAP for aquatic species. [1]

Results of the survey will be used to develop flow-related license requirements and/or other mitigation measures that will optimize habitat for these Vermont SGCN.

Public Interest Consideration

The requestor is a state resource agency.

Existing Information

The Puritan tiger beetle (*Cicindela puritana*) is a federally threatened species only known historically from a single Vermont site, although other historic sites were known along the New Hampshire side of the river. [1]

Impoundments along the Connecticut River likely caused the extirpation of this species. Other habitat losses may have also been a factor. Reintroduction could be considered if sufficient habitat improvements are made. Riverside recreational use has had a significant impact on populations at other New England sites. Historically found along lower portion of Connecticut River in Hartland, VT and nearby NH sites, this species prefers wide sand deposits along big rivers or narrow beaches along rivers with clay banks.[1]

The Cobblestone tiger beetle (*Cicindela marginipennis*) is a state-threatened species and has been studied in Vermont to a greater degree than other *Cicindela* species. Habitat losses along the Connecticut River and possibly other rivers have been significant due to impoundments. *C.*

marginipennis is found in the lower Connecticut River, White River, West River, and single Winooski River, Southern Vermont Piedmont and Northern Green Mountains. [1]

The Cobblestone tiger beetle is in extremely restricted habitat, being found on cobble beaches of shores and islands of large rivers. Adults inhabit areas of cobble and sand where vegetation is very sparse. Larvae occupy burrows in the sand along the edges of cobblestones. [1]

Project Nexus

The project impounds several miles of river that otherwise would be free flowing. Currently the projects operate in a peaking (daily run-of-river) mode resulting in large and rapid changes in flow below the dams. Rapid changes in flow and water level have the potential to cause direct adverse effects to tiger beetle habitat within the three project areas. If tiger beetles inhabit the project areas, it is important to assess whether project operations are having any adverse effects to these populations. The Agency request a study to determine the effects of project operations on cobblestone and puritan tiger beetles.

Proposed Methodology

The methodology should be similar to that used by Brust, M. L., Hoback , W. W. and Johnson, J. J., *Fishing for Tigers: A Method for Collecting Tiger Beetle Larvae Holds Useful Applications for Biology and Conservation*, 2010, The Coleopterists Bulletin 64(4):313-318.

Results should include presence, relative abundance, evidence of reproduction, and available habitat. Additionally, the methodology should collect information on habitat used by each species of tiger beetles and identify potential habitat. The portion of habitat that is affected by project operations should also be determined, and the frequency of inundation of each site.

Level of Effort and Cost

The estimated level of effort and costs for this recommended study is expected to be moderate. The applicant did not propose any alternative studies in its PAD to address this specific issue.

Literature Cited

[1]Vermont's Wildlife Action Plan. 2005. Vermont Fish & Wildlife Department. Waterbury, Vermont. http://www.vtfishandwildlife.com/swg_cwcs_report.cfm.

Wilder Hydroelectric Project – FERC No. 1892-026
Bellows Falls Hydroelectric Project – FERC No. 1855-045
Vernon Hydroelectric Project – FERC No. 1904-073

Study Request 31: Survey the distribution, population size and habitat conditions of Fowler's Toad (*Bufo fowleri*) within the project areas

Goals and Objectives

The goal of this study is to conduct a survey to obtain baseline distributional and abundance data on Fowler's Toads along the Connecticut River throughout the project areas to determine the potential impacts of project operations.

The objectives of the study are:
Survey for and map occurrences of Fowler's Toads and suspected hybrids with American Toads.

Define the preferred habitat requirements of the species.

Document and map current and suitable habitat, including connectivity of patches.[1]

Assess the vulnerability of Fowler's Toads to project operations such as flow fluctuations, siltation, and changes in shoreline composition and vegetation.

Determine if Project operations are adversely affecting the survival success of Fowler's Toads (i.e. if flow alterations are impacting breeding habitat).

If it is determined that the Project operations are adversely affecting survival, identify operational regimes that will reduce and minimize impacts on Fowler's Toads and Fowler's Toad habitat within the project area.

Resource Management Goals

The Agency's goals related to aquatic natural resources are to:

1. Protect, enhance, or restore, diverse high quality habitat necessary to sustain healthy aquatic and riparian plant and animal communities.
2. Provide an instream flow regime that meets the life history requirements of resident fish and wildlife (including invertebrates such as freshwater mussels) throughout the area impacted by project operations.
3. Minimize the potential negative effects of project operation on water quality and aquatic habitat, and mitigate for loss or degradation.

The Connecticut River is classified by the state of Vermont as Class B cold water fish habitat. Vermont Water Quality Standards state that Class B waters should be managed to achieve and maintain a level of quality that fully supports aquatic biota and habitat. Furthermore, the VTFWD's mission is "the conservation of all species of fish, wildlife, and plants and their habitats for the people of Vermont" (Kart et al. 2005).

Two of the Department's planning goals are:

1. Conserve, enhance, and restore Vermont's natural communities, habitats, and species and the ecological processes that sustain them.
2. Provide a diversity of fish- and wildlife-based activities and opportunities that allow the safe and ethical viewing, regulated harvesting, and utilization of fish, plant and wildlife resources consistent with the North American model of fish and wildlife conservation.

Fowler's Toad populations have been documented within the Connecticut River drainage in the Project area.[1]

The Fowler's Toad is a Vermont's Species of Greatest Conservation Need (SGCN). It is currently being considered for recommendation as an endangered species by the Vermont Endangered Species Committee (See Appendix B). It is ranked as an S1, Very Rare species.[1]

Fowler's Toads breed in Vermont in shallow pools along the disturbed shoreline of the Connecticut River and perhaps its larger tributaries. It forages and overwinters primarily in well-drained sites, particularly floodplain forests and sandy deciduous woodlands along shorelines and river valleys, but may also occupy gardens, lawns, and fields.[1].

Fowler's Toads have specialized breeding habitat requirements that benefit from shoreline disturbance as a result of flooding and wave action. They also undergo regular short-term population fluctuations. Any habitat conversion, alteration, or fragmentation that disrupts the species' ability to move between breeding and terrestrial sites as well as recolonize appropriate habitat may have negative effects.[1]

Conversion of habitat, habitat alteration, and habitat fragmentation are all identified in the Vermont Wildlife Action Plan (VWAP) as current problems facing Fowler's Toads.[1] In addition, a lack of flood events that would deposit sand and gravel along the shoreline of the Connecticut River and clean away vegetation, will limit appropriate breeding habitat.

A strategy in the VWAP for Fowler's Toad management is to protect currently known breeding sites and adjacent terrestrial habitat through easement or purchase.[1]

Protecting and restoring aquatic and riparian habitats through improved water quality; flow, water level and temperature regimes; sediment reduction; establishment of streamside buffers; and suitable aquatic habitat structure, diversity and complexity is a conservation strategy identified in the VWAP for aquatic species.[1]

Results of the survey will be used to develop flow-related license requirements and/or other mitigation measures that will optimize habitat for this Vermont SGCN.

Public Interest Consideration
The requestor is a state resource agency.

Existing Information

To date no studies have been conducted to identify Fowler's Toad populations within the three project areas and whether Project operations are affecting these populations.

Project Nexus

The Wilder Project impounds 45 miles of river that would otherwise be free flowing. The project currently operates in a peaking mode, with allowable impoundment fluctuations of up to 5 feet, with proposals to continue as such. The below-project flow requirement is equal to 0.20 csm (675 cfs), but can increase rapidly during times of power generation.

The Bellows Falls Project impounds 26 miles of river that would otherwise be free flowing. The project currently operates in a peaking mode, with allowable impoundment fluctuations of up to 3 feet, with proposals to continue as such. The below-project flow requirement is equal to 0.20 csm (1080 cfs), but can increase rapidly during times of power generation.

The Vernon Project impounds 26 miles of river that would otherwise be free flowing. The project currently operates in a peaking mode, with allowable impoundment fluctuations of up to 8 feet, with proposals to continue as such. The below-project flow requirement is equal to 0.20 csm (1250 cfs), but can increase rapidly during times of power generation.

Project operations have the potential to cause direct adverse effects to Fowler's Toad habitat within the three Project areas. Releases that mimic natural flood events would probably benefit this species by creating and maintaining breeding habitat. Since Fowler's Toads are known to inhabit the project areas, it is important to assess whether Project operations are having any adverse effects to their populations.

Proposed Methodology

Adapt methods below to river shores:
Amphibian Calling Surveys, Author: Sam Droege, USGS Patuxent Wildlife Research Center, 12100 Beech Forest Rd., Laurel, MD 20708, frog@usgs.gov, 301-497-5840.
http://www.pwrc.usgs.gov/monmanual/techniques/amphibcallingsurveys.htm

Improving calling surveys for detecting Fowler's toad, Bufo fowleri*, in southern New England, USA*, Todd A. Tupper, Robert P. Cook, Brad C. Timm, and Amy Goodstine
http://www.nps.gov/caco/naturescience/upload/Bufo_fowleri_Poster_Tupper.pdf

May also include nighttime wet road surveys, near-shore boat surveys, the use of FrogLoggers and environmental DNA sampling.

Level of Effort and Cost

The estimated level of effort and costs for this recommended study is expected to be moderate. The applicant did not propose any alternative studies in its PAD to address this specific issue.

Literature Cited

[1]Vermont's Wildlife Action Plan. 2005. Vermont Fish & Wildlife Department. Waterbury, Vermont. http://www.vtfishandwildlife.com/swg_cwcs_report.cfm.

Wilder Hydroelectric Project – FERC No. 1892-026
Bellows Falls Hydroelectric Project – FERC No. 1855-045
Vernon Hydroelectric Project – FERC No. 1904-073

Study Request 32: Recreational survey and enhancement study

Goals and Objectives
The goal of this study is to identify opportunities for improving recreational opportunities at project facilities and on project lands, including new or improved recreational facilities and changes in project operations.

The objectives are to:

- Survey recreational users and potential users to identify to what extent existing recreational opportunities are being utilized by the public within the project boundaries and why potential recreational users are not using the resource.
- Identify any safety issues to recreational users from project operations, how project operations impacting recreational users and how operations could be modified to improve recreational opportunities.
- Identify how recreational opportunities in the vicinity of the project could be developed to enhance future recreational opportunities, including, but not limited to, river access points, primitive camping sites, improvement in portage trails, etc.

Resource Management Goals
The 1993 Vermont Recreation Plan (Vermont Department of Forests, Parks and Recreation), through extensive public involvement, identified water resources and access as top priority issues. The planning process disclosed that recreational use of surface waters is increasing, resulting in greater concern about water quality, public access to Vermont's waters, and shoreland development. The plan's Water Resources and Access Policy states:

> It is the policy of the State of Vermont to protect the quality of the rivers, streams, lakes, and ponds with scenic, recreational, cultural and natural values and to increase efforts and programs that strive to balance competing uses. It is also the policy of the State of Vermont to provide improved public access through the acquisition and development of sites that meet the needs for a variety of water-based recreational opportunities.

Another priority issue identified in the Recreation Plan is the loss or mismanagement of scenic resources. The plan notes "[t]he protection of the scenic and visual resources in Vermont is paramount if Vermont is to maintain its renowned charm and character."

The Connecticut River is considered Class B waters. Vermont Water Quality Standards require that Class B waters be managed to provide full support for all recreational uses, including swimming and other primary contact forms of recreation and boating, fishing and other recreational uses.

Public Interest Consideration
The requestor is a state natural resource agency.

Existing Information
The PAD provides information on the existing recreational resources, but does not provide information on how project operations adversely affect recreational opportunities or perceptions of recreational users utilizing opportunities in the project areas.

Project Nexus
These projects affect the Connecticut River from the vicinity of Wells River, Vermont to the Massachusetts boundary. Recreational opportunities on these public waters are affected by the presence of the projects and their operation. The Agency requests a recreational assessment that can be used to inform the development of recreational plans for the projects.

Proposed Methodology
The proposed study methodology should include an inventory of all the recreational facilities and opportunities within the project boundary, and a determination of the number of recreational users utilizing the resources. The study should include a component to survey an equal proportion of recreational users utilizing different activities to determine how project operations affect their recreational use and experience, and identify any safety issues associated with project operations or current recreational facilities. Potential recreational users in the area should be identified to determine why potential recreational users do not use the resource. An analysis of the recreational facilities should be conducted to identify future projects that could improve the recreational resources and/or the need to improve existing recreational facilities or access to the resource.

The approach used during the relicensing of TransCanada's Fifteen Mile Falls Project can serve as a model.

Level of Cost and Effort
The cost and effort of this study will be moderate, but it will provide essential information for certification and licensing of the projects.

Wilder Hydroelectric Project – FERC No. 1892-026
Bellows Falls Hydroelectric Project – FERC No. 1855-045
Vernon Hydroelectric Project – FERC No. 1904-073

Study Request 33: Assess the amount of development within the floodplain of the lower Connecticut River

Goals and Objectives
The goal of this study is to determine the number of developments within the 100 year floodplain to determine if river profile operations during high flow events, aimed to reduce overland flow and contain flows to the channel, are necessary to protect public or community economic investments.

The objectives of this study are:

- Determine the number of public and community development within the 100 year floodplain in New Hampshire and Vermont.
- Determine if river profile operations could be modified in locations to allow over land flow in the floodplains where waters would not cause damage or endanger public safety and community investments.

Resource Management Goals
The Connecticut River is classified by the state of Vermont as Class B cold water fish habitat. Vermont Water Quality Standards state that Class B waters should be managed to achieve and maintain a level of quality that fully supports aquatic biota, wildlife or habitat.

Under Act 138 (Sec. 9. 10 V.S.A. § 1427) – River Corridor and Floodplain Management, the Agency is responsible for identifying where the sensitivity of a river poses a probable risk of harm to life, property, or infrastructure, and to develop recommended best management practices for the management of river corridors, floodplains, and buffers.

Public Interest Consideration
The requestor is a state natural resource agency.

Existing Information
The PAD does not provide any information on this topic.

Project Nexus
The PAD indicates that at all three projects have river profile operations during high flow events. The PAD states that during high flows the dams operate with the goal to reduce overland flow and contain flow to the channel. During river profile operations the impoundments are drawn down prior to high flow events to allow inflows to stay within the channel and reduce the flow entering the river floodplain communities. The Agency requests a study to determine if river profile operations are necessary to protect public safety, community or public economic investment.

Proposed Methodology

The Agency recommends that the Licensee use the latest Flood Insurance Studies to determine the number of residents, commercial buildings or other infrastructure within the 100 year floodplain. If a recent Flood Insurance Study has not been completed, aerial photos could be used with the 100 year floodplain for the Lower Connecticut River overlaid to complete the study.

Level of Effort and Cost

The effort and cost of this study is expected to be relatively low, but is important to document the potential impact operations have on floodplain communities and whether river profile operations are necessary to protect public safety and investments.

Bellows Falls Hydroelectric Project – FERC No. 1855-045

Study Request 34: Bellows Falls aesthetic flow study

Goal and Objective
The goal of this study is to determine the flow required at Bellows Falls dam and bypass reach to support aesthetics under the Vermont Water Quality Standards.

Resource Management Goals
The Connecticut River is considered a Class B waters. Good aesthetic values are a management objective for Class B waters in Vermont. Vermont's Water Quality Standards provide that waters shall be of a quality that consistently exhibits good aesthetic values, including water character, flows, water level, bed and channel characteristics.

Public Interest Consideration
The requestor is a state resource agency.

Existing Information
The PAD provides limited information on this issue, only briefly indicating that during flows that exceed project capacity that the excess is spilled over the dam into the bypass reach. During other times of year no minimum flow is required in the bypass reach, and the amount of flow present is determined by the amount of spillage.

Project Nexus
Flow over the dam and in the bypass reach directly impacts aesthetics, which must be supported to conform to Vermont Water Quality Standards. The Agency requests a study of alternate spillage flows at the facility. This information will be needed before the Agency can certify that the project meets Vermont Water Quality Standards.

Proposed Methodology
A range of alternate spillages can be videotaped and qualitatively analyzed, or a demonstration study can be arranged for direct observation of flows by a team for subjective grading. If the latter approach is used, the flows should be documented using both still photographs and videotaping. Typically, a range of flows are observed from several vantage points. If direct observation is used, a rating form is employed to provide a structure for the individual observations.

Level of Effort and Cost
The effort and cost would be determined by the approach used. Under appropriate conditions, one day of field work should be required.

Vermont Agency of Natural Resources

Study Requests for Wilder, Bellows Falls and Vernon Projects

Appendix A

Natural Community Survey Form

NATURAL COMMUNITY SURVEY FORM

Natural Heritage Inventory (NHI)

Vermont Fish and Wildlife Department

Revised: October 16, 2012

Contact Eric Sorenson with questions about natural communities or this form: 802-476-0126; eric.sorenson@state.vt.us

Natural Community Type: Click here to enter text.

Natural Community Variant Name (if applicable): Click here to enter text.

Association Name (NHI office only): Click here to enter text.

Is this an update of an existing NHI record? (NHI office only) Yes ☐ No ☐

Site Name: Click here to enter text.

Site Location Road Address: Click here to enter text.

Town: Click here to enter text.

Surveyor(s): Click here to enter text.

Mailing Address: Click here to enter text.

Phone: Click here to enter text.

E-mail: Click here to enter text.

Survey Date(s): Click here to enter text.

Owner(s) of Natural Community: Name(s): Click here to enter text.

Address: Click here to enter text.

Phone: Click here to enter text.

E-mail: Click here to enter text.

GENERAL DESCRIPTION OF THE SITE

Briefly describe the natural and man-made features of the site and setting in which the natural community occurs, including topography, size of the contiguous forested area, other natural community types present, surface waters and drainage patterns, and land use history and land management.

Click here to enter text.

NATURAL COMMUNITY INFORMATION

Concisely describe the natural community, including canopy cover, dominant species, the physical setting, evidence of human and natural disturbance, forest community age, woody debris abundance, and presence of invasive species.

Click here to enter text.

Elevation (feet): minimum: Click here to enter text. **maximum**: Click here to enter text.

Slope (degrees): Click here to enter text.

Aspect (degrees or cardinal direction): Click here to enter text.

Bedrock geologic type (2012 VT bedrock geology map): Click here to enter text.

Soil type (Natural Resources Conservation Service) or description: Click here to enter text.

Vegetation Description: To be applied to a representative area of the community large enough to capture most species.

Total Canopy Cover: Click here to enter text.% Total Shrub Cover: Click here to enter text.%

	Trees			Shrubs				
	T1Emergent	T2 Canopy	T3 Subcanopy	S1 Tall (> 4 ft.)	S2 Short (<4 ft.)	H Herbaceous	N Nonvascular	V Vine
Height (ft.)								
% Cover								

Dominant Species and their cover for each stratum (T1- emergent, T2-main canopy, T3-subcanopy, S1-tall shrub, S2-short shrub, H-herb, N-nonvascular, V-vine). Give average DBH (inches) for trees. For each species estimate actual percent cover or use one of the cover class categories below. Use the species list table below or attach a separate sheet.

Stratum	Species	DBH	Cover	Stratum	Species	Cover

Cover Classes	
r	< 1% rare
+	< 1% occs
1	1-5 %
2	6-25 %
3	26-50 %
4	51-75 %
5	76-100 %

OR

Cover Classes	
D	Dominant; cover > 50%
C	Common; 6 to 50 % or numerous individuals
O	Occasional; 1 to 5% or scattered individuals
R	Rare; < 1% or one to a few individuals

Provide ages for representative trees in the community (optional).

Tree Species	DBH	Age

Comments about the natural community that do not fit in another field:

Click here to enter text.

NATURAL COMMUNITY MAPPING

Attach GIS shapefiles (preferred) or digital or paper map of the natural community boundaries with labeled polygons.

Estimate percent of mapped polygon occupied by the natural community: >95%☐; 80-95%☐; 20-80%☐; 0-20%☐
Explain if <95%, explain what other communities are present: Click here to enter text.

Indicate type and scale of Base Map used to map the natural community: Click here to enter text.

Confidence in the Extent of the Natural Community as Mapped (check one)

☐ Confident that the full extent is known and mapped:

☐ Full extent is not known:

☐ Uncertain if full extent is known:

Comments: (If the natural community extends off the subject property, explain, and estimate total area of community.)

Click here to enter text.

COMMUNITY OCCURRENCE RANKING: a range of ranks may be used (such as AB)

Using **VT NHI ranking specifications** (if available)*: OR Using **Generic ranking specifications** (provided below):

	Rank (A-D)	**Comments**
Current Condition		Click here to enter text.
Landscape Context		Click here to enter text.
Size (acres)		Community size and how determined: Click here to enter text.
Overall Rank		Click here to enter text.

* Available for some natural communities from Eric Sorenson (eric.sorenson@state.vt.us) or 802-476-0126.

Generic ranking specifications

Use the following guidelines to fill in the grid above if VT NHI ranking specifications are not yet available for the community type.

Current Condition

A: mature example of the community type (forests with trees generally >150 years old); natural processes intact; no exotics
B: some minor alteration of vegetation structure and composition, such as by selective logging; minor alterations in ecological processes; exotics species present in low abundance
C: significant alteration of vegetation structure and composition, such as by heavy logging; alteration of ecological processes are significant, but community recovery/restoration is likely; exotic species are abundant and control will take significant effort

D: ecological processes significantly altered to the point where vegetation composition and structure are very different from A-ranked condition and restoration/recovery is unlikely; exotic species are abundant or control will be difficult

Landscape Context

A: highly connected; area around EO (>1,000acres) is largely intact natural vegetation, with species interactions and natural processes occurring across communities; surrounding matrix forest meets at least B specifications for Condition.
B: moderately connected; area around EO (>1,000acres) is moderately intact natural vegetation, with species interactions and some natural processes occurring across many communities, although temporary disturbances such as logging have reduced condition of the landscape; surrounding matrix forest meets at least C specifications for Condition

C: moderately fragmented; area around EO is largely a combination of cultural and natural vegetation with barriers to species interactions and natural processes across communities; surrounding land is a mix of fragmented forest, agriculture, and rural development

D: highly fragmented; area around EO is entirely, or almost entirely, surrounded by agriculture or urban development

Size

No Generic ranking applicable. Please provide size of community in grid above.

Overall Rank (based on best judgment)

A: excellent estimated viability

B: good estimated viability

C: fair estimated viability

D: poor estimated viability

NATURAL COMMUNITY MANAGEMENT

Discuss management needs and plans for this natural community, including need for invasive species monitoring and control. If the natural community requires a buffer with specific management, describe and map the buffer width and specifically explain the ecological need for the buffer:

Click here to enter text.

ADDITIONAL INFORMATION; (none required) (check those that are attached):

☐ Additional plant species list attached

☐ Plot form(s) attached

☐ Animal list attached

Please send completed form and GIS shapefiles to Eric Sorenson:

eric.sorenson@state.vt.us

or

Eric Sorenson

Natural Heritage Inventory

Vermont Fish and Wildlife Department

5 Perry Street, Suite 40

Barre, Vermont 05641

Vermont Agency of Natural Resources

Study Requests for Wilder, Bellows Falls and Vernon Projects

Appendix B

Documentation for the listing of the Fowler's Toad as an endangered species in Vermont

SPECIES STATUS REVIEW

STATE OF VERMONT
ENDANGERED SPECIES COMMITTEE

Common Name: **Fowler's Toad**	Current Status: **None** (Special Concern by SAG - Reptiles & Amphibians, S1 Vermont Heritage Rank, and high priority SGCN)
Scientific Name: ***Anaxyrus fowleri* (Previously *Bufo fowleri*)**	Recommended Status: **Endangered**
Scientific Advisory Group Chair: James S. Andrews	Endangered Species Committee Chair: Sally Laughlin
Date:	Date:

Wildlife and plant species are added to or removed from the list of endangered and threatened species by action of the Secretary of the Agency of Natural Resources, upon recommendation of the Vermont Endangered Species Committee, according to 10 V.S.A., Chapter 123. The Vermont Endangered Species Committee is advised by scientific advisory groups on vascular plants, non-vascular plants, invertebrates, fish, reptiles and amphibians, birds, and mammals.

DEFINITIONS

ENDANGERED: A species that normally occurs in the State and whose continued existence as a viable component of the State's wild fauna or flora is in jeopardy, or a species determined to be an endangered species under the Federal Endangered Species Act. [V.S.A. Title 10, Chapter 123, Sections 5401(6) & 5402(b).]
THREATENED: A species whose numbers are significantly declining because of loss of habitat or human disturbance and unless protected will become an endangered species, or a species determined to be a threatened species under the Federal Endangered Species Act. [V.S.A. Title 10, Chapter 123, Section 5401(7) & 5402(c).]

GUIDELINES FOR LISTING AS ENDANGERED OR THREATENED

1. Species (including subspecies and varieties) which may be listed include all wild and free-ranging or naturally-occurring mammals, birds, amphibians, reptiles, fish, invertebrates, vascular and non-vascular plants.
2. Species which may be listed include those native to the State or known to exist as viable, naturalized populations in Vermont.
3. Species which may be listed must have spent at least some portion of their life cycle in Vermont on a sustained basis, breeding or otherwise.
4. Species listed by the Secretary of the Interior as endangered or threatened in the U.S., if occurring as historical or current residents or transients in Vermont, shall be listed in their respective categories.
5. Attached to this review shall be a SPECIES DOCUMENTATION including the best scientific information available with sources cited.
6. The Endangered Species Committee and its scientific advisory groups shall consider the CATEGORIES and CRITERIA FOR LISTING when recommending species for listing or delisting, using the best scientific information available and their best expert judgments.
7. Specific numbers cited in the Primary Criteria of the CRITERIA FOR LISTING are guidelines only, and are to be interpreted with respect to the biology of the species. Definitions of terms such as *population* and *reproductive potential* for each species shall be provided by the appropriate scientific advisory groups according to accepted practices in their field of biology.

(Guidelines continued on page 2)

CRITERIA FOR LISTING AS ENDANGERED OR THREATENED

1.0 **ENDANGERED**

____ 1.1 The species is known to have occurred historically in Vermont but has not been documented in the last 25 years; OR

__X__ 1.2 The species meets at least one of the following primary criteria of rarity:

__X__ 1.2.1 There are estimated to be three or fewer viable, reproducing populations separated by unfavorable habitat in Vermont; OR

__X__ 1.2.2 There are estimated to be fewer than 100 reproducing individuals in Vermont; OR

____ 1.2.3 The species is known in the last 25 years from 20 or fewer sites throughout its global range;

AND one of the following secondary criteria:

____ 1.2.4 The species has declined overall or noncyclically throughout a significant portion of its global range; OR

____ 1.2.5 The species is restricted to localities within or immediately adjacent to Vermont; OR

__X__ 1.2.6 One or more special factors cause the species to be vulnerable to extirpation:

____ 1.2.6.1 The species is in danger of exploitation or is threatened with disturbance; OR

__X__ 1.2.6.2 The species occurs in rare or specialized habitat that is vulnerable to loss, modification, or variations in quality; OR

____ 1.2.6.3 The species has low reproductive potential or is experiencing reduced reproductive success; OR

__X__ 1.2.6.4 The species has other factors that render it vulnerable to extirpation (*list*).

This species was last documented from Vermont in 2007. Since known populations have declined precipitously, there are clearly factors or combinations of factors that occur (or did occur) that render it vulnerable to extirpation. However, it is unclear exactly what factors or combination of factors brought about the current decline. In addition to habitat loss, habitat modification, and habitat fragmentation as listed above, this species has also shown sensitivity to lowered pH, herbicides, pesticides, some metals, road mortality, disease, parasites, and weather extremes such as those that could bring about mortality as a result of freezing (cold weather and lack of snow) or dehydration (drought). In addition, the cyclical nature of these populations in itself renders this species more vulnerable as it requires repopulation across an increasingly fragmented landscape. These threats are all discussed in greater detail in the species documentation.

Fowler's Toad (*Anaxyrus fowleri*)
Narrative Summary
December 18, 2012

The Endangered Species Committee recommends to the Secretary of Natural Resources that the Fowler's Toad (*Anaxyrus fowleri*) be listed as Endangered.

Fowler's Toad (*Anaxyrus fowleri*, previously *Bufo fowleri*) is a close relative of the more common American Toad (*Anaxyrus americanus*). The Fowler's Toad is an edge of range species that seems to have always been limited in distribution in Vermont. The Fowler's Toad was last documented in Vermont in 2007. We do not know what has caused this recent decline.

We have very little historical data on some of our rare reptiles and amphibians in Vermont. For example the Four-toed Salamander (*Hemidactylium scutatum*) was first documented in Vermont in 1960 and our only known large population of Spotted Turtles (*Clemmys guttata*) was not discovered until 2010. Both of these species are presumed to have existed in Vermont for hundreds if not thousands of years prior to our discovery of their presence.

Fowler's Toad was first reported and photographed in Vermont in 1983 in White River Junction (town of Hartford; Andrews, 2011) where it was reported as numerous. They have been reported from three other sites in the Connecticut River Valley of Vermont. A population in Vernon was well documented from 1994 through 2007.

Breeding choruses took place along the shores of the Connecticut River in Vernon and its islands (NH). Despite general herpetological survey efforts and multiple targeted surveys covering Windham County, no additional Fowler's Toads have been seen. Repeated (26 visits) and targeted surveys in 2008 by a graduate student from Antioch New England, did not locate any Fowler's Toads in the Vernon area or any surrounding areas including south of the Massachusetts border. Disturbed river-shore seems to be the primary breeding habitat used by this species in Vermont.

Species whose habitat needs are more restrictive and whose numbers are limited are at a heightened risk from anthropogenic and natural events. Since we have been unable to locate this species in Vermont since 2007, there are clearly factors or combinations of factors that occur (or did occur) that render it vulnerable to extirpation. However, it is unclear exactly what factors or combination of factors brought about the current low population levels. Controlling flooding along the lower Connecticut River may be limiting the creation of appropriate breeding habitat for this species. Gravel and sand deposits in the lowlands are prime development areas. Increased road building and road traffic in the river valleys are direct threats to individuals and general threats to breeding and foraging habitats and safe movement between them. In addition, this species has shown sensitivity to lowered pH, herbicides, pesticides, some metals, disease, parasites, and weather extremes such as those that could bring about mortality as a result of freezing (cold weather and lack of snow) or dehydration (drought). This species has undergone short-term population swings in Ontario but the duration of the swings is much shorter than the period of time since we last observed this species in Vermont. The short-term cyclical nature of these populations in itself renders this species more vulnerable particularly if it requires repopulation across an increasingly fragmented landscape.

Populations of species at the edge of their ranges often carry unique gene combinations selected for by the specific environmental conditions at their edge locations. These genetic differences often allow them to survive weather extremes, disease, or other stressors that other populations of the same species would not be able to survive. Some studies of vertebrates have shown declines in populations taking place from the

center of a species range to the edges, with the marginal populations surviving after more central populations have disappeared. Hence conserving edge-of-range populations is an important step toward conserving populations as a whole and the genetic diversity within species.

We are concerned that this species does not have the appropriate conservation status in Vermont and hence that it does not get the conservation attention it deserves from state, regional, and local planners and managers; as well as local conservation commissions and land owners.

Benefits of listing this species:

- Increased awareness of natural resource planners and land managers (e.g., Regional Planning in Windham County did not have this species on its radar screen as a result of its not being listed. Local entities and landowners are not aware of the relative significance of this species and its habitat).

- Make it easier for land conservation organizations, conservation commissions, planning commissions, land owners, the Vermont Fish and Wildlife Department, and other land managers to justify allocating time and money for the monitoring and conservation of this species.

- Increase the availability of federal and private funding to governmental and non-governmental organizations, and individuals for conservation of this species.

- Provide accurate and current information on the status of Vermont's wildlife species to the citizens of Vermont by assigning this species its appropriate status under Vermont law.

I. Species Documentation

A. STATE OF VERMONT

1. ENDANGERED SPECIES COMMITTEE

1.	Scientific Name:	*Anaxyrus fowleri* (Previously *Bufo fowleri*)
2.	Common Name:	Fowler's Toad
3.	Species Code (*Department use only*):	
4.	Current Vermont Status:	S1, SC, High Priority SGCN
5.	Recommended Vermont Status:	Endangered
6.	Federal Status:	US: None, Global status S5
7.	Surrounding State & Provincial Status:	Canada: Endangered (COSEWIC, April 2010) NH S3, NY & CN S4 MA S4 (but extirpated from Nantucket, Muskeget, & Cuttyhunk) Ontario: Endangered (SARO)

POPULATION STATUS

8. Global, North American, and Vermont Ranges:

This species distribution is centered in the eastern US from the Mississippi drainage to the Atlantic coast but not including the Florida peninsula, coastal North or South Carolina, or northern Michigan, northern New York, northern New Hampshire, or any of Maine. However, in the Midwest this species has recently disappeared from portions of its former range in Ohio and other states where it was once common (Quinn and Scott, 2005). It is not native anywhere else in the world (see map below).

In New Hampshire this species has not been monitored (Mike Marchand pers. comm., 2011). However, reports exist from Hinsdale (2002) and Westmoreland (2001) along the Connecticut River in Cheshire County, from Boscawen (1938 & 2011) and Concord (1997 & 2002) along the Merrimack River in Merrimack County, and from Enfield (2004) and Grafton (2004) in the Mascoma Valley of Grafton County (2004). The Enfield site is approximately 10 miles east of our Hartford records.

The stronghold for this species in New York State is Long Island. However, populations reach north along the Hudson River drainage to the Albany Pine Bush (where they have been difficult to locate in the last 10 years). They were rarely reported anywhere east of the Hudson River in upstate New York (Al Breisch pers. comm., 2011).

In Canada this species "only occurs on sandy beaches in three disjunct areas along the north shore of Lake Erie (Ontario). It has disappeared from numerous historic sites on the Lake Erie shore and continues to decline in abundance and number" (COSEWIC, 2010).

In Massachusetts, Fowler's Toads are primarily located on or near Cape Cod but they were also found along the Connecticut River as far north as Amherst during the 1992-1998-atlas effort (Jackson et al., 2010).

In Vermont, Fowler's Toad was found along the southern Connecticut River Valley reaching as far north as White River Junction (Hartford) in the early- to mid-1980s but it has been found only in Vernon during the last two decades with the exception of one 2002 report from along the Saxton's River in Rockingham. It was last reported from Vernon in 2007.

9. Vermont's Position within Global Ranges: ____ Central __X__ Peripheral _____ Disjunct

10. Historic Occurrences in Vermont More Than 25 Years Ago (*Type, Number, General Location, Regularity of Use, Confidence in Records, etc.*):

This species had been confused with others from the same genus (American toad, *Anaxyrus americanus* in this area) in the past. It was first reported in Vermont in 1983 by Michael Caduto and Margaret Barker in White River Junction (town of Hartford). They reported numerous sightings in the vicinity of Hillcrest Terrace in that year and documented one sighting with a photograph. Doug Kibbe remembers hearing what he was convinced were Fowler's Toads from Allen Brother's Marsh in Westminster in late May 1985 but this report was not accompanied by photographs. Additional visits to these sites have not turned up any more recent reports. These locations made sense as an extension of the Connecticut River lowlands populations of Massachusetts. However, they were quite distant from the nearest populations in Massachusetts and no other populations were known in Vermont at that time.

The 1983 report served as a wake-up call for those collecting data on Vermont's amphibians. From then on, toads were checked carefully to rule out the possibility of Fowler's Toads. However, no other toads of this species were located at any site until they were located in Vernon in 1994. This species has a very distinctive call, quite unlike that of American Toads. Consequently it is fairly easy to locate during its calling season if it is present.

11. Historic Abundance More Than 25 Years Ago (*number of Breeding Individuals or Size of Area Occupied, Confidence in Records, etc.*):

The Hartford records were documented, photographed, and published. Mark DesMeules (Vermont Nongame and Natural Heritage Program at that time), Jim Andrews (Vermont Reptile and Amphibian Atlas 2011), and others confirmed the identification from the photo. Caduto and Barker reported numerous sightings in the vicinity of Hillcrest Terrace in 1983. We have no other data on the historic abundance of this species in Vermont. Historical abundances throughout the range of this species are unknown but populations have been known to vary widely over time and space (Breden, 1988; Green 1992, 1997; Hranitz et al., 1993).

12. Current Occurrences in Vermont (*Type, Number, General Location, Regularity of Use, Confidences in Records, Extent to which the Species has been Inventoried, etc.*):

This species was last documented in Vermont in 2007. Since the initial discovery of this species in Vermont in Hartford in 1983, we have gathered 19 reliable reports of this species from the southern Connecticut River Valley. The next report came in 1985 from Allen Brother's Marsh in Westminster. This marsh is in the immediate flood plain of the Connecticut River and the report of calls heard comes from experienced naturalist Doug Kibbe. After that report, there are no new reports until Jim Andrews traveled to the region in 1994 along with some students with the specific goal of finding Fowler's Toads. During that brief but focused survey, Fowler's Toads were found only along Stebbins Road in Vernon. Stebbins Road is a sparsely developed rural road on a plateau above the current floodplain of the Connecticut River. On that trip a minimum of four Fowler's Toads were heard calling, captured and/or photographed. A return trip to the region in 1996 revealed at least one Fowler's Toad along the same road. A volunteer crew from Bonnyvale Environmental Education Center in Brattleboro was trained to survey for this species but again located it only from the Stebbins Road area. Patti Smith of Bonnyvale found or heard about eight Fowler's Toads (could include duplicates) from the Stebbins Road area in July of 2002. She taped a breeding chorus from along the edge of the Connecticut River near the north end of Stebbin's Road. That same year, a surprisingly disjunct report came from one of

the same naturalists who first reported the White River Junction Fowler's toads back in 1983 (Michael Caduto). He reported hearing calls from one spot along the Saxton's River in Rockingham. In 2003, Jim Andrews again did survey work in the region and found two toads along Stebbins Road despite a wider search. In 2004, Wendy Hardy (a student of Jim Andrews) did an extensive survey along the Connecticut River for this species from Rockingham south and west to Guilford. Again, Fowler's Toads were found only from the Stebbins Road area. She found the species four times between July and October of that year and took photographs to document the species. She and her husband boated the Connecticut in search of this species and found them calling from an island (technically NH) in the river adjacent to the Stebbin's Road area. Jim Andrews again found them from the same area in 2005 and Patti Smith found and photographed the last one seen in 2007. Despite the targeted and extensive efforts of graduate student Angela Michael in 2008 and brief but repeated visits by Jim Andrews, Patti Smith and other members of the Reptile and Amphibian Scientific Advisory Group to the Stebbin's Road area, to Allen Brothers Marsh, and to other potential habitat up and down the Connecticut River Valley south of Hartford, this species has not been located since the 2007 sighting.

Seven additional unverified and poorly documented reports from the Connecticut River drainage come from Baltimore, Guilford, Jamaica, Townshend, Vernon, and Weathersfield spanning the years from 2000 through 2009. The 2009 report from Vernon appears to be a hybrid between a Fowler's Toad and an American Toad (*Anaxyrus americanus*) and was found upstream only a short distance (< 0.5 miles) from the Stebbin's Road population.

Single unverified reports also exist from Middlebury, Sudbury, and Hartford, NY in the southern Lake Champlain basin. These span the years from 1983 through a 2008 report from Hartford, NY along Route 149 east of Fort Ann. Since none of these reports were documented with either photographs or tapes and were widely disjunct, they have not been included on maps but they could possibly represent populations.

13. Current Abundance (*Number of Breeding Individuals or Size of Area Occupied, Confidence in Records, Problems in Estimating Abundance, etc.*):

This species was last documented in 2007. This species is known to hybridize with American Toad (*A. americanus*) and some possible hybrids have been seen and heard in the southern Connecticut River Valley in the last few years; however, the current population of Fowler's Toads, if it exists at all, is small enough so that none have been located in the last five years.

14. Population Trend:

__X__ Declining
____ Stable
____ Increasing
____ Unknown

Estimate Based On:

__X__ Surveys
____ Counts
__X__ Observations
____ Other (*explain*) (see below)

Documentation & Comments:

Surveys for this species have targeted the Connecticut River Valley primarily south of Rockingham. Fortunately this species has a very distinctive and easily recognizable call. The Vermont Reptile and Amphibian Database contains over 70,000 reports from all corners of Vermont gathered by professional wildlife biologists and some very knowledgeable laypeople; however, no other documented reports for this species exist. All well-documented reports come from along the southern Connecticut River valley and in recent years, only from the Stebbin's Road area of Vernon.

According to the 2010 COSEWIC status report for this species, Fowler's Toad populations "fluctuate widely in abundance". At Long Point in Ontario, "their numbers have gone from dozens to hundreds of individuals and back over the 10 years from 1988 through 1997". In Ontario, their preferred habitat is "early stages of ecological succession in sand dune and lake-shore habitats". These habitats are inherently unstable and changing. Irregularly occurring severe storms both cause direct mortality and

create new breeding habitat. Population viability analyses in Canada give the species a 20% chance of becoming extirpated from Canada in the next 100 years.

In the Ontario recovery strategy for this species (Green et al., 2011), they state that Fowler's Toads can repopulate areas after local extirpations "provided there are no barriers" since a small percentage (~2%) travel up to 8 miles from their place of birth. "Fowler's Toads repopulated Big Creek National Wildlife Area at Long Point in 1991 after an absence of a few years (Smith and Green, 2006).

We may be experiencing the depth of one of those cycles currently in Vermont. However, in Ontario those cycles began to rebound after a period of three years. It has been five years since we have seen the Vernon population and almost thirty years since we have seen the Hartford population. Given our inability to locate these populations in recent years and the distance to the nearest known populations (Gill, Massachusetts is roughly 10 miles south), we feel it is worthy of and would benefit from listing. Tom Tyning (Pers. comm. 2012) states that the species was still found in the Gill area in 2011. The most recently published data available are from Amherst in the mid 1990s (Jackson et al., 2010). Assuming the Gill population is still healthy, 4-6 years (two to three toad-generations) of optimal conditions might allow a population in the Gill area to recolonize the Vernon area if appropriate habitat is present here and along the way. However, this is based on the untested assumption that there are no insurmountable barriers to dispersal between Gill and Vernon. If small numbers of this species exist here or nearby, recolonization could occur sooner.

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(1) HABITAT IN VERMONT

15. General Description:

Fowler's Toads are tolerant of and dependent upon warmer temperatures then American Toads (Frost and Martin, 1971).

Along the north shore of Lake Erie all Fowler's Toad reports are within ½ kilometer of the shore and the toads require habitat in the early stages of ecological succession. At those sites they require five habitat types in close proximity to sustain a population (COSEWIC, 2010):

- Hibernation habitat (sandy dunes)
- Breeding, egg-laying habitat (sparsely vegetated still-water ponds, sandy bottom pools, shallow rocky shoals, or rocky pools)
- Feeding and hydration habitat (sandy riverside and lakeshore habitats with bare to sparse vegetation cover)
- Daytime retreat and aestivation habitat (sandy beaches and shoreline debris), and
- Dispersal corridor habitat.

Overwintering habitat is mentioned as a potential limiting factor in Canada (COSEWIC, 2010). Burrows must be deep enough for the toads to avoid freezing, close enough to the water table to be damp, but not so deep as to be flooded. Toads are not tolerant of freezing or of long-term submergence while over wintering.

Stille (1952) reported small home ranges with most toads emerging from the ground within 60-210 meters of the water's edge. In Canada (COSEWIC, 2010) Fowler's Toads (nocturnal) spend days buried in soil up to 400 m from the waters edge but they must move to the water as soon as they emerge to replace moisture lost while in the soil.

Along Lake Erie, Fowler's Toads depend upon breeding sites that are continually created or maintained by disturbance.

Breeding habitat in Vermont appears to be the disturbed margins of the Connecticut River and its tributaries in Windham and Windsor Counties, and perhaps shorelines of other water bodies near sandy soils in those floodplains. Terrestrial habitat appears to be largely open areas of adjacent floodplains

and lower-elevation uplands within a few hundred meters of those breeding sites, particularly those with sandy or gravelly soils. This includes yard edges and moderately developed residential or agricultural areas. According to Klemens (1993) the species prefers well-drained sand and gravel habitat in Connecticut. Wright and Wright (1949) state "wherever Fowler's Toads are sympatric with American Toads (as they are anywhere in Vermont), Fowler's Toads occur in rivers, streams, or lake beaches" and American Toads in the uplands. This appears to be the case in Vermont. Soil maps show large deposits of sand in the Vernon area.

16. Habitat Losses in Past (*Amount and Location*):

Early successional habitat in sandy soils within 400 meters of the Connecticut River has probably been reduced significantly with the development of an extensive series of flood control dams in the Connecticut River drainage. In addition, sandy and gravelly soils in the floodplain have been desirable sites for shoreline development and agriculture. Some types of low-density development and agriculture (pasture, some crops, new farm ponds) may have created open early-successional foraging habitat or breeding habitat for this species; however, high-density development with heavy road traffic (toads suffer high road mortality), row crops and intensive pesticide or herbicide use (atrazine) are probably not consistent with continued Fowler's Toad use. Bank stabilization activities would also limit the amount of potential habitat for this species.

This floodplain area has also seen significant road building. Routes 91 and 5 both parallel the river within the floodplain on the Vermont side as well as numerous smaller roads such as 142 in Vernon.

17. Probable Habitat Losses in Future (*Amount, Location, and Type*):

The frequency and severity of floods in the future will likely be controlled as much as is possible with the extensive series of flood control dams in the Connecticut River drainage. This will continue to limit the creation and maintenance of the early successional habitat required by this species.

Although it seems unlikely that there will be many new roads built within 400 m of the Connecticut River and its major tributaries, traffic on the many roads already existing within these zones will continue to increase.

The area between Stebbins Road and the Connecticut River is currently changing from small scale farming with scattered seasonal camps to permanent homes. The area west of Stebbins Road and Route 142 has some large tract developments already in place. Traffic on area roads continues to increase.

According to VTrans (Chris Slesar pers. comm., 2011) the frequency of what once were considered one-hundred-year floods has increased over the last decade. In the future, these may produce appropriate habitat in larger tributaries of the Connecticut River without flood control dams.

18. Current Protected Status of Habitat:

___ Unknown Whether Any Protected
__X__ Believed To Be None Protected
___ At Least One Protected Occurrence
___ Several Protected Occurrences
___ Many Protected Occurrences
__X__ Other (*explain*) There are state-owned lands west of Route 142 but we have no historic or current records of Fowler's in those areas despite herpetological surveys on those lands.

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(2) POPULATION BIOLOGY

19. Population Threats (*Contaminants, Predation, Competition, Disease, Human Disturbance from Recreation, Collection, Harvest, etc.*)

Degree of Threat:

_X_ Very Threatened, Species Directly Exploited or Threatened by Natural or Man-caused Forces
___ Moderately Threatened, Habitat Lends Itself to Alternate Use but is not Currently in Jeopardy
___ Little Threat, Self-protecting by Unsuitability for Other Uses
___ Unknown

Documentation & Comments:

Since this species has not been documented in Vermont since 2007, there are clearly factors or combinations of factors that occur (or did occur) that render it vulnerable to extirpation. However, it is unclear exactly what factors or combination of factors brought about the current situation. As noted above, this species regularly undergoes large population changes. If the population has dropped to zero, the existence of nearby healthy populations to recolonize previously occupied areas is essential. In addition, the colonizers within those populations need to be able to safely traverse the landscape along the river for some distance as populations rebuild. Given distances between populations that may be larger than the dispersal range of juvenile toads, all five required habitat types will need to be located fairly regularly (~every 8 miles) along the shore of the Connecticut River in order for recolonization to take place from a distant source. Impediments to travel exist in increased road traffic, more intensive or chemical dependent agricultural methods, and intensive development such as in the towns along the river.

According to Freda and Dunson (1986) this species shows decreased larval growth rates with increased acidity (lowered pH) due to acid rain. It is also less tolerant than most amphibians to atrazine (Birge et al., 2000), and is particularly sensitive to the insecticide azinphos-methol (Guthion; Mayer and Ellersieck, 1986). The organochlorides endrin, toxaphene, dieldrin, toxaphene, DDT, and lindane are also highly toxic to larval Fowler's Toads (Sanders, 1970). Adults were also highly sensitive to organochlorides (Ferguson and Gilbert, 1968) as well as pyrethroid insecticides (Bennett et al., 1983) and the metals chromium, gallium, titanium, and aluminum (Birge et al., 2000). In southwestern Ontario, agricultural chemicals were listed as a possible contributing factor to Fowler's Toads declines. The herbicide Trifluralin and the insecticide Endrin were reported to be particularly toxic to toads (COSEWIC, 2010). The disappearance of Fowler's Toads from many of the Massachusetts islands was thought to be the result of DDT use according to Lazell (1976). DDT is also suspected of eliminating populations on Point Pelee in Canada (COSEWIC, 2010). We have not looked at the available data on the level of any of these substances in the Connecticut River or on surrounding lands, although we expect atrazine is widely used on corn crops along the Connecticut River.

Fowler's Toads are susceptible to mycobacterial (Shively et al., 1981) and parasitic infections (Jilek and Wolff, 1978; Ashton and Rabalais, 1978; McAllister et al., 1989; and Vences et al., 2003). Botulism is also considered a potential threat to Fowler's Toads (COSEWIC, 2010). Along the north shore of Lake Erie is was noticed that shoreline mats of algae created the anaerobic conditions that allow *Clostridium botulinum* to survive.

20. Tolerance To Human Activity:

___ Fragile
_X_ Fairly Resistant
___ Tough
____Unknown

Documentation & Comments:

Fowler's Toads were reported from a residential area of White River Junction and were regularly found along and near Stebbins Road in Vernon. Historic clearing near the Connecticut River may have added to the open areas that this species frequently uses. Historically, frequent flooding as a result of over harvesting of trees may also have created more of the soil deposits and open pools along rivers that this species requires. However, flood control, chemical use, tilling, increased traffic, migration

barriers, and intensive development may have limited available habitat for Fowler's Toads, their access to it, and or their ability to survive in it.

Toads overwinter and avoid predation and desiccation during the day and during dry periods by digging into sandy or loose soil (Harding and Holman, 1992). By the end of the winter they have burrowed to depths of up to 15-30 cm (R. Latham quoted in Oliver, 1955). Tilling of the soil in late fall or early spring may disturb or kill overwintering Fowler's Toads. Tilling during other times of the year could have the same impact on toads underground for the daytime hours or when aestivating to escape dehydration.

21. Reproduction Parameters (*Age to Sexual Maturity, Annual Production of Offspring, Reproductive Life, or Other Factors that Warrant Consideration*):

Fowler's Toads have a reported maximum life expectancy of five years in the wild (Kellner and Green, 1995), with most adult toads living to three years of age. Clarke (1977) reports a 22.5% annual survival rate after metamorphosis. However, both males and females reach reproductive age at an average age of two years (Breden, 1987) and females can produce up to 8000 eggs in a single breeding event (Wright and Wright, 1995). Survivorship from egg to adult is roughly 1 in 1,430 eggs (Clarke, 1977).

22. Reproductive Status: *Documentation & Comments*:

___ Reproduces in Vermont
- ____Confirmed In Last 2 Years
- _X_ Confirmed In Last 10 Years
- ___ Confirmed In Last 25 Years
- ___ Confirmed Prior To 25 Years Ago
- ___ Unconfirmed

___ Does Not Breed or is Migratory

Documentation & Comments:

Singing male Fowler's Toads were heard in 2002 in Vernon and Rockingham and in 2004 in Vernon. However, we have no evidence of the success of those breeding attempts. Since Fowler's Toad have a limited life span in the wild (maximum of five years, Kellner and Green, 1995) and were seen in 2007 they must have reproduced in the last decade.

23. Additional Study or Documentation Needed:

Annual surveys along the Connecticut River in both Windham and Windsor Counties on warm wet nights from June through July (timing based on Andrews, 2011A; The Vermont Reptile and Amphibian Atlas Database).

24. Attachments:
- 24.1 List of literature cited or other references
- 24.2 Map of worldwide distribution (IUCN, 2012)
- 24.3 Map of statewide distribution (Andrews, 2011)
- 24.4 Map of Fowler's Toad observations in southeastern VT (Andrews and Briggs, 2012)
- 24.5 Amphibian abundance chart (Andrews, 2012)
- 24.6 Narrative summary

25. Scientific Subcommittee Chairman: Date:

James S. Andrews

Sources cited:

Andrews, J.S. 2011A. The Vermont Reptile and Amphibian Atlas Database.

Andrews, J.S. 2011B. The Vermont Reptile and Amphibian Atlas 2011

Andrews, J.S. 2012. Relative Abundance of Vermont Reptiles and Amphibians

Andrews, J.S. and K.V. Briggs. 2012. Fowler's Toad Observations in Southeastern VT

Ashton, A.D. and F.C. Rabalais. 1978. Helminth parasites of some anurans of northwestern Ohio. Proceedings of the Helminthological Society of Washington 45:141-142.

Bennett, R.S., E.E. Klaas, J.R. Coats, M.A. Mayse and E.J. Kolbe. 1983. Fenvalerate residues in nontarget organisms from treated cotton fields. Bulletin of Environmental Toxicology 31:61-65.

Birge, W.J., A.G. Westerman and J.A. Spromberg. 2000. Comparative toxicology and risk assessment of amphibians. Pp. 727-791. *In* Sparling, D.W., G. Linder and C.A. Bishop (Eds.), Ecotoxicology of amphibians and reptiles. Society for Environmental Toxicology and Contaminents (SETAC) Press, Pensacola, Florida.

Breden, F. 1987. Population structure of Fowler's Toads *Bufo woodhousei fowleri.* Copeia 1987:386-395.

Breden, F. 1988. The natural history and ecology of Fowler's Toad, *Bufo woodhousei fowleri* (Amphibia: Bufonidae) in the Indiana Dunes National Lakeshore. Fieldiana Zoology 49:1-16.

Clarke, R.D. 1977. Postmetamorphic survivorship of Fowler's Toads *Bufo woodhousei fowleri.* Copeia 1977 594-597.

COSEWIC. 2010. COSEWIC assessment and status report on the Fowler's Toad *Anaxyrus fowleri* in Canada. Ottawa. vii + 58 pp.

Ferguson, D.E. and C.C. Gilbert. 1968. Tolerances of three species of anuran amphibians to five chlorinated hydrocarbon insecticides. Journal of the Mississippi Academy of Sciences 13:135-138.

Freda, J. and W.A. Dunson. 1985. The influence of external cation concentration on the hatching of amphibian embryos in water of low pH. Canadian Journal of Zoology 63:2649-2656.

Frost, J.S. and E.W. Martin. 1971. A comparison of distribution and high temperature tolerance in *Bufo americanus* and *Bufo woodhousii fowleri.* Copeia 1971:750-751.

Green, D.M. 1992. Fowler's Toads *Bufo woodhousii fowleri,* at Long Point, Ontario: Changing abundance and implications for conservation. Pp. 37-45. *In* Bishop, C.A. and K.E. Pettit (Eds.), Declines in Canadian amphibian populations: designing a national monitoring strategy. Canadian Wildlife Service, Occasional Publications, Number 76, Environment Canada, Ottawa, Ontario, Canada.

Green, D.M. 1997. Temporal variation in abundance and age structure in Fowler's Toads, *Bufo fowleri* at Long Point, Ontario. Pp. 45-56. *In* Green D.M. (Ed.), Amphibians in decline: Canadian studies of a global problem. Herpetological Conservation, Number 1, Society for the Study of Amphibians and Reptiles, St. Louis, Missouri.

Green, D.M,. A.R. Yagi, and Stewart E. Hamill. 2011. Recovery Strategy for the Fowler's Toad, (*Anaxyrus fowleri*) in Ontario. Ontario Recovery Strategy Series. Prepared for the Ontario Ministry of Natural Resources, Peterborough, Ontario. vi + 21 pp.

Harding J. H. and J. A. Holman. 1992. Michigan frogs, toads and salamanders. A field guide and pocket reference. Michigan State University Museum Press, East Lansing, Michigan.

Hranitz, J.M., T.S. Klinger, F.C. Hill, R.G. Sagar, T. Mencken and J. Carr. 1993. Morphometric variation between *Bufo woodhousii fowleri* Hinckley (Anura: Bufonidae) on Assateague Island, Virginia and the adjacent mainland. Brimleyana 19:65-75.

IUCN. 2012. International Union for the Conservation of Nature online map of Fowler's Toad worldwide distribution http://maps.iucnredlist.org/map.html?id=54640

Jackson, S.D., R.M. Richmond, T.F. Tyning and C.W. Leahy (eds). 2010. *Massachusetts Herpetological Atlas 1992-1998*, Massachusetts Audubon Society & University of Massachusetts (www.massherpatlas.org).

Jilek, R. and R. Wolff. 1978. Occurrence of *Spinitectus gracilis* Ward Magath 1916 (Nematoda: Spiruroidea) in the toad (*Bufo woodhousii fowleri*) in Illinois. Journal of Parasitology 64:619.

Kellner, A. and D.M. Green. 1995. Age structure and age of maturity in Fowler's Toads *Bufo woodhousii fowleri* at their northern range limit. Journal of Herpetology 29:417-421.

Klemens, M.K. 1993. Amphibians and reptiles of Connecticut and adjacent regions. State Geological and Natural History Survey of Connecticut, Bulletin No. 112 318 pp.

Lannoo, M. (Ed.) 2005. Amphibian declines: the conservation status of United States species. University of California Press, Berkeley and Los Angeles, California 926 pp.

Lazell, J.D. Jr. 1976. This broken archipelago. Cape Cod and the islands, amphibians and reptiles. Demeter Press, New York. 260 pp.

Mayer, F.L. and M.R. Ellersieck. 1986. Manuel of acute toxicity: interpretation and database for 410 chemicals and 66 species of freshwater animals. U.S. Fish and Wildlife Service, Resource Publication, Number 160, Washington, D.C.

McAllister, C.T., S.J. Upton and D.B. Conn. 1989. A comparative study of endoparasites in three species of sympatric *Bufo* (Anura: Bufonidae), from Texas. Proceedings of the Helminthological Society of Washington 56:162-167.

Oliver, J.A. 1955. The natural history of North American amphibians and reptiles. D. Van Nostrand Company, Princeton, New Jersey.

Quinn, H.R. and C. Scott. 2005. Critical areas, *In* Lannoo, M. (Ed.). Amphibian declines: the conservation status of United States species. University of California Press, Berkeley and Los Angeles, California 926 pp.

Sanders, H.O. 1970. Pesticide toxicities to tadpoles of the Western Chorus Frog *Pseudacris triseriata* and Fowler's Toads *Bufo woodhousii fowleri*. Copeia 1970: 246-251.

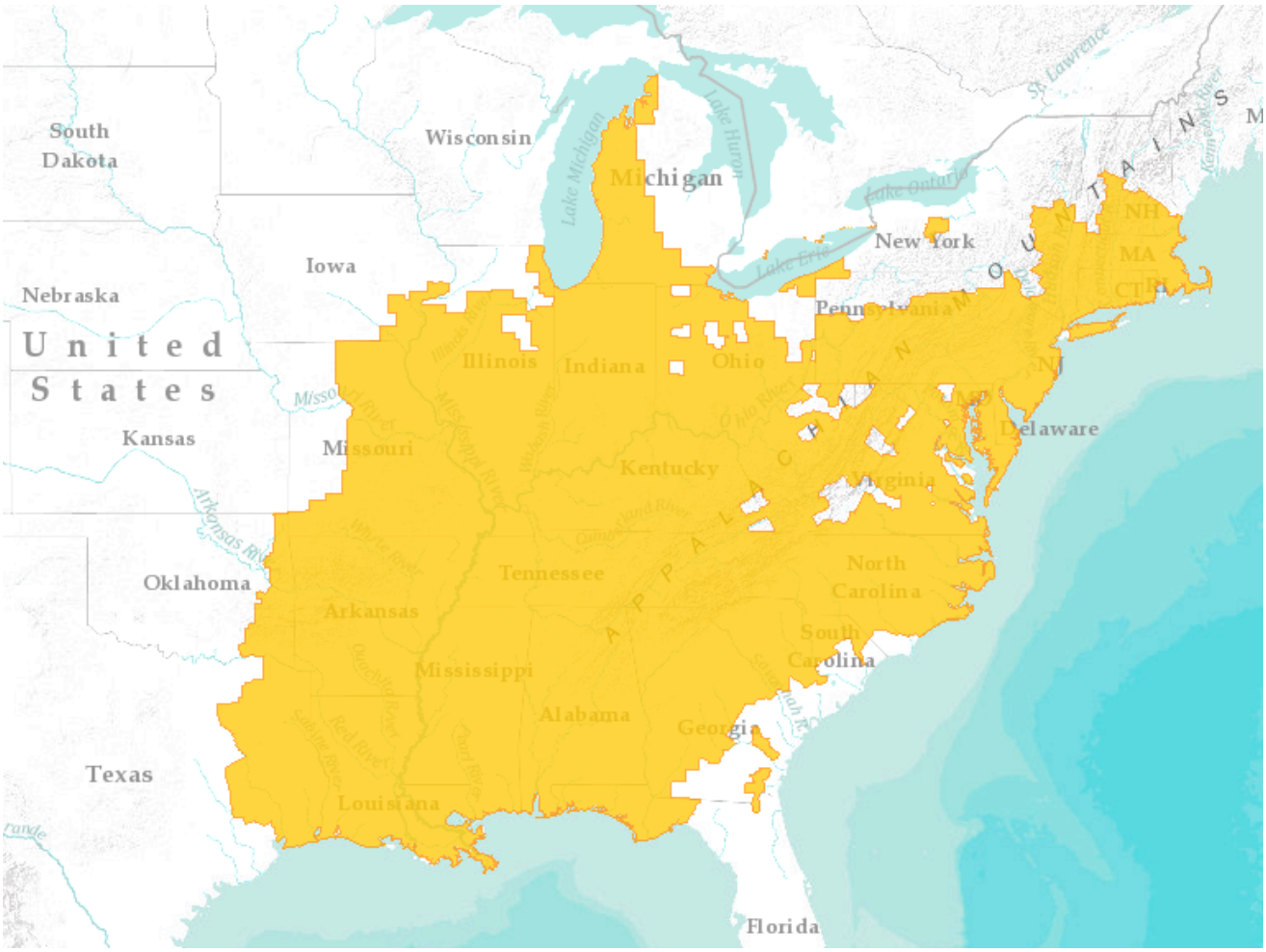
Shively, J.N., J.G. Songer, S. Prchal, M.S. Keasey III, and C.O. Thoen. 1981. *Mycobacterium marinum* infection in Bufonidae. Journal of Wildlife Diseases 17:3-7.

Smith, M. A. and D.M. Green. 2006. Sex isolation and fidelity: unbiased long distance dispersal in a terrestrial amphibian. Ecography 29:649-658.

Stille, W.T. 1952. The nocturnal amphibian fauna of the southern Lake Michigan beach. Ecology 33:149-162.

Vences, M., M.W. Penuel-Matthews, D.R. Vieites and R. Altig. 2003. Natural history notes: *Rana temporaria* (Common Frog) and *Bufo fowleri* (Fowler's Toad). Protozoan infestation. Herpetological Review 34:237-238.

Wright, A.H. and A.A. Wright. 1949. Handbook of frogs and toads of the United States and Canada. Comstock Publishing Associates, A Division of Cornell University Press, Ithaca, New York 640 pp.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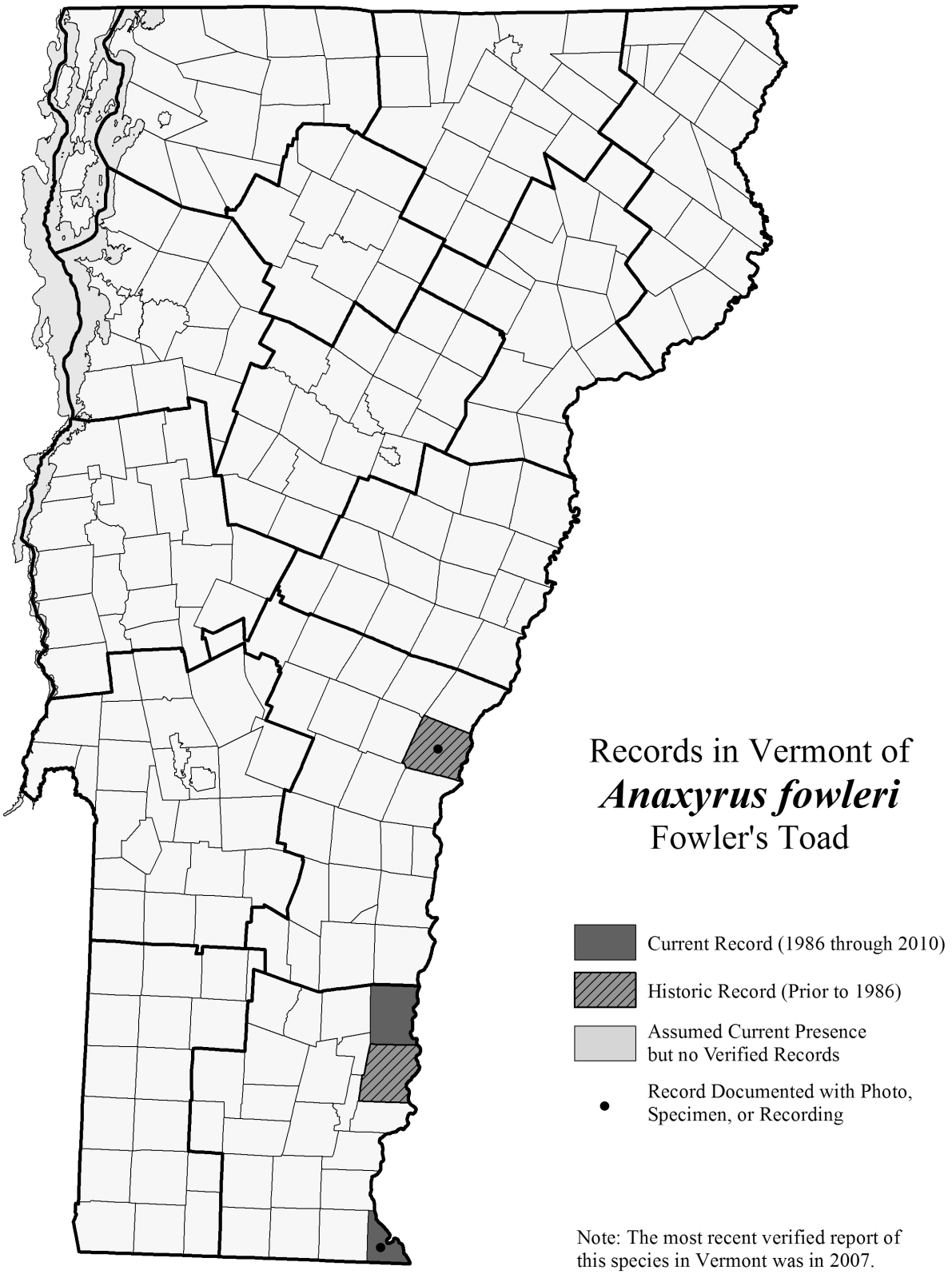
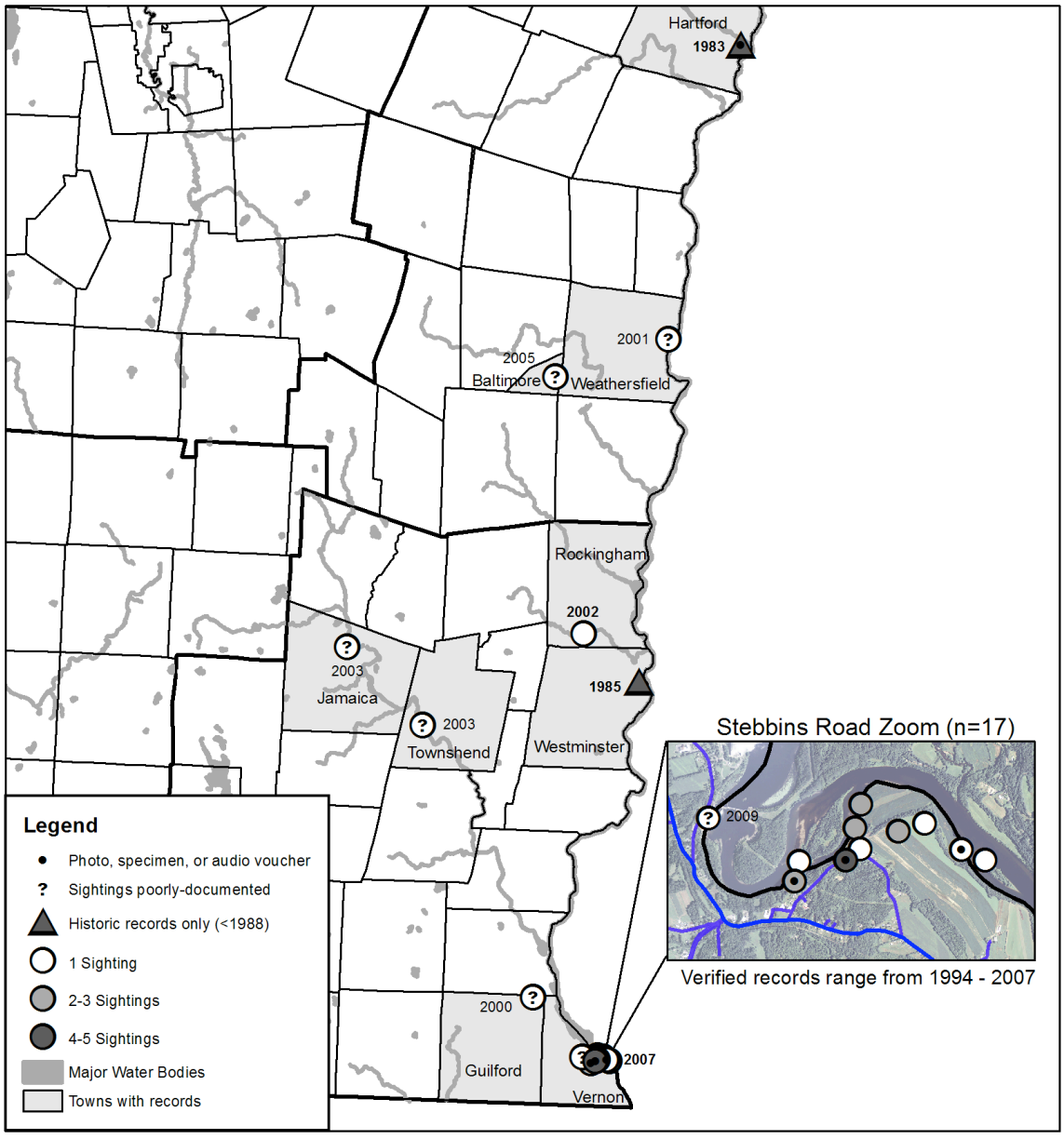

Records in Vermont of
Anaxyrus fowleri
Fowler's Toad
Current Record (1986 through 2010)
Historic Record (Prior to 1986)
Assumed Current Presence
but no Verified Records
Record Documented with Photo,
Specimen, or Recording
Note: The most recent verified report of
this species in Vermont was in 2007.

All Fowler's Toad Observations in Southeastern Vermont including unverified (?) reports



Map current as of Dec. 31, 2012

Vermont Amphibian Records
January 1, 1987 to December 31, 2011

Jim Andrews, Elizabeth Volpe, & Erin Talmage

These tables give a rough idea of the relative abundance and distribution of Vermont's herptiles. The comparisons are subject to bias by the audibility, visibility, notoriety, and ease of identification of species. For example, since salamanders don't call and are usually under cover, they are reported less often than frogs. Consequently, the species are sorted by taxonomic group so that some of these biases are alleviated. However, some other biases remain. For instance, Eastern Ribbonsnakes when observed may be assumed to be Common Gartersnakes and hence they may be under-reported. Aquatic species of turtle that bask only infrequently are probably reported less often than terrestrial or basking species. Still, these tables help the Scientific Advisory Group decide if the state rank and/or state status of a species needs to be reevaluated. Species are listed in descending order of the number of "sites" from which they have been reported. Errors in the number of known sites and towns for the more abundant species are almost certainly included and those numbers are changing monthly. There are a total of 255 "towns" (political units including towns, cities, gores, and unincorporated areas) in the state of Vermont.

Salamanders

Species	# of towns	# of sites	State Rank	State Status	Site Size	SGCN Priority
Eastern Newt	221	1151	S5		0.5km	
Spotted Salamander	218	861	S5		0.5km	Medium
Eastern Red-backed Salamander	239	777	S5		0.5km	
Northern Two-lined Salamander	216	557	S5		0.5km	
Northern Dusky Salamander	191	413	S5		0.5km	
Spring Salamander	102	181	S4		0.5km	
Blue-spotted Salamander Group	57	175	S3	SC	0.5km	Medium
Jefferson Salamander Group	54	94	S2	SC	0.5km	High
Mudpuppy	26	38	S2	SC	0.5km	High
Four-toed Salamander	21	26	S2	SC	0.5km	Medium

Frogs

Species	# of towns	# of sites	State Rank	State Status	Site Size	SGCN Status	Notes
Green Frog	253	1373	S5		0.5km		
Wood Frog	257	1170	S5		0.5km		
Spring Peeper	234	1042	S5		0.5km		
American Toad	250	1002	S5		0.5km		
Gray Treefrog	163	519	S5		0.5km		
Pickerel Frog	175	456	S5		0.5km		
American Bullfrog	170	423	S5		0.5km		
Northern Leopard Frog	74	357	S4		0.5km		
Mink Frog	43	75	S3		0.5km		
Fowler's Toad	2	2	S1	SC	0.5km	High	Missing since 2007
Boreal Chorus Frog	1	1	S1	E	0.5km	High	Missing since 1999