

**GREEN RIVER WHITEWATER STUDY  
FOR THE MORRISVILLE PROJECT  
(FERC NO. 2692)**



Submitted by:

**Village of Morrisville  
857 Elmore Street  
Morrisville, VT 05661 – 0460**

Prepared by:

**Morrisville Water & Light**

## INTRODUCTION AND PURPOSE

The Morrisville Project (FERC Project No. 2629) is located in the northern half of Vermont on the Lamoille and Green rivers in Lamoille County, Vermont. The Project currently consists of four developments: the Morrisville and Cadys Falls dams located on the Lamoille River in Morrystown, the Lake Elmore dam located on Elmore Brook in Elmore, a tributary to the Lamoille River, and the Green River development on the Green River in Hyde Park. This study focuses on the Green River development and its potential to provide whitewater boating opportunities on the Green River.

The Green River drops about 400 feet over the 2.75 miles from the Garfield Road to Route 15 and in to the Lamoille River. The river meanders through an uninhabited, deeply wooded area with several exceptional gorges, falls and drops that provide an exceptional opportunity for whitewater boating. The upper part of the river has a gentler slope dropping about 150 feet over the 1.6 miles from the dam to the Garfield Road.

The original FERC license was issued on August 28, 1981 and required a minimum flow of 5 cfs from the generating station on a year round basis. Morrisville Water and Light (MWL) is in the process of relicensing the project which is due in 2015. The purpose of this study is to assess the whitewater boating opportunities while considering any effects on generation or other operational issues associated with the project.

## METHODOLOGY

### Background:

A study plan was developed in collaboration with MWL, American Whitewater (AW) and the Vermont Paddlers Club (VP) to assess the whitewater boating opportunities at various levels of release from the Green River Generation Plant primarily on the 2.75 mile stretch of river from Garfield Road to Route 15. The goal of the study was to determine an acceptable range of flows, including a minimum and optimum flow, the number of days the current operation of the Plant meets the criteria; operational considerations with providing scheduled releases to meet the required flows; identify access points to accommodate boaters and any other effects that need to be considered with planned releases.

AW and VP developed a systematic evaluation process to be used by participants in the study to aid in the overall assessment of the various flow release levels. This included a single flow evaluation form completed by each participant after each run that captured specific information on such things as the type of boat, acceptable water level, navigability, aesthetics, safety, portages etc. This was followed by a comparative flow evaluation form which provided the opportunity for comparison of runs and thoughts on minimum and maximum acceptable flows.

AW and VP assembled a team of boaters of varying skills to participate in the scheduled runs. Two days were identified for scheduled releases, with a morning and afternoon run at different release volumes. MWL installed a staff gauge scaled in inches at the upper and lower ends of the run to provide additional corroboration for evaluating flow levels.

Safety steps were in place by having participants go in several teams and people were positioned on shore at predetermined potentially hazardous locations on the river. No incidents occurred during the two days of scheduled releases. The boaters were able to negotiate the river safely, using appropriate judgment for the hazards and obstacles they encountered.

## Field Evaluations of Flows:

The field evaluation took place on October 1<sup>st</sup> and 2<sup>nd</sup>, 2011. The event was video taped at several locations and supplemented with individual pictures and some participant videos.

The four flow levels were as follows:

Flow 1	Flow 2	Flow 3	Flow 4
10/1/2011 AM	10/1/2011 PM	10/2/2011 AM	10/2/2011 PM
1 Tube	1 1/3 Tubes	2/3 Tube	2 Tubes
848 kW	1140 kW	635 kW	1790 kW
LG - 2' 8"	LG - 3' 0"	LG - 2' 5"	LG - 3' 5"
UG - N/A	UG - 3' 0"	UG - 2' 5"	UG - 3.5"

First, a brief explanation of the word "tube" as listed in the above chart and referenced throughout the report. The Green River Generation Plant has two identical generators rated at 925 kW each with a four and one-half foot (4 ½') penstock (tube) to each unit. The word "Tube" in the report is directly related to the flow of water from each penstock which is directly related to the level of generation in the units. As an example "2/3 Tube" equates to one generator (1) running approximately at 66% full capacity and "2 Tubes" equates to both generators operating at full capacity.

A total of 26 individuals participated in the two day event consisting of four different runs. Participants completed individual assessment forms and a comparative assessment form that allowed them to rate access, navigability, technical requirements, whitewater "play" areas, safety, aesthetics, acceptable minimum flow, optimum flow and other factors. An individual form was completed by each participant after each run. The comparative assessment form was completed after all the runs were completed summarizing the experience and each person's recommendation for minimum and optimum flows. Hard shell kayak's were used by approximately 90% of participants in the first three runs and 100% in the final run. One inflatable kayak and one open canoe with flotation participated in runs one and three. A closed deck canoe also participated in the first three runs.

The area received approximately two inches (2") of rain in the week prior to the October 1<sup>st</sup> and 2<sup>nd</sup> field evaluation, and another one and a third inches (1.3") of rain during the two days of the evaluation. This resulted in the boating flows being higher due to tributary and ground water in-flow during the study than the dam released flows. MWL coordinated with VP to schedule another evaluation run when there had not been little or no precipitation prior or during the release. This evaluation occurred on November 9<sup>th</sup> and 10<sup>th</sup>, 2011. The three flow levels were as follows:

Flow 1	Flow 2	Flow 3
11/9/2011 PM	11/10/2011 AM	11/10/2011 PM
1 1/3 Tubes	1 2/3 Tubes	2 Tubes
1135 kW	1410 kW	1707 kW
LG - 2' 10"	LG - 3' 0"	LG - 3' 5"
UG - 2' 10"	UG - 3' 0"	UG - 3' 5"

MWL also conducted a separate test on December 16, 2011 with a flow of one tube and generation at 815 kW. The reading on both gauges was 2' 5". There was less than one-quarter inch (.25) rain the night before this test.

MWL has checked the gauges several times during non generation times with normal flows on the river and the gauges read four inches (4") in these cases. There was no gauge reading taken before the start of generation during the October evaluation. Both gauges read 4" before the November evaluation and both gauges read 6" before the December test. This is important because during the October evaluation there was consensus that a minimum navigable flow equated to a 2' 5" gauge reading which was achieved with a two-third tube (2/3) flow. A couple of weeks after the October evaluation, a VP member traversed the river when MWL was running one tube (1) and the reading on the gauges was 2' 3", which does not provide an acceptable run based on the results of October's evaluation. The generation at this time was approximately 730 kW.

The results of all the above information has been analyzed and used to develop an acceptable minimum flow and an optimum flow.

### **Results:**

A group of 26 people from all over the Northeast and representing various whitewater experience levels participated in the two-day evaluation (October 1-2, 2011) of scheduled flows on the Green River. Four different flow levels were evaluated with morning and afternoon runs during each day. The numbers of boaters for each run differed based on individual boater's skill level and the various flows. The two higher flow levels had a lower number of boaters, however fifteen was the minimum number of participants for any run. The entire group was very enthusiastic and responsive in completing the forms, resulting in a valid evaluation of the river.

Participants were asked to complete a "Single Flow Evaluation" form immediately after each run they participated in and a "Comparative Flow Evaluation" form after the final release on October 2<sup>nd</sup> which provided an opportunity to compare and rate all of the runs. The single flow evaluation forms for each release were analyzed and are summarized on the following tables.

### Individual Evaluation Summary

Table 1 shows the number of participants and the kW generation level for each individual run. A couple of the categories were rated very similar for each of the runs – aesthetics and length of run. All of the runs were rated a minimum Class IV on the International White Water Scale and as might be expected the Paddler Skill Rating for each of the runs was advanced. All of the runs received an acceptable rating, but the rating for 2/3 Tube run was approximately 33% lower than 1 Tube. Based on the river gauge readings discussed earlier, the rains around the time of the test runs had an effect on the experience on the river and seems to have more of an impact on the lower level releases, by making the lower flows more boatable due to additional in-flow from tributaries and ground water.

**TABLE 1: SUMMARY OF INDIVIDUAL EVALUATION SCORES**

DATE	10/2/2011	10/1/2011	10/1/2011	10/2/2011
FLOW REGIMEN	2/3 TUBE	1 TUBE	1 1/3 TUBES	2 TUBES
MEASURED KW GENERATION LEVEL	637	848	1140	1790
PARTICIPANTS	25	23	18	15

CATEGORY	AVG. RATING			
Navigability	0.96	1.74	1.94	1.93
Availability of challenging technical boating	1.43	1.74	1.89	2.00
Availability of powerful hydraulics	0.48	0.91	1.22	1.67
Availability of whitewater "play areas"	-0.17	-0.17	0.17	0.40
Overall whitewater challenge	1.35	1.74	1.72	1.93
Safety	1.04	1.18	1.61	1.53
Aesthetics	1.96	2.00	1.94	1.93
Length of run	1.87	1.87	1.89	1.87
Actual number of portages during run	1.74	2.70	1.39	1.67
Overall rating	1.30	1.74	1.94	2.00
Class Whitewater Difficulty Rating	4.04	4.17	4.18	4.55
Paddler Skill Level Assessment	3.00	3.00	3.11	3.17

**CATEGORY RATING SCALE**

Totally Unacceptable	Unacceptable	Neutral	Acceptable	Totally Acceptable
-2	-1	0	1	2

**PADDLER SKILL RATING SCALE**

Novice	Intermediate	Advanced	Expert
1	2	3	4

Comparative Evaluation Summary

The comparative form was completed at the end of the October 2<sup>nd</sup> afternoon run and provided an opportunity for participants to compare the four flows to determine a minimum acceptable flow, a standard trip optimum flow, a high challenge trip optimum flow and if MWL could only provide one flow what level of flow would be recommended. The participants also rated the Green River run compared to other available whitewater opportunities in the area, State, northeast etc. All of the responses are summarized in Table 2:

TABLE 2: COMPARATIVE FLOW ANALYSIS

**IMPORTANCE OF COMPONENTS**

CATEGORY	AVG. RATING
Navigability	4.20
Availability of challenging technical boating	4.13
Availability of powerful hydraulics	2.80
Availability of whitewater "play areas"	1.64
Overall whitewater challenge	4.20
Safety	4.08
Aesthetics	4.32
Length of run	3.36
Few portages	3.00
Easy put -ins and take-outs	1.96

**CATEGORY RATING SCALE**

Not at all important	Slightly important	Moderately Important	Very Important	Extremely Important
1	2	3	4	5

**EVALUATION OF FLOWS**

RELEASE	FLOW	~ CFS	KW GEN LEVEL	AVG. RATING
FLOW 1	1 TUBE	140	848	1.27
FLOW 2	1 1/3 TUBES	186	1140	1.70
FLOW 3	2/3 TUBE	105	637	0.42
FLOW 4	2 TUBES	280	1790	1.53

**RATING SCALE**

Totally Unacceptable	Unacceptable	Neutral	Acceptable	Totally Acceptable
-2	-1	0	1	2

**RATING OF FLOW LEVELS FOR DIFFERENT TYPE RUNS**

(May include flows not seen, but think provide best answer on participants experience)

	~ CFS		~ KW GEN. LEVEL	HIGHEST LEVEL	LOWEST LEVEL
	AVG	MEAN			
Minimum Acceptable Flow	128	140	780	232	93
Optimum Flow for this run	218	221	1330	300	140
Optimal Flow for "Standard" run	194	186	1183	280	140
Optimal Flow for "High Challenge" run	273	280	1700	350	186
Level if MWL released only one flow	215	280	1320	280	140

OTHER INFORMATION				
		For different types of boating experience		For different skill levels and crafts
Importance of releasing a variety of		3.25		3.96
Scale				
Not at all important	lightly importa	Moderately Important	Very Important	Extremely Important
1	2	3	4	5
Rating of boating opportunities on the Green River compared to....				
... other rivers within 1hour drive				3.96
... other rivers in Vermont				3.52
... other rivers in the Northeast				3.29
... other rivers in the country				3.00
Scale				
Worse than average	Average	Better than average	Excellent	Among the very best

Based on the tabulated data the minimum acceptable flow is between 128 and 140 cfs which equates to 1 Tube or +/- 800kW of generation. The optimum flow and the flow level to select if only one flow was available were almost exactly the same with an average of ~218 cfs representing approximately 1 ½ Tubes or ~ 1330kW of generation. The optimum flow for a high challenge run is running with both generators at full capacity.

### Conclusions:

The evaluation of the potential of whitewater boating on the Green River provided some clear results for the level of flow required to navigate the Green River at various levels of boating and provided data as to how this run compares to other available venues in the Northeast. The fact that some of the data obtained from the first evaluation with all participants may have been skewed slightly because of the level of rain that occurred during that period did not negate the usefulness of the data. By doing a subsequent run at a time when rainfall was not a factor and taking some readings on the river gauges has allowed the data to be corroborated and yield clear results.

The data shows the minimum acceptable flow to be 1 Tube, a standard run to be 1.5 Tubes and a high challenge run to be 2 Tubes. Two river gauges were installed as part of the study and these are very useful in determining the navigability of the river. A reading of 2' 5" on either gauge signifies the river is navigable at approximately minimum flow level.

The participants rated the boating experience above average when compared to other rivers in the Northeast and the length of the run also rated high. This run does require advanced paddler skills and boater safety needs to be considered with higher flows.

The overall conclusion is the Green River can provide a quality whitewater boating experience that includes a variety of advanced paddler challenges with an above average length run in a picturesque setting.