Final Application for New License for Major Water Power Project – Existing Dam

Northfield Project
Northfield Mountain Pumped Storage Project (FERC Project Number 2485)
Turners Falls Hydroelectric Project (FERC Project Number 1889)

EXHIBIT A-PROJECT DESCRIPTION

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EXHIBIT A – PROJECT DESCRIPTION

The following excerpt from the Code of Federal Regulations (CFR) at 18 CFR § 4.51(b) describes the required content of this Exhibit.

Exhibit A is a description of the project. This exhibit need not include information on project works maintained and operated by the U.S. Army Corps of Engineers, the Bureau of Reclamation, or any other department or agency of the United States, except for any project works that are proposed to be altered or modified. If the project includes more than one dam with associated facilities, each dam and the associated component parts must be described together as a discrete development. The description for each development must contain:

1. *The physical composition, dimensions, and general configuration of any dams, spillways, penstocks, powerhouses, tailraces, or other structures, whether existing or proposed, to be included as part of the project;*

2. *The normal maximum surface area and normal maximum surface elevation (mean sea level), gross storage capacity, and usable storage capacity of any impoundments to be included as part of the project;*

3. *The number, type, and rated capacity of any turbines or generators, whether existing or proposed, to be included as part of the project;*

4. *The number, length, voltage, and interconnections of any primary transmission lines, whether existing or proposed, to be included as part of the project (see 16 U.S.C. 796(11));*

5. *The specifications of any additional mechanical, electrical, and transmission equipment appurtenant to the project; and*

6. *All lands of the United States that are enclosed within the project boundary described under paragraph (h) of this section (Exhibit G), identified and tabulated by legal subdivisions of a public land survey of the affected area or, in the absence of a public land survey, by the best available legal description. The tabulation must show the total acreage of the lands of the United States within the project boundary.*

1 TURNERS FALLS DEVELOPMENT

The Northfield Project (Project) consists of the Turners Falls Development and Northfield Mountain Pumped Storage Development.

The Turners Falls Development is located on the Connecticut River in the Commonwealth of MA, and the states of New Hampshire (NH) and Vermont (VT) (Figure 1.0-1). The greater portion of the Turners Falls Development, including developed facilities and most of the lands within the Project boundary, is located in Franklin County, MA; specifically, in the towns of Erving, Gill, Greenfield, Montague and Northfield. The northern reaches of Project boundary extend into the town of Hinsdale, in Cheshire County, NH, and the town of Vernon, in Windham County, VT. The Turners Falls Dam is located at approximately river mile 122 (above Long Island Sound) on the Connecticut River, at coordinates 42°36’38.77” north and 72°33’05.76” west, in the towns of Gill and Montague, MA.

The Turners Falls Dam creates the Turners Falls Impoundment (TFI), which is approximately 20 miles long, and extends upstream to the base of TransCanada’s Vernon Hydroelectric Project and Dam (FERC No. 1904). Most of the TFI lies in MA, however, approximately 5.7 miles of the northern portion of the impoundment is located in NH and VT. The TFI also serves as the lower reservoir for the Northfield Pumped Storage Development (described later).

The Turners Falls Dam is located on a “Z turn” in the river, and is oriented on a northeast-southwest axis, with the impounded area on the east side of the dam, and extending north. At the southwest end of the Turners Falls Dam is the gatehouse (Figure 1.0-2). Below the dam, originating at the gatehouse, is the Turners Falls power canal. Paralleling this power canal is a bypassed section of the Connecticut River. Associated with this power canal are the two hydroelectric generating facilities: Station No. 1 and Cabot Station. Station No. 1 is located approximately one-third of the way down the power canal. Water is conveyed from the power canal, to a small branch canal feeding the Station No. 1 turbines, before discharging into the bypassed reach of the Connecticut River. Cabot Station is located at the downstream terminus of the power canal, where it rejoins the main stem of the Connecticut River. Station No. 1 and Cabot Station discharge into the Connecticut River approximately 0.9 miles and 2.7 miles downstream of the Turners Falls Dam, respectively.

At Turners Falls Dam, the total drainage area is approximately 7,163 square miles (mi^2), or about 64% of the Connecticut River Basin drainage area (11,250 mi^2). The Connecticut River is the largest and longest river in New England, and is tidal up to Windsor Locks, CT, which is located approximately 60 miles from Long Island Sound.

The Turners Falls Development consists of: a) two individual concrete gravity dams separated by an island; b) a gatehouse controlling flow to the power canal; c) the power canal and a short branch canal; d) two hydroelectric powerhouses, located on the power canal, known as Station No. 1 and Cabot Station; e) a bypassed section of the Connecticut River and f) a reservoir known as the TFI. Each of these is described in detail below.

1.1 Turners Falls Dam

The Turners Falls Dam consists of two individual concrete gravity dams, referred to as the Gill Dam and Montague Dam, which are connected by a natural rock island known as Great Island. The 630-foot-long Montague Dam is founded on bedrock and connects Great Island to the west bank of the Connecticut River.

It includes four bascule[1] type gates, each 120 feet wide by 13.25 feet high and a fixed crest section which is normally not overflowed. All four bascule gates are operated by hydraulic cylinders. The bascule gate closest to the gatehouse (bascule gate no. 1) is typically used to provide any required flow releases to the bypass reach by means of "pond-following". Pond-following means that the gate can be set to discharge a certain magnitude of flow and the gate position automatically adjusts to release the same flow based on changes in the TFI elevation. The average height above bedrock is 35 feet and the dam crest elevation is 172.26 feet (NGVD29[2]). When fully upright, the top of the bascule gates are at elevation 185.5 feet.

The Gill Dam is approximately 55-feet-high and 493-feet-long extending from the Gill shoreline (east bank) to Great Island. It includes three 40-foot-wide by 39-foot-high tainter spillway gates. The tainter gates discharge water from the base of the gates. Each tainter[3] gate is operated by a motor/gearbox driving a torsion shaft connected to two lifting chains. When closed, the elevation atop the tainter gate is at elevation 185.5 feet.

1.2 Turners Falls Impoundment

The TFI, formed by the Turners Falls Dam, extends upstream approximately 20 miles to the base of TransCanada's Vernon Dam in Vernon, VT. To provide storage capacity for the Northfield Mountain Pumped Storage Development, the TFI elevation may vary, per the FERC license, from a minimum elevation of 176.0 feet to a maximum elevation of 185.0 feet constituting a 9 foot fluctuation as measured at the Turners Falls Dam. The usable storage capacity in this 9 foot fluctuation, as measured at the Turners Falls Dam, is approximately 16,150 acre-feet. This fluctuation decreases as one travels upstream. The impoundment has a surface area of approximately 2,110 acres and a gross storage volume of approximately 20,300 acre-feet at elevation 185.0 feet msl (as measured at Turners Falls Dam).

The TFI, between Turners Falls Dam and Vernon Dam, has a water surface profile that varies pending the magnitude of flow in the Connecticut River and the storage used for the Northfield Mountain Pumped Storage Development. The profile slope steepens as the magnitude of flow increases. At pinch-points or hydraulic controls such as at the French King Gorge, the water level upstream of the hydraulic control is higher than below. Under inflow above the useable Project capacity, the TFI level upstream of the Turners Falls Dam will exceed 185.5 ft in accordance with the river backwater curve and inflow amount.

1.3 Gatehouse

The power canal gatehouse is located on the Montague side of the Connecticut River. The gatehouse dimensions are 33 feet wide by 214 feet long. It forms the abutment for connecting the Montague Dam spillway with the shoreline and is equipped with headgates controlling flow from the TFI to the power canal. The structure is of masonry and reinforced concrete foundations with a brick walled superstructure. The gatehouse houses 15 operable gates controlling flow to the power canal. Six (6) of the gates are 10'-8" high

[1] A bascule gate is a hinged crest gate. Each bascule gate is controlled by a pair of hydraulic cylinders, mounted in the concrete gravity dam.

[2] Unless otherwise noted in this License Application, reported elevations are based on the National Geodetic Vertical Datum (NGVD) of 1929.

[3] A tainter gate is a spillway gate whose face is a section of a cylinder; it rotates about a horizontal axis on the downstream end of the gate and can be closed under its own weight.

by 9 feet wide wooden gates and nine (9) of the gates are 12'-7" high by 9'-6" wide wooden gates. The Gatehouse fishway passes through the gatehouse at the east bank.

The local controls and operating equipment for the dam's bascule gates are in the gatehouse. They are normally operated remotely from the control room located at Northfield Mountain. The tainter gates are operated locally at the Gill Dam. The magnitude of flow passing through the gatehouse is a function of the gate(s) opening and the hydraulic head or the differential in the TFI elevation and the power canal elevation.

1.4 Power Canal

The power canal is approximately 2.1 miles long and ranges in width from approximately 920 feet in the Cabot forebay (downstream terminus of canal) to 120 feet in the canal proper. Under a normal power canal elevation of 173.5 feet, the power canal depth varies from 17 feet deep just below the Gatehouse to 30 feet deep above Cabot Station. The canal has a design capacity of approximately 18,000 cubic feet per second (cfs). There are several entities that have indentured rights to the first flows from the canal; Table 1.4-1 lists the water users, approximate hydraulic capacity, and FERC project number (where applicable).

Table 1.4-1: Entities Having Rights to Withdraw Water from Power Canal

Facility Name	Owner	Approximate Hydraulic Capacity (cfs)	FERC Project No.
Paperlogic	Southworth Company**	113 cfs	N/A
Turners Falls Hydro, LLC	Turners Falls Hydro**	288 cfs	2622
Station No. 1	FirstLight Hydro Generating Co.	2,210 cfs	1889
Cabot Station	FirstLight Hydro Generating Co.	13,728 cfs	1889
United States Geological Survey, Conte Anadromous Fish Laboratory	United States Geological Survey	Variable[4]	N/A

**Paperlogic[5] and Turners Falls Hydro, LLC[6] have indentured water rights. FirstLight currently has an agreement with each of these entities which provides that the entity will not generate power unless the hydraulic capacity of the Station No. 1 and Cabot stations is exceeded. The United States Geological Survey (USGS), which withdraws water for the Conte Anadromous Fish Laboratory, also has a water use agreement with FirstLight; however, its water use is minimal.

[4] Per Exhibit B of the May 25, 1988 conveyance agreement, the allowable withdrawal rate (in cfs) and number of days of withdrawal varies based on the month. It can range from a maximum of 200 cfs for 13 days in October to a minimum of 2 cfs for 28 days in February.

[5] A water use agreement between then Esleeck Manufacturing Company (a predecessor to Paperlogic) and then Turners Falls Power and Electric Company (a predecessor to FirstLight) was signed in August 1928.

[6] A water exchange agreement between then Keith Paper Company (a predecessor to Turners Falls Hydro, LLC) and then Western Massachusetts Electric Company (a predecessor to FirstLight) was signed in September 1951.

The power canal can be drained via the Keith Drainage Tunnel near the upper end of the power canal (between the gatehouse and Station No. 1 branched canal) and via a Lower Drainage Tunnel near Cabot (located just upstream of where the power canal widens above Cabot Station). The Keith Drainage Tunnel is constructed of concrete, is approximately 7 feet in diameter and 200 feet long. The Lower Drainage Tunnel is constructed of concrete, is approximately 5 feet in diameter and 955 feet long. The Lower Drainage tunnel is abandoned and has never been used. Both tunnels discharge into the Connecticut River.

1.5 Station No. 1

From the power canal there is an approximate 700-foot-long by 100-foot-wide branch canal. Under the normal power canal elevation of 173.5 feet, the depth of the branch canal ranges from 23 feet deep at the intersection of the power canal and branch canal to 16 feet deep in front of the Station No. 1 intake. At the end of the branch canal is the entrance to Station No. 1, consisting of eight bays, each 15 feet wide for a total intake width of 120 feet. Trashracks are angled across the entire entrance, totaling 120 feet wide by 20.5 feet high. With a normal canal elevation of approximately 173.5 feet, the effective trashrack opening is approximately 114 feet wide by 15.9 feet high, resulting in a gross area of 1,812.6 square feet (ft^2). The bar rack thickness is 0.375 inches and the bars are 3 inches on center, thus the clear spacing between bars is 2.625 inches.

After passing the trashrack, the intakes narrow down to four individual 13’-1.5” diameter steel penstocks, approximately 100 feet long, feeding the original seven horizontal Francis turbines housed in the powerhouse. The steel penstocks were lined with reinforced gunite. Only five of the turbines are operational. The powerhouse consists of brick masonry on concrete foundations. The powerhouse has five generators, all alternating current (AC) horizontal type, 60 cycle, and 2300 volt. The powerhouse dimensions are approximately 64 feet wide by 134 feet long.

Penstock 1 feeds Unit 1, penstock 2 feeds Units 2 and 3, penstock 3 feeds Units 4 and 5, and penstock 4 feeds Units 6 and 7. Note that penstock 2 bifurcates into pipes leadings to Unit 2 and Unit 3, penstock 3 bifurcates into pipes leading to Unit 4 and 5, and penstock 4 originally bifurcated into pipes leading to Units 6 and 7, but the branch pipe to Unit 6 was removed and a bulkhead was installed; Units 4 and 6 are no longer in service. The steel branch pipes leading to Units 2 and 4 are approximately 23 feet long and 5 feet in diameter. The branch pipe leading to Unit 2 is lined with epoxy reinforced with fiberglass. The main penstocks at Units 1, 3, 5, and 7 increase to 14 ft diameter at the upstream turbine, which is situated inside the penstocks. Station No. 1 operates under a gross head of 43.7 feet, and has an approximate total electrical nameplate capacity and hydraulic capacity of 5,693 kilowatts (kW) and 2,210 cfs, respectively.

The Station No. 1 steel draft tubes are approximately 21 feet long and 6.5 feet in diameter (the diameter does vary).

Table 1.5-1 includes information on Station No. 1’s generators and turbines. FirstLight does not throttle these smaller units, thus the minimum hydraulic capacity for each of the turbines listed below is unknown.

Table 1.5-1: Generator and Turbine Characteristics of Station No. 1

	Generators		Turbines			
Unit No.	**Electrical Capacity (kW)**	**Amps**	**Runner Size**	**Hydraulic Capacity (cfs)**	**Horsepower (hp)**	**Speed (rpm)**
1	1,500	376	2-48” horizontal double runners	560	2100	200
2*	365	—	1-33” horizontal runner	140	590	257

Unit No.	Generators		Turbines			
	Electrical Capacity (kW)	Amps	Runner Size	Hydraulic Capacity (cfs)	Horsepower (hp)	Speed (rpm)
3	1,276	314	2-42" horizontal double runners	500	1900	200
4						
5	1,276	252	2-39" horizontal double runner	490	1635	200
6						
7	1,276	251	2-42" horizontal double runner	520	1955	200
Total	**5,693**			**2,210**		

*Unit 2 is directly connected to a 1600 amp, 257 rpm, 115 volt exciter.

Transmission facilities at Station No. 1 include generator leads and the 2.4 kV bus. Station No. 1 has one bank consisting of a single, three phase, 4.8/6.0 VA, 13800-2400 volts, oil immersed, self-cooled transformer. Table 1.5-2 includes information on the generator leads.

Table 1.5-2: Generator Leads at Station No. 1

Leads	Length	Voltage	Conductors per phase
Unit 1 to bus	50'	2.4 KV	1
Unit 2 to bus	45'	2.4 KV	1
Unit 3 to bus	40'	2.4 KV	1
Unit 5 to bus	45'	2.4 KV	1
Unit 7 to bus	70'	2.4 KV	1
Bus to substation	110'	2.4 KV	4
To set up transformer	20'	2.4 KV	1

None of these items above are transmission voltage items.

The three single phase pole mounted station service transformers are rated 50KVA, 13800-480 WYE/277 V.

1.6 Cabot Station

Cabot Station is located at the downstream terminus of the power canal. The trashrack opening is 217 feet wide by 31 feet high, resulting in a gross area of 6,727 ft^2. The trashracks are angled, and include upper and lower racks. The top 11 feet of the upper racks have clear bar spacing of 0.94 inches (15/16-inch, and the bottom 7 feet of the upper racks have clear bar spacing of 3 9/16 inches. The entire 13 feet of the lower racks have clear bar spacing of 3 9/16 inches. After passing through the trashracks, flow is conveyed through one of six concrete penstocks to turbines housed in the powerhouse. Each penstock has three headgates followed by a 13'-6" high x 9'-4" wide section that join into one scroll. The total length of penstock from headgate to centerline of turbine is approximately 70 feet long. The powerhouse footprint is approximately 79.5 feet wide by 235 feet long. It is a brick and steel structure set on a concrete substructure on a rock foundation. It houses six identical vertical, Francis type, single runner turbines. At a 60-foot head, each unit is rated at 13,867 horsepower. The wicket gates for each unit are operated by two servomotors.

Each concrete draft tube is approximately 41 feet long and has a diameter of approximately 13.5 feet (the diameter varies between 12.5 feet and 14.5 feet).

Transmission facilities at Cabot Station consist of (i) generator leads and two 13.8 kV buses for three units each for a total of six units, (ii) one 13.8 kV transmission line, about 200 feet long and extending across the power canal to the Montague substation, and (iii) one 13.6/115 kV oil immersed air cooled transformer and appurtenant facilities. Table 1.6-1 includes information on the generator leads.

The six generators are 13.8 kV. Each unit has its own static excitation system rated at 160 volts DC, 781 amps.

Table 1.6-1: Generator Leads at Cabot Station

Leads	Length	Voltage	Conductors per phase
Unit 1 to bus	80’	13.8 KV	1
Unit 2 to bus	80’	13.8 KV	1
Unit 3 to bus	100’	13.8 KV	1
Unit 4 to bus	125’	13.8 KV	1
Unit 5 to bus	250’	13.8 KV	1
Unit 6 to bus	250’	13.8 KV	1
Bus to roof	60’	13.8 KV	4
Overhead cable to step up transformer	200’	13.8 KV	2

Cabot Station has a total station nameplate capacity of 62.016 megawatts (MW) or approximately 10.336 MW/unit. The station has a total hydraulic capacity of approximately 13,728 cfs or 2,288 cfs/unit. The minimum hydraulic capacity of a single unit is approximately 1,400 cfs.

At the downstream terminus of the power canal and adjacent to the Cabot Powerhouse are eight wooden 16’-8” high by 13’-7” wide spillway gates, which permit the discharge of approximately 12,000 cfs. These gates are used to rapidly draw down the power canal in the event of a Cabot Station load rejection or canal dike breach or to sluice ice and debris. In addition, there is a 16’-2” wide by 13’-1” high log sluice gate located at the downstream end of the forebay.

1.7 Fish Passage Facilities

1.7.1 Upstream Fish Passage Facilities

The Turners Falls Development is equipped with three upstream fish passage facilities, including (in order from downstream to upstream): the Cabot fishway, the Spillway fishway, and the Gatehouse fishway. These fish passage facilities were based on a design recommended by the United States Fish and Wildlife Service (USFWS). Fish ladders of similar design pass Pacific salmon species and American shad on the Columbia River. It was believed that these same designs could be applied to pass Atlantic salmon and American shad, the original target species. American shad is the primary species using these fish passage facilities.

The Cabot fishway is a modified “ice harbor” design; it consists of 66 pools, with each pool situated approximately one foot higher than the previous pool. Fish enter the Cabot fishway below Cabot Station. Fish pass through the Cabot fishway into the power canal; from there, they swim 2.1 miles upstream to the Gatehouse fishway. The dimensions of the Cabot fishway are 16 feet wide by 10 feet high by approximately 850 feet long. The hydraulic capacity of the Cabot fishway is approximately 33 cfs. The Cabot attraction flow is 400 cfs per the design specifications. A programmable logic computer (PLC) maintains a one foot differential at the ladder entrance. As the river level changes, the attraction gates will open to maintain the one foot differential. There are two attraction gates, each capable of 350 cfs.

Fish that bypass the Cabot fishway move upstream via the bypassed reach, where they will ultimately encounter the Turners Falls Dam. Fish arriving here are passed upstream via the Spillway fishway into a gallery leading to the Gatehouse fishway, where they rejoin fish that have passed to this point via the Cabot Ladder. The Spillway fishway is also of modified ice harbor design, with 42 pools. The dimensions of the Spillway fishway are 10 feet wide by 10 feet high by approximately 500 feet long. The hydraulic capacity of the Spillway fishway is approximately 18 cfs. The attraction flow is 64-400 cfs per the design specifications. A PLC maintains a one foot differential at the ladder entrance. As the river level changes, the attraction gates will open to maintain the one foot differential. There are two attraction gates, each capable of 350 cfs.

Fish from the upstream end of the power canal can enter the gallery via two entrances; a 70-foot-long flume extending into the canal on the river side of the canal, and a 5-foot-wide opening on the town side of the canal and are passed upstream of the gatehouse via the Gatehouse fishway. The Gatehouse fishway is a vertical slot fishway which delivers fish into the TFI to continue their journey up the Connecticut River. The dimensions of the Gatehouse fishway are 16 feet wide by 17.5 feet high at the entrance (21.5 feet high at the gatehouse) by approximately 225 feet long. The Gatehouse attraction flow is 400 cfs per the design specifications, but will vary with changing TFI elevation, power canal elevation and with varying flows in the entrance for the Gatehouse ladder. The slotted fishway flow, per modeling, is on average approximately 250 cfs, but could be as low as 210 cfs and as high as 270 cfs.

The Connecticut River Atlantic Salmon Commission (CRASC[7]) establishes an annual schedule for the operation of upstream fish passage facilities at the Connecticut River dams. The schedules are based on the projected movement of migratory fish and may be adjusted in season to address actual observations. Table 1.7.1-1 lists the 2016 schedule for upstream fish passage operations at the Turners Falls Development.

Table 1.7.1-1: Upstream Fish Passage Schedule for Cabot, Gatehouse, and Spillway Fishways

Development	Species	Life Stage	Dates of Operation	Hours of Operation
Turners Falls	Salmon	adult	Apr 7-Jul 15	24 hours/day
	Salmon	adult	Sep 15-Nov 15	24 hours/day
	shad & herring	adult	Apr 7-Jul 15	24 hours/day

Source: CRASC letter to FirstLight, 3/4/2016

Downstream Fish Passage Facilities

The downstream fish passage facility is located at Cabot Station, at the downstream terminus of the power canal. Assuming no spill is occurring at Turners Falls Dam, fish moving downstream pass through the gatehouse (which has no racks) and into the power canal. Downstream fish passage facilities at Cabot Station consist of: reduced bar-spacing in the upper 11 feet of the intake racks; a broad-crested weir with an elliptical floor developed specifically to enhance fish passage at the log sluice; the log sluice itself, which has been resurfaced to provide a passage route; above-water lighting; and a sampling facility. Although the log sluice gate is approximately 16 feet wide, there is an 8 foot wide weir that is inserted in the sluice opening during downstream fish passage season. The sluiceway is 6 feet high and 180 feet long. With the

[7] CRASC membership consists of the USFWS, NMFS, and state fishery agencies from CT, MA, NH, and VT.

weir in place, the amount of flow conveyed downstream varies based on the power canal elevation, but typically ranges from 110 to 253 cfs. During fish passage season, the gate is set 3.5 feet open if/when the weir is removed, which results in a flow of approximately 130 cfs.

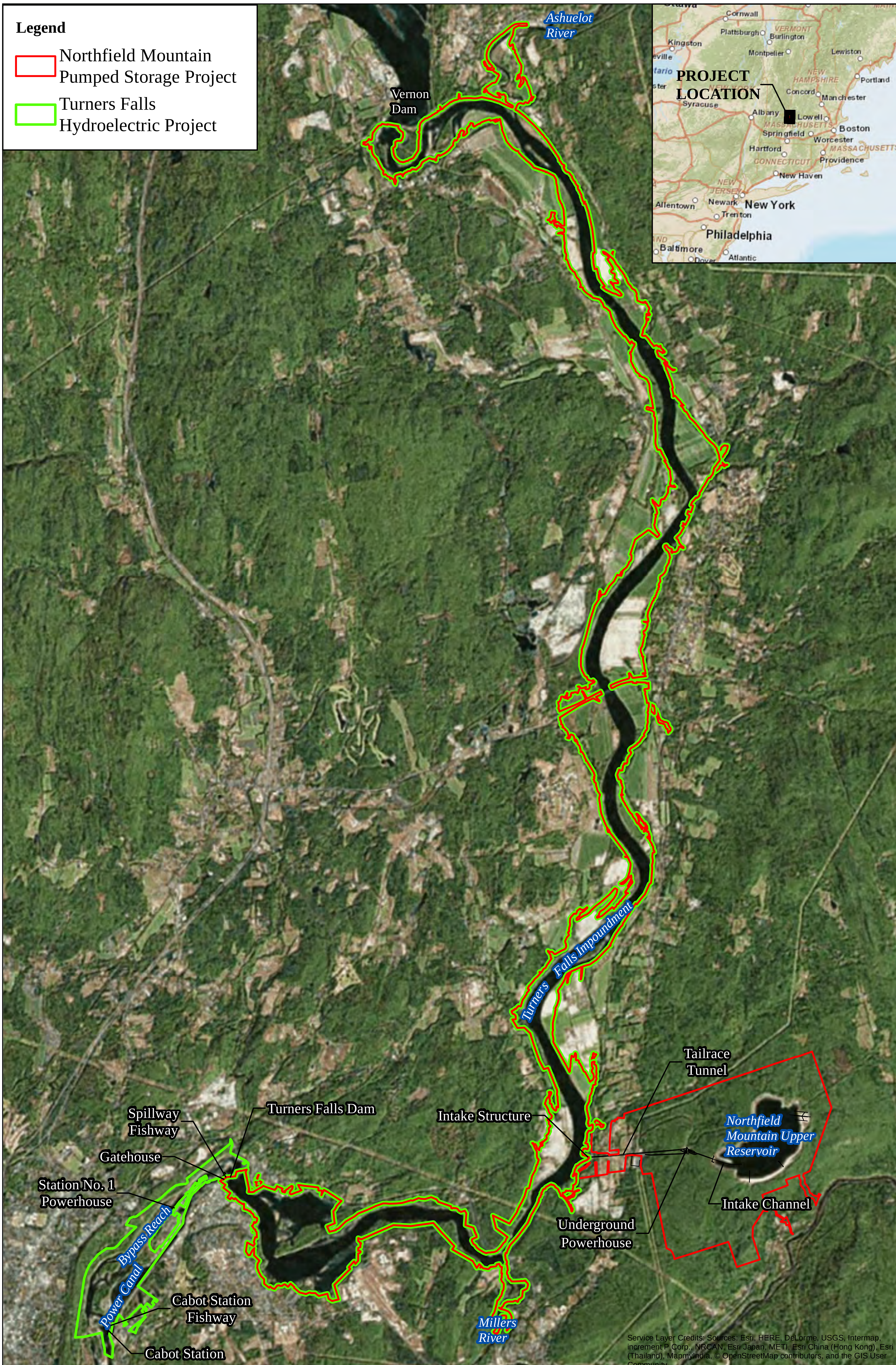
The log sluice gate can be lowered to an elevation of 163.6 ft, NGVD 1929 (i.e., open 11.5 feet). With the weir removed, and the gate fully open, the log sluice can pass approximately 1,600 cfs.

As described for upstream passage, the CRASC also establishes an annual schedule for the operation of downstream fish passage facilities at the Connecticut River dams. Table 1.7.1-2 lists the 2016 schedule for downstream fish passage operations at the Project.

Table 1.7.1-2: Downstream Fish Passage Schedule

Development	Downstream Fish Passage Exit	Species	Life Stage	Dates of Operation	Hours of Operation
Turners Falls	Log sluice and trash sluice	salmon	smolt	Not required	24 hours/day
		salmon	adult	Oct 15-Dec 31[1]	24 hours/day
		shad	adult	Apr 7-Jul 31	24 hours/day
		shad	juvenile	Aug 1-Nov 15	24 hours/day
		eels	adult	Sep 1-Nov 15	24 hours/day

[1]Downstream passage operation, for adults will only be required if 50 or more adults are documented as passing upstream of a dam/facility.
Source: CRASC letter to FirstLight, 3/4/2016



FirstLight
GDF SUEZ

FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

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N

0 0.5 1 2 Miles
1 in = 1 miles

Figure 1.0-1
Turners Falls Development and Northfield Development Boundary Map

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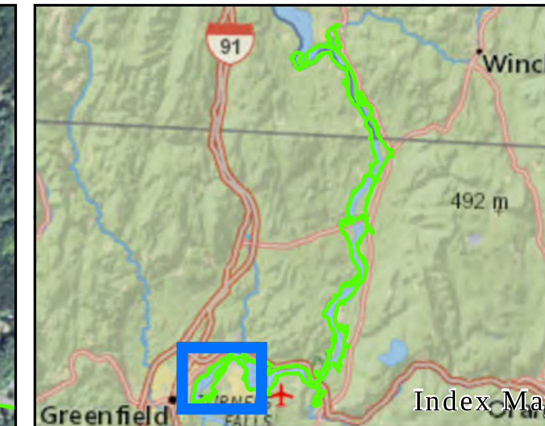

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Figure 1.0-2
Turners Falls Development
Features

Legend

Project Boundary

N

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community
Content may not reflect National Geographic's current map policy.

0 600 1,200 2,400 Feet

1 inch = 1,200 feet

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2 NORTHFIELD MOUNTAIN PUMPED STORAGE DEVELOPMENT

The Northfield Mountain Pumped Storage Development (Figure 2.0-1) is a pumped-storage facility located on the Connecticut River in Massachusetts (MA) that uses the TFI as its lower reservoir. The tailrace of the Northfield Mountain Pumped Storage Development is located approximately 5.2 miles upstream of Turners Falls Dam, on the east side of the TFI. The Development's Upper Reservoir is a man-made structure situated atop Northfield Mountain, to the east of the Connecticut River. During pumping operations, water is pumped from the TFI to the Upper Reservoir. When generating, water is passed from the Upper Reservoir through an underground pressure shaft to a powerhouse cavern and then a tailrace tunnel delivers the water back to the TFI.

The Northfield Mountain Pumped Storage Development consists of: a) the Upper Reservoir dam/dikes; b) an intake; c) pressure shaft; d) an underground powerhouse; and c) a tailrace.

2.1 Northfield Mountain Upper Reservoir Dams and Dikes

Main Dam

The crest of this structure, known as the Main Dam, is at elevation 1010 feet, and is 30 feet wide, with a 2 foot high rock/earthfill wave berm along the upstream edge. The height of the Main Dam varies between 30 to 140 feet; it is approximately 1 mile long. The upstream slope is 1:1.8 (V:H) (the top 15 feet of the upstream slope is at a steeper 1:1.5 slope); downstream slope = 1:1.6. The top of impervious core is at elevation 1005.25 feet. The core is 12 feet wide with 3:1 (V:H) upstream and downstream slopes. The core is founded on sound groutable rock at approximately elevation 860 feet. There are sand and gravel filter zones upstream and downstream of the impervious core. Oversize rock zones form the upstream and downstream faces. The impervious core was raised in 1979 on the downstream portion of the crest in the Main Dam to elevation 1006.25 feet from station 3+00 to station 31+00 in response to settlement shortly after construction. This dam contains an intake structure at station 27 + 28 and sub-foundation pipe for possible future water-supply diversion to the Quabbin Reservoir, a principal water supply for the City of Boston and parts of the Greater Boston metropolitan area. The base of the intake structure is at elevation 921 ft and the top is at elevation 1010 ft. The structure is designed with two 7 ft x 9 ft sluice gates and an 8 ft ID outlet pipe with invert elevation of 923 ft. The Main Dam has a 24-inch diameter x 589 foot long low level outlet pipe at station 8 + 00 with an inlet at elevation of 893 ft, with a Gage House at the end.

Three Vertical Impervious-Core Rock-Fill Dikes

The three dikes, known as the North, Northwest and West Dikes, are constructed in a similar manner and to the same crest elevation as the main rock fill dam, with a central impervious core-filter and compacted rock-filled embankments. They help form the Upper Reservoir. The North dike is approximately 25 feet high and 425 feet long. The Northwest dike is approximately 45 feet high and 2,800 feet long. The West dike is approximately 40 feet high and 1,700 feet long.

Concrete Gravity Dam

Located at the west end of the intake channel, the concrete gravity dam is 327 feet long and 10-20 feet high, with a crest at elevation 1010 feet. The downstream face has been back-filled to elevation 1002 feet. The concrete walls at both ends of the gravity section are constructed to a higher level, allowing a parapet wall to be constructed against the retaining wall on the right side of the intake. The remaining section, approximately perpendicular to the main section, varies from 5-10 feet in height.

Intake Channel

The intake channel directs water from the Upper Reservoir into the pressure conduit intake. The channel is 1,890 feet long and is excavated in rock with side slopes of 4:1 (V:H). The invert is 130 feet wide at elevation 880 feet. There is a small check dam (submerged) at the upstream end of the intake channel with a stoplog and gate structure. The purpose of this control structure, a low dam between the Upper Reservoir and intake channel, is to prevent stormwater from entering the pressure conduit when the intake channel is dewatered. The submerged check dam is 63 feet long and approximately 9 feet high with a crest at elevation 900 feet. It has two manually operated sluice gates (2.75 feet high by 6 feet wide), two 18 foot wide stoplog slots which usually hold eight concrete stoplogs (weighing approximately 3,000 lbs each).

Concrete Gravity Spillway Structure

The ungated concrete gravity overflow structure is 550 feet long with a crest elevation of 1006.5 feet. There is a 20 foot long notch at elevation 1005.0 feet near the center of the structure which is designed to concentrate small discharges due to precipitation and runoff when the reservoir is full. The overflow spillway is approximately 6 feet high on the upstream side. The remaining spillway length has been sized to prevent overtopping of the embankments due to over-pumping.

2.2 Pressure Shaft

The pressure conduit system consists of a reinforced concrete intake portal, a 200 foot long concrete lined transition section, a portal 55 feet wide by 80 feet high, an inclined concrete-lined pressure shaft connecting the intake and manifold shaft (31 feet diameter, 853 feet long, inclined 50º from the horizontal), concrete-lined manifold formed by branching of the pressure shaft into two 22 feet diameter conduits (approximately 100 to 150 feet long) and then into four 14 feet diameter tunnels leading to four steel-lined penstocks (340 feet long, diameter decreases from 14 to 9.5 feet). During pumping operation, water is pumped from the TFI through a tailrace tunnel to the powerhouse cavern and then through the pressure shaft to the Upper Reservoir. During generation, water flows from the Upper Reservoir back through the pressure shaft to the powerhouse and then the tailrace tunnel delivers the water back to the TFI.

2.3 Tailrace Tunnel

Water flows between the powerhouse cavern and the TFI via the tailrace tunnel. There are four 11 foot diameter concrete draft tubes, approximately 25 feet long[8] connected by a manifold to a common tailrace tunnel. The tailrace tunnel is concrete-lined, horseshoe shaped and 5,136 feet long, with a maximum width of 33 feet and a height of 31 feet. The tunnel discharges during generation through a concrete exit structure into the TFI. The exit structure includes a transition from the horseshoe shape into a trapezoidal shape. Steel stop logs (approximately 35 feet long and 8 tons each) are used in the exit structure when needed to dewater the tailrace tunnel; the stoplogs are stacked to a total height of approximately 40 feet when in use. A floating boom, approximately 400 feet long, is provided across the exit channel to provide a barrier to large debris and boaters.

The trapezoidal trashrack opening has the following dimensions: top width: 99’-6”, bottom width: 74’4”, depth: 48’-0”, resulting in a gross area opening of 4,400 ft^2. The bar thickness is 0.75 inches, with a clear-spacing of 6 inches.

[8] The length does not include a transition to a 17 foot diameter draft tube, which is approximately 20 feet long.

2.4 Upper Reservoir

The Upper Reservoir, formed by the Main Dam, the Rockfill Dikes, and the Concrete Gravity Dam, has a gross storage capacity of 17,050 acre-feet. Per the current FERC license for the Northfield Mountain Pumped Storage Development, the Upper Reservoir may operate between 1000.5 feet and 938 feet (constituting a 62.5 foot drawdown), which equates to a useable storage capacity of approximately 12,318 acre-feet. This is equivalent to approximately 8,729 MWhs (formerly 8,475 MWhs) of stored energy. The surface area at elevations 938 and 1000.5 feet are 134 and 286 acres, respectively. The Upper Reservoir was constructed to accommodate an elevation of 1004.5 feet as approved by FERC in 1976. In addition, the reservoir retains useable storage capacity down to elevation 920 feet. The useable storage volume between elevation 1004.5 feet and 920 feet is approximately 15,327 acre-feet, which is equivalent to approximately 10,779 MWhs (formerly 10,465 MWhs) of stored energy. FirstLight has received temporary amendments from FERC in the past to use more of the Upper Reservoir Storage. Most recently, from December 1, 2015 to March 31, 2016 FirstLight was granted a temporary amendment from FERC to use the storage between elevations 1004.5 feet and 920 feet.

2.5 Powerhouse

The underground powerhouse is 328 feet long and 70 feet wide, the floor of the spherical valve gallery is at elevation 56 feet, the roof is at 190 feet. It contains four reversible pump/turbines operating at gross heads ranging from 753 to 824.5 feet. Each of the four units has an electrical capacity of 291.7 MW, for a total station nameplate capacity of 1,166.80 MW. Historically, the total station capacity was 1,080 MW (270 MW/unit); however, Units 2, 3 and 4 underwent efficiency improvements with the replacement of the turbine runner, and rewind of the motor-generator[9]. A new runner was installed in Unit 1 in 2004, and the rewind commenced in August 2015 and was completed in February 2016.

When operating in a pumping mode, the maximum hydraulic capacity (4 pumps) is approximately 15,200 cfs (3,800 cfs/pump). Alternatively, when operating in a generation mode, the approximate maximum hydraulic capacity (4 turbines) is approximately 20,000 cfs (5,000 cfs/turbine). The minimum flow to safely spin one unit and produce power is approximately 2,300 cfs.

At the north end of the underground powerhouse is a ventilation and emergency access shaft from elevation 123 feet to elevation 751 feet. The shaft is 18 feet in diameter at the lower end and 15 feet in diameter at the upper end. At the ground level opening of the shaft is the ventilation shaft house. The shaft provides ventilation for exhaust air from the powerhouse, ventilation for intake and exhaust air from the surge shafts, access to the powerhouse by means of stairs, and access to the surge gallery and draft tube gantry crane from the powerhouse.

Transmission Facilities

Each of the four generators is connected to its respective unit breaker by means of an Iso phase bus. Each pair of units is provided with a dual secondary step-up transformer (rated 345/13.8 kV, 666 MVA, 3 phase, 60 cycle) to step from 13.8 kV generating voltage up to 345 kV. Each transformer is located in a vault, excavated in the rock adjacent to the powerhouse. For these two transformers, power is transmitted through two 345 kV pipe type cables, installed in the access tunnel (approximately 24 feet high by 26 feet wide by

[9] On August 17, 2011, and supplemented on January 17, 2012, February 14, 2012, and February 24, 2012, FirstLight filed an amendment application to revise the authorized installed capacity of Northfield Mountain. FERC issued an order amending the license and revising annual changes on March 23, 2012.

2,365 feet long), to the Northfield Switching Station which is located near the access tunnel. Table 2.5-1 includes information on the generator leads.

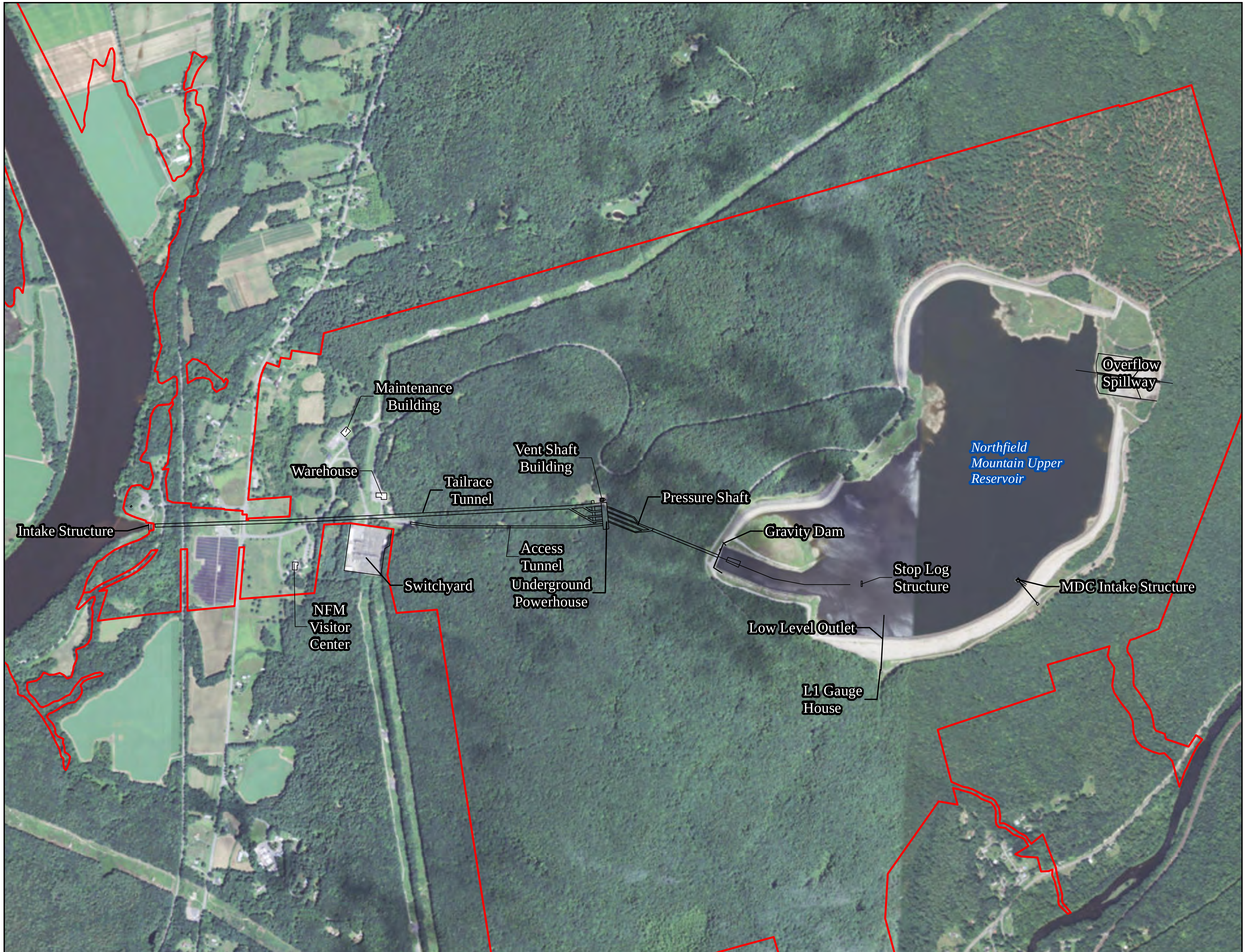
Table 2.5-1: Generator Leads at Northfield Mountain Pumped Storage Facility

Leads	Length	Voltage	Conductors per phase
Unit 1 to1X Transformer	26’	13.8 KV	1
Unit 2 to 1X Transformer	26’	13.8 KV	1
1X Transformer to Switching Station	3000’	345 KV	1
Unit 3 to 3X Transformer	26’	13.8 KV	1
Unit 4 to 3X Transformer	26’	13.8 KV	1
3X Transformer to Switching Station	3000’	345 KV	1

The pipe cables to the switchyard are of transmission voltage.

2.6 Fish Passage Facilities

A fixed-position guide net approximately 650 feet long by 15 feet deep, has historically been deployed since 1995 to reduce entrainment of Atlantic salmon smolts in flows pumped from the TFI to the Upper Reservoir during downstream migration. After the initial evaluation in 1995, further net modifications were field tested in 1996 and 1997. Since then, the guide net has been deployed annually during downstream smolt migration season. During the period when the guide net was installed, FirstLight limited the number of pumps operating to a maximum of three during the downstream migration. In 2015, the CRASC agreed to not require the installation of the barrier net. In 2016, CRASC did not require installation of the barrier net. This decision was based on concerns for a variety of potential negative impacts or other effects to the relicensing studies being conducted in 2015. The barrier net is not intended to be installed in 2016 and thereafter.



FIRSTLIGHT HYDRO GENERATING COMPANY
Northfield Mountain Pumped Storage Project No. 2485
Turners Falls Hydroelectric Project No. 1889

Final License Application
Exhibit A

Figure 2.0-1
Northfield Mountain Pumped Storage Development Features

Legend

Project Boundary

N

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0 600 1,200 2,400 Feet

1 inch = 1,200 feet

FirstLight
GDF SUEZ

Path: W:\gis\maps\Exhibit_A\Figure_2_0-1_opt.mxd

3 ADDITIONAL EQUIPMENT

The Project also includes various turbine governors, generator exciters, batteries, control panels and circuit breakers.

4 LANDS OF THE UNITED STATES

There are approximately 20 acres of federal lands within the current Project boundary associated with the USGS's Conte Anadromous Fish Laboratory. However, the proposed Project boundary would not include any federal lands, because the lands are not needed for project purposes.