THE STATE OF NEW HAMPSHIRE

SITE EVALUATION COMMITTEE

DOCKET NO. 2010-01

Application of Groton Wind, LLC
for a Certificate of Site and Facility

CONTESTED MOTION OF GROTON WIND, LLC TO AMEND CERTIFICATE OF SITE AND FACILITY

NOW COMES Groton Wind, LLC ("Groton Wind"), by and through its undersigned counsel, and respectfully requests that the New Hampshire Site Evaluation Committee ("SEC" or "Committee") amend the Certificate of Site and Facility in the above-captioned docket in the event that the SEC determines that Groton Wind should have sought SEC approval of revised site plans that were submitted to and approved by the New Hampshire Department of Environmental Services ("DES")[1]. In support of this Motion, Groton Wind states as follows:

I. Introduction

On May 6, 2011, the Committee issued its Decision Granting Certificate of Site and Facility With Conditions ("Decision") and Order and Certificate of Site and Facility With Conditions ("Certificate") to Groton Wind. The Decision and Certificate authorize Groton Wind to site, construct and operate a renewable energy facility ("Project" or "Facility") consisting of 24 Gamesa G82 wind turbines each having a nameplate capacity of 2 megawatts ("MW") for a total nameplate capacity of 48 MW to be located in the Town of Groton, New Hampshire. The Certificate ordered the issuance of all permits

[1] The issue of whether DES had sole authority to review and approve revised site plans for the Groton Wind Project is discussed in a separate pleading filed contemporaneously with this Motion.

and/or certificates recommended by the New Hampshire Department of Environmental Services ("DES"). Certificate at 3. The Certificate was "conditioned upon compliance with all conditions of said permits and/or certificates..." and authorized DES "to approve modifications or amendments to said permits and certificates..." *Id.* The Wetlands Permit and Alteration of Terrain ("AoT") Permit issued as Appendix I to the Certificate both contain project specific conditions referring to revised plans dated July 9, 2010, as well as conditions (i.e. condition #2 in both permits) requiring that, prior to construction, any plan revisions or changes in construction details or sequences shall be submitted to DES for review and approval.

As the Groton Project progressed from the design and permitting phase to the pre-construction, site-preparation phase, Groton Wind and its consultants determined that certain refinements to the July 9, 2010 site plans would be appropriate and prudent. On November 10, 2011, in accordance with the provisions of the Certificate, Wetlands Permit and AoT Permit, Groton Wind's consultant, Vanasse Hangen Brustlin, Inc. ("VHB"), submitted to DES revised Project plans dated October 28, 2011[2]. *See* Attachment 1[3] submitted herewith. VHB's submission to DES included updated site plans showing "additional detail required for construction" and "eight minor changes to the project plans relative to the permitted plan set dated July 9, 2010." *Id.* at 1. These changes are discussed in section II, below. The net result of these changes reduced the overall footprint of the Project by approximately 12 acres. *Id.*

[2] The revised Project site plans dated October 28, 2011 were previously filed with the SEC and are posted on its website as "Construction Site Plans". Due to the size of those plans, they are not being resubmitted with this Motion.

[3] Attachment 1 was previously filed with the SEC and is posted on its website.

On December 5, 2011, DES approved the revised plans showing "minor roadway modifications, relocation of the O&M building, minor transmission line relocations, and a reduction in stone mattresses" and "determined that these minor modifications are acceptable as presented." *See* Attachment 2[4] submitted herewith. DES issued amended Wetland and AoT permits which DES characterized as "confirmation to proceed with the minor modifications as depicted on the revised plans by VHB dated October 28, 2011." *Id.* Groton Wind presented the foregoing information in a letter dated January 16, 2013 to Chairman Burack.

On November 4, 2013, Chairman Burack issued a Procedural Order in the instant docket that, among other things, directed parties to file briefs on the issue of whether DES had the authority to modify the Certificate regarding the placement of the O&M buildings and the turbines. Contemporaneously with the filing of the within Motion, Groton Wind has filed a brief explaining that DES had such authority. Without conceding its position that DES had sole authority to grant approvals of its minor site plan revisions, Groton Wind submits the instant Motion and requests that the Committee consider it in the event that the Committee determines that the Certificate must be amended.

II. Site Plan Revisions

In advancing construction level design details for the Project, Groton Wind and its engineering team determined that certain refinements of the Project's site plans were necessary and prudent. Although the overall Project layout is essentially the same as that approved by the SEC, the minor site plan revisions constitute improvements over the original plans. The net result of all of the revisions reduced the overall footprint of the

[4] Attachment 2 was previously filed with the SEC and is posted on its website.

project by approximately 12 acres. The site plan revisions have been deemed "minor" by DES and do not substantively modify Groton Wind's application for a certificate of site and facility. As such, they do not affect the original determinations made by the SEC under RSA 162-H:16. Maps showing the areas of site plan revisions are contained in Attachment 1, pages 6 and 7. A description of the revisions submitted to DES and reasons for them are set forth in Attachment 1 and are summarized below. Attachment 3 shows the variance between the proposed turbine locations and the as-built locations.

Revision 1. Operations and Maintenance Facility. The location of the O&M building was moved from the east site of Clark Brook to the west side of Groton Hollow Road to a location where a fenced in switch yard[5] was previously proposed. The total area of the O&M building and adjacent storage area was reduced. This revision had several environmental advantages, including: elimination of the need to cross Clark Brook to access the building; reduction of the building's land disturbance by approximately .7 acres; and reduction in proposed clearing within a 50' buffer to two perennial streams from 12,400 square feet to only 4,250 square feet.

Revision 2. Overhead Electric Transmission Interconnect. (Note: This change was reviewed and approved by the SEC during the adjudicative phase of this docket.) The overhead line from the Project to Route 25 was originally proposed to run north along Groton Hollow Road. During the adjudicative phase of the SEC proceedings, Groton Wind revised this route in response to concerns expressed by a few residents of Groton Hollow Road and the New Hampshire Electric Cooperative (regarding its lack of

[5] The proposed switch yard was to be enclosed within a fenced area or pole-mounted, and included "switching equipment, protective relay and control equipment, transfer trip equipment, disturbance analyzer equipment, transducers, Remote Terminal Unit, and telemetry equipment, and meters." Application at 30.

complete easement documentation). *See* Second Supplemental Prefiled Testimony of Edward J. Cherian (Nov. 19, 2010) at 3. The revised route for the interconnection line from the Project to Route 25 runs along private property and is approximately 1.24 miles. *Id.* This reduced the length of the originally proposed overhead line to Route 25 by nearly 1.5 miles. *Id.* The Certificate (at pages 1-2) reflects the fact that the SEC has already considered and approved this revision.

Revision 3. East Ridge Overhead Electric Collector Line. An adjustment to the overhead transmission line from turbine E2 to the O&M building shortened the proposed route and therefore decreased the amount of clearing on East Ridge.

Revision 4. East Ridge Access Road. The access road and overhead electric line on the East Ridge of the Project was revised to eliminate separate access roads to turbines E4 and E5, and to turbines E2 and E3. The revision results in a single road which reduces the length of access roadways for these turbines. Turbines E2 and E3 were relocated slightly as indicated in the attached map showing the proposed and as-built locations of the wind turbines. *See* Attachment 3. The new location of turbine E3 and the revised roadway layout reduced the overall Project footprint in this area but increased clearing within a vernal pool and its buffer. Changes in the access road around turbine E6 reduced impacts to a wetland.

Revision 5. Groton Hollow Road from Sta. 168+ to 174+00. (Note: This change was reviewed and approved by the SEC during the adjudicative phase of this docket.) Approximately 600 linear feet of Groton Hollow Road was realigned to avoid an archeologically sensitive area. This change was presented to the SEC during the adjudicative phase of the proceedings. *See* Supplemental Prefiled Testimony of Michael

J. Leo (Oct. 12, 2010) at 2. The change did not result in any additional disturbance area and did not change previously assessed wetland impacts.

Revision 6. Turbine W2 Elevation Change. The elevation of turbine W2 was lowered approximately 9 feet to ensure that the base would be on bedrock. This required a minor change in the profile of a short segment of the access road which resulted in an additional impact (38 linear feet/80 square feet) to an intermittent stream.

Revision 7. West Ridge Overhead Electric Transmission Line. Approximately 700 linear feet of overhead transmission line was relocated east of turbine W1. This moved the line further away from the turbine location and completely eliminated a clearing impact of 830 square feet to a wetland.

Revision 8. Stone Mattress Revisions. Adjustments to several stone mattress locations were made. Stone mattresses at roadway low points were replaced with culverts and were removed from areas of little flow. Stone mattress or culvert changes do not affect overall runoff (pre vs. post) discharge rates from the site. Only one of these changes resulted in wetland impact.

III. Standard of Review.

The Committee has employed the following standard when reviewing a motion to amend a certificate: The Committee must determine whether its original findings under RSA 162-H:16 are affected by the amendments. If the changes "do not undermine the initial findings of the Committee, then that would favor granting the Motion. And, if the proposed amendments are determined…to be reasonable, that would also favor the granting of the Motion to Amend." SEC Docket No. 2011-01, Berlin Station, LLC, *Motion of Berlin Station, LLC for Amendment of the Certificate of Site and Facility,*

Transcript of Public Meeting held January 10, 2013 ("Tr.") at 73-74. For the reasons set forth below and in the attached prefiled testimony of Peter Walker, the above-referenced certificate amendment standard is met in this case.

With respect to the issues of aesthetics, historic sites, air and water quality, natural environment, and public health and safety, the Committee made no specific findings regarding the impacts of the O&M facility on a standalone basis. However, because the O&M building was constructed in the same general vicinity within the Project area as originally proposed, it is reasonable to conclude that the Committee's original determinations are not undermined by the revised location. The Committee noted that the location of the proposed O&M building was "on a lightly used private road." Decision at 48. Groton Wind's aesthetics expert, John Hecklau, testified that this location "is well removed from any sensitive aesthetic resources." Prefiled Testimony of John Hecklau (March 2010) at 15. The Visual Impact Analysis ("VIA") submitted with Groton Wind's application stated that the O&M building would be "well screened from Route 25 and other nearby public vantage points by surrounding hills and forest...Consequently, the O&M building should not be visible to a significant number of viewers..." Application, Appendix 24 at 9. For these reasons, the VIA did not evaluate the O&M building further. *Id.*

The O&M building was constructed much the same as the originally-proposed facility, but its parking area was reduced in size from 13 spaces to 5, and the gravel storage area was reduced by approximately .7 acres. *See* Prefiled Testimony of Peter J. Walker, attached. In view of the foregoing and given the benefits of the revised location

of the O&M building noted in Mr. Walker's prefiled testimony, this change does not undermine the Committee's initial findings.

As Attachment 3 indicates, the majority (i.e. 16 of 24) of the wind turbines were constructed within inches of their proposed locations. The as-built locations of the other turbines are in very close proximity to the locations presented in Groton Wind's application. As such, the Committee's initial findings are not undermined by these slight changes.

IV. Prefiled Testimony of Peter Walker.

In support of this Motion, Groton Wind is submitting Prefiled Testimony of Peter Walker who was the Project Manager for VHB's work on the Groton Wind Project. *See* Attachment 4 submitted herewith. Mr. Walker's testimony supports a finding that the site plan revisions do not undermine the Committee's initial findings and that they are reasonable.

V. Parties' Positions on this Motion

Pursuant to SEC Rule Site 202.14 (d) the first undersigned counsel made a good faith effort to obtain concurrence with the relief sought herein from the parties. At the time of the finalizing of this Motion, the following parties had indicated their positions: Mario Rampino objects to the extent the motion seeks waiver of the application and hearing requirement under RSA 162-H:6-a, 7 & 10; the Department of Safety and the Office of the Fire Marshal do not concur; the Buttolph/Lewis/Spring Intervenor Group strongly objects to the motion; and Counsel for the Public, Senior Assistant Attorney General Peter Roth, does not concur with the relief sought and will object to it.

WHEREFORE, Groton Wind respectfully requests that in the event that the Committee determines that the Committee's approval of the above-described minor site plan revisions is needed that the Committee:

A. Amend the Certificate to incorporate the changes described above and in the attachments submitted herewith; and

B. Grant such further relief as it deems appropriate.

Respectfully submitted,
Groton Wind, LLC
By Its Attorneys

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Dated: December 4, 2013

Certificate of Service

I hereby certify that, on this 4th day of December, 2013, a copy of the foregoing Motion was sent by electronic mail or U.S. mail, postage prepaid, to the persons named on the service list for this docket.

Susan S. Geiger

1083020_1

Transportation
Land Development
Environmental
Services

VHB *Vanasse Hangen Brustlin, Inc.*

VIA HAND DELIVERY
November 10, 2011

Ref: 52036.00

Rene Pelletier
Assistant Director, Water Division
NH Department of Environmental Services
P.O. Box 95
29 Hazen Drive
Concord, NH 03302-0095

Re: Groton Wind Farm, Revised Site Plans
SEC Docket No. 2010-01
Wetlands File No. 2010-00745
Alteration of Terrain Permit No. 100325-033

Dear Mr. Pelletier:

On behalf of our client, Groton Wind, LLC, Vanasse Hangen Brustlin, Inc. (VHB) is pleased to submit the enclosed revised plans for the Groton Wind Farm. These plans are "Issued for Construction" and are dated October 28, 2011.

This submission is made in accordance with the NH Site Evaluation Committee's *Order and Certificate of Site and Facility with Conditions*, dated May 6, 2011, including Condition 2 of the *Wetlands Bureau Final Decision* and Condition 2 of the *Alteration of Terrain (AoT) Bureau Final Decision.*

Included with this submission please find the following materials:

- Site Plans, Groton Wind Farm dated October 28, 2011, Issued for Construction. (one copy full sized plans, one copy 11"x17" plans and one disk with PDF copy of Site Plans).
- A figure entitled *"Project Revisions"* showing eight minor changes to the project plans relative to the permitted plan set dated July 9, 2010.
- Updated Table: *"Total Impacts to Aquatic Resources"* from Wetland Permit Application
- Table: *"Summary of Impacts to Aquatic Resources"*
- Drainage Report: Addendum No. 1 (October 2011)

The Site Plans have been updated to show additional detail required for construction. In addition, eight revisions have been made to Site Plans relative to the July 9, 2010 plan set (i.e., the "Permitted Plans") as described below.

The net result of these changes is to reduce the overall footprint of the project, as defined by the limits of grading, from 115.6 acres to 103.6 acres, a reduction of about 12 acres.

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Bedford, NH 03110-6532
603 644 0888
FAX 603 644 2385
www.vhb.com

Direct wetland and stream impacts have increased, but only by a negligible amount - about 280 sq ft – from 71,680 sq ft to 71,960 sq ft. (See the enclosed impact tables.)

Each of the eight revisions is highlighted in the enclosed plan set and is further described below.

Revision 1. Operations and Maintenance Facility (Drawing C-3.1)
The proposed Operations & Maintenance (O&M) Facility has been revised. The O&M facility was moved from the east side of Clark Brook to the west side of Groton Hollow Road to a location where a fenced in switch yard was previously proposed. In addition, the total area for the O&M building and adjacent storage area has been reduced. Refer to Drawing C-3.1 for a plan showing the revised layout of the O&M area and to the enclosed Drainage Report Addendum for updated drainage calculations. This change has several environmental advantages:

- Eliminates the need for crossing Clark Brook to access the O&M area,
- Reduces the required land disturbance for the O&M area by approximately 0.7 acre, and
- Pursuant to AoT Condition 19, reduces the proposed clearing within a 50 ft buffer to two perennial streams (i.e., Clark Brook and Stream OM100) by approximately 8,150 sq ft (July 9, 2010 plans show approximately 12,400 sq ft of clearing within the buffer, while the revised plans require only 4,250 sq ft).

During the field review of the revised O&M location for any additional wetlands, a wetland was identified (GH47) that had been previously covered by debris. This wetland area will be impacted by the proposed alignment of Groton Hollow Road and increases the wetland impact at this location by 500 sq ft (See Impact #128, Drawing C-3.1).

The stormwater management design for the relocated O&M Facility is based on the stormwater BMPs that were proposed for the original location and approved by the NHDES through the SEC process. Stormwater treatment will continue to be provided by a filtration basin (with sediment forebay) as previously proposed. The filtration basin will also serve to help maintain peak runoff flow rates from the O&M building area.

Revision 2. Overhead Electric Transmission Interconnect (Drawing C-2.9, C-2.10 and C-3.1)
The overhead electrical transmission interconnect is now shown to run cross-country from the O&M Facility to NH 25. Refer to Drawings C-2.9, C-2.10 and C-3.1 for location of overhead transmission line from the O&M Facility to NH 25. As you know, the electricity from the wind farm will be transmitted to the grid along existing right-of-way except for a small portion from the site to existing NH Electric Cooperative poles that run along NH 25. Previously, the overhead line had been proposed to run north along Groton Hollow Road, but is now planned to run cross-country to NH 25 along property owned by Green Acre Woodlands, Patricia and Frederick Langford and Christopher and Therese Sheehan. This change was presented and approved as part of

the SEC proceedings and was proposed to decrease the impact along the residential section of Groton Hollow Road.

There are no direct wetland impacts associated with this change. However, clearing for the line will result in three clearing impacts of 3,050 sq ft to wetlands IC-1; IC-6 and IC-8 (Impacts #129-131).

Revision 3. East Ridge Overhead Electric Collector Line (Drawings C-2.6, C-5.1, C-5.2, C-5.3 and C-5.4)
A short segment of the overhead transmission line heading from Turbine E2 to the O&M Facility has been adjusted. This revision shortens the route and therefore decreases the amount of clearing on the East Ridge.

Revision 4. East Ridge Access Road (Drawings C-2.6, C-5.1, C-5.2, C-5.3 and C-5.4)
The access road and overhead electric line on the East Ridge has been revised. Previously, there were separate access roads to Turbines E4 and E5 and to Turbines E2 and E3. The access for the East Ridge has been combined into a single road that will reduce the length of road required to access these turbines. Turbines E2 and E3 were relocated very slightly as part of these changes. The new location of Turbine E3 and the revised road layout reduces the overall project footprint in this area, but does increase clearing within Vernal Pool ERVP1 and its buffer from 10,320 sq ft to 20,200 sq ft (See Impact #80, Sheet C-5.3). Other changes to the access road in the vicinity of Turbine E6 have resulted in a reduction in impacts to Wetland ER38 from 820 sq ft to 470 sq ft (See Impact # 73, Sheet C-5.1).

Revision 5. Groton Hollow Road from Sta. 168+00 to 174+00 (Drawings C-3.8 and C-3.9)
Approximately 600 linear feet of Groton Hollow Road has been realigned to avoid an archaeologically-sensitive area. The location of Groton Hollow Road from Sta. 168+00 to Sta. 174+00 has been modified to go around the west side of an existing old stone foundation. The road had been previously aligned around the east side of the old stone foundation. This change was presented to SEC during review their process. This change does not result in any additional disturbance area and does not require any change in wetland impacts.

Revision 6. Turbine W2 Elevation Change (Drawing C-7.4)
The elevation of Turbine W2 has been lowered approximately 9 feet to ensure the turbine base foundation will be on bedrock. This change requires a minor change in the profile of a short segment of the access road which result in additional impact of 80 sq ft (38 linear feet) to Intermittent Stream WR106B (See Impact #104, Sheet C-7.4).

Revision 7. West Ridge Overhead Electric Transmission Line (Drawing C-7.3)
Approximately 700 linear feet of overhead transmission line has been relocated east of Turbine W1 to move the overhead line further away from the turbine location. This change in the location of the overhead line completely removes the previous clearing impact of 830 sq ft to Wetland WR5 (Impact #122 is now 0 sq ft).

Revision 8. Stone Mattress Revisions
Adjustments to several stone mattress locations have been made. Stone mattresses at roadway low points have been replaced with culverts and stone mattresses have been removed in areas where very little flow was being conveyed. Attached is updated culvert spreadsheet indicating location and design flow for each culvert on project site. Stone mattress or culvert changes do not affect overall runoff (pre vs. post) discharge rates from the site. The concept of maintaining existing flow patterns in the post development condition has been retained and only one of these changes resulted in an additional wetland impact (sees Impact #120, Wetland NWR11, Drawing C-9.2). Stormwater calculations are also attached for the revised Operations and Maintenance area.

Relative to the potential effects on site drainage, none of the revisions significantly alter the Time of Concentration (Tc), Curve Number (CN) or size of the Subcatchment Areas previously analyzed. When combined with the fact that changes reduce the project footprint by about 12 acres, we determined that these changes have no significant impact on peak runoff rates, and the conclusions in our original Drainage Report remain valid. We have, however, included an addendum to the Drainage Report to update information relative to the Operation and Maintenance Facility.

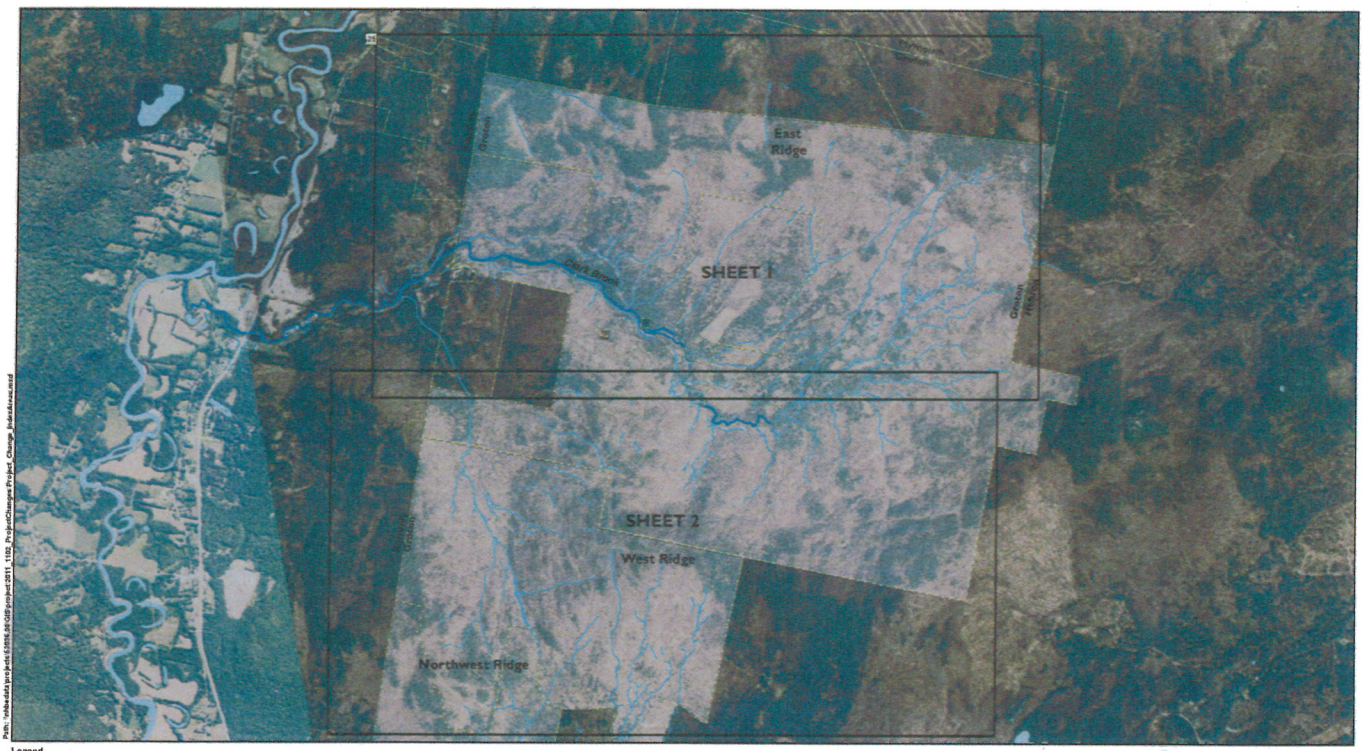
As you know, construction of the site has commenced with clearing operations underway as of last week. Iberdrola Renewables is therefore anxious to resolve any questions the Department might have regarding these plan revisions. We have already met with Craig Rennie to review these issues, and I will be contacting you to arrange for a meeting to review the project in the near future. In the meantime, as always, please don't hesitate to contact me if you have any questions or comments regarding the Groton Wind Farm project.

Very truly yours,

VANASSE HANGEN BRUSTLIN, INC.

Peter J. Walker
Director, Environmental Services

cc: Craig Rennie, NHDES
Doren Emmett, Iberdrola
Ed Cherian, Iberdrola
Jebby Varughese, Iberdrola
Mike Leo, VHB
Nancy Rendall, VHB



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Legend

Property Boundary

Project Study Area - Shaded in White

River/Stream (based on USGS, Aerial Survey, Field Delineation)

0 2,000 4,000 Feet

Vanasse Hangen Brustlin, Inc.

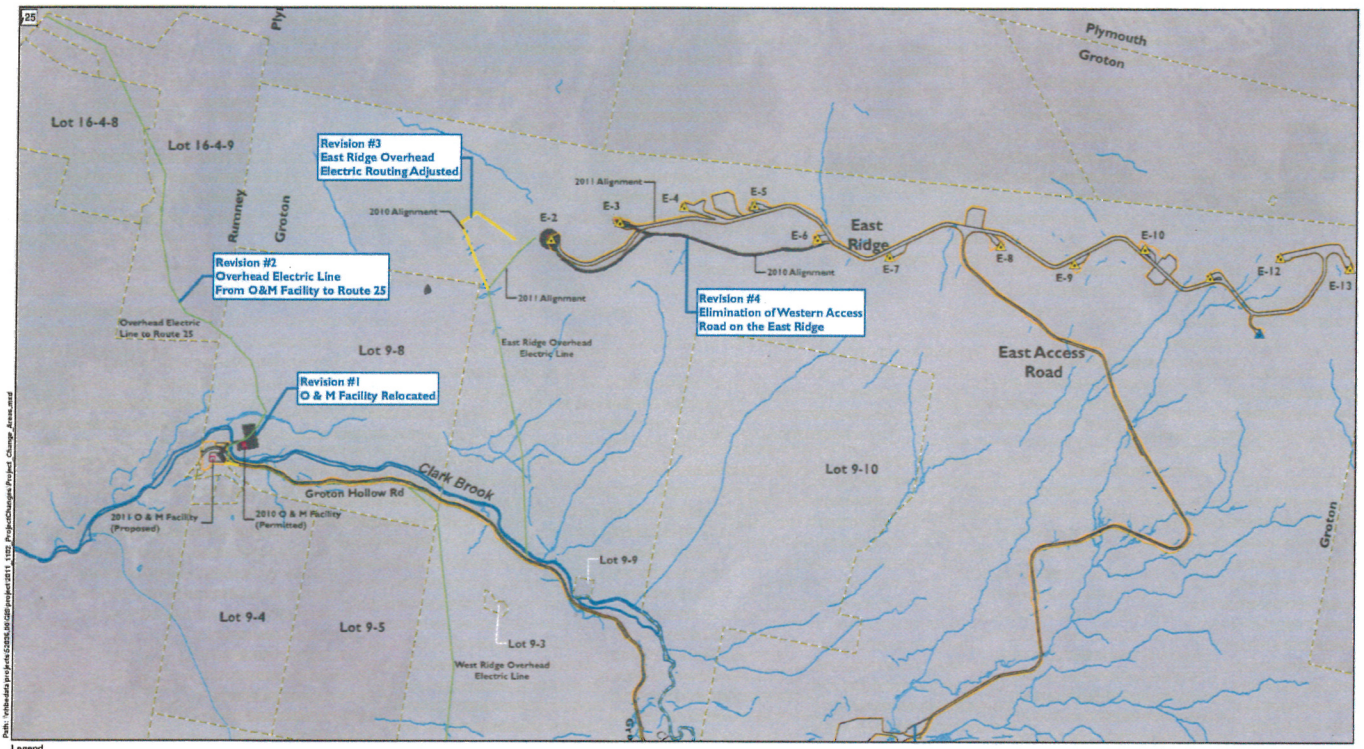
Project Revisions

Index Sheet

Groton Wind, LLC

Groton Hollow Road
Groton, NH

IBERDROLA RENEWABLES



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Legend

- Propsed Turbine
- Proposed Met Tower

October 2011 Construction Layout

- Proposed Building
- Proposed Gravel Areas
- Proposed Overhead Wire
- Proposed Clearing Line

Design Changes from the July 2010 Road Alignment

- July 2010 Overhead Line Layout
- July 2010 O & M Building Facility
- July 2010 Edge of Gravel

- Property Boundary
- Project Study Area - Shaded in White
- River/Stream (based on USGS, Aerial Survey, Field Delineation)

Note:
The intent of this figure is to show changes from the July 9, 2010 Site Plan to October 28, 2011 Site Plans for the Groton Wind Farm.

2010 aerial photography provided by NHDOT.

0 1,000 2,000 Feet

Vanasse Hangen Brustlin, Inc.

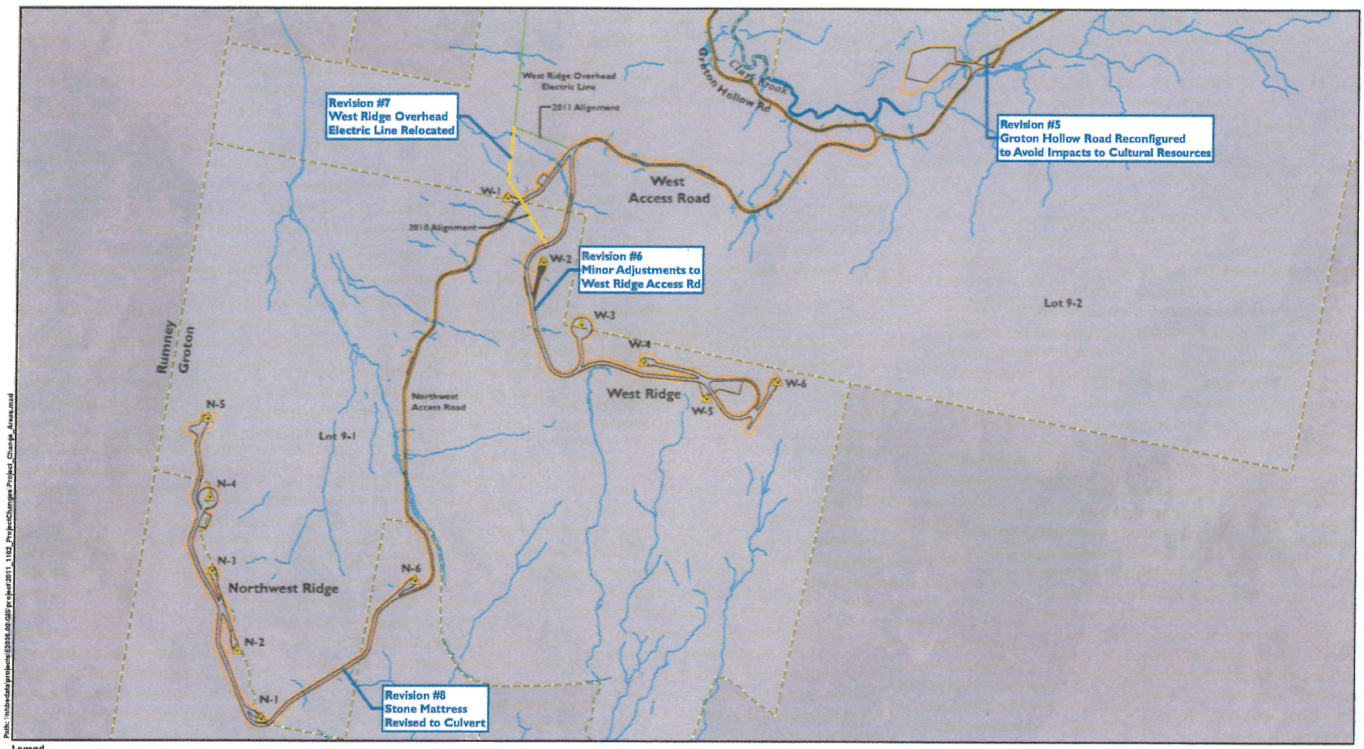
Project Revisions

Sheet 1 of 2

Groton Wind, LLC

Groton Hollow Road
Groton, NH

IBERDROLA RENEWABLES



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Legend

- Proposed Turbine
- Proposed Met Tower

October 2011 Construction Layout

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- Proposed Overhead Wire
- Proposed Clearing Line

Design Changes from the July 2010 Road Alignment

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2010 aerial photography provided by NHDOT.

0 1,000 2,000 Feet

Vanasse Hangen Brustlin, Inc.

Project Revisions

Sheet 2 of 2

Groton Wind, LLC

Groton Hollow Road
Groton, NH

IBERDROLA RENEWABLES

Groton Wind Farm - Summary of Impacts, November 2011

Type of Impact	2010 Impacts (SF)	2011 Impacts (SF)	Net Change Area	2010 (LF)	2011 (LF)	Net Change Linear
Direct Impacts						
Wetland Impacts - Groton Hollow Road	7,050	7,550	500	NA	NA	NA
Wetland Impacts - East Ridge	24,270	23,920	-350	NA	NA	NA
Wetland Impacts - West Ridge	7,760	7,760	0	NA	NA	NA
Wetland Impacts - Northwest Ridge	6,310	6,360	50	NA	NA	NA
Subtotal Wetland Impacts	45,390	45,590	200	NA	NA	NA
Intermittent Stream Impacts - GHR	5,290	5,290	0	1,917	1,917	0
Intermittent Stream Impacts - New Culverts	8,330	8,410	80	2,742	2,780	38
Subtotal Intermittent Stream Impacts	13,620	13,700	80	4,659	4,697	38
Perennial Stream Impacts - GHR	2,160	2,160	0	179	179	0
Perennial Stream Impacts - New Culverts	10,510	10,510	0	715	715	0
Subtotal Perennial Stream Impacts	12,670	12,670	0	894	894	0
TOTAL DIRECT JURISDICTIONAL IMPACTS	**71,680**	**71,960**	**280**	**5,553**	**5,591**	**38**
Indirect Impacts						
Wetland Clearing Impacts - Turbines	12,790	12,790	0	NA	NA	NA
Wetland Clearing Impacts - Overhead Lines	3,740	3,740	0	NA	NA	NA
Upland Buffer Clearing Vernal Pools	31,610	41,490	9880	NA	NA	NA
TOTAL INDIRECT IMPACTS	**48,140**	**58,020**	**9,880**			

Total Impacts to Aquatic Resources
(Includes VP Upland Buffer Impacts)

November 2011 Submittal

Impact Area ID[1]	Wetland ID	NWI Code	Crossing Length	2011 Impact Area (SF)[2]	2010 Permitted Impact Area (SF)[3]	Type of Resource	Type of Impact	Reason for Change
1	GH-128	R3RB1H	10	80	80	Perennial	Upgrade Culvert	NA
2	GH-127A	R4SB3E	108	220	220	Intermittent	Upgrade Culvert	NA
3	GH-127B	R4SB3E	16	50	50	Intermittent	Upgrade Culvert	NA
4	GH-125	R4SB3C	80	280	280	Intermittent	Upgrade Culvert	NA
5	GH-124A	R4SB3E	45	90	90	Intermittent	Upgrade Culvert	NA
6	GH-124B	R4SB3E	10	20	20	Intermittent	Upgrade Culvert	NA
7	GH-122	R4SB3C	330	780	780	Intermittent	Upgrade Culvert	NA
8	GH-120	R4SB3C	83	250	250	Intermittent	Upgrade Culvert	NA
9	GH-119	R2UB1H	11	80	80	Perennial	Upgrade Culvert	NA
10	GH-35	PEM1E	0	1,040	1,040	Wetland	Road Widening	NA
11	GH-38	PFO1C	0	40	40	Wetland	Road Widening	NA
12	GH-31	PEM2E	0	70	70	Wetland	Road Widening	NA
13	GH-30	PFO1C	0	960	960	Wetland	Road Widening	NA
14	GH-118	R3UB1H	12	140	140	Perennial	Upgrade Culvert	NA
15	GH-26	PEM1E	0	70	70	Wetland	Road Widening	NA
16	GH-25	PFO1C	0	170	170	Wetland	Road Widening	NA
16A	GH-113	R4SB3C	15	30	30	Intermittent	Upgrade Culvert	NA
17	GH-23	PEM2C	0	520	520	Wetland	Road Widening	NA
18	GH-112A	R4SB3E	21	100	100	Intermittent	Upgrade Culvert	NA
19	GH-112B	R4SB3E	9	80	80	Intermittent	Upgrade Culvert	NA
20	GH-21	PEM1C	0	450	450	Wetland	Road Widening	NA
21	GH-22	PEM1E	0	50	50	Wetland	Road Widening	NA
22	GH-20	PSS1F	0	570	570	Wetland	Road Widening	NA
23	GH-110A	R3UB1H	36	320	320	Perennial	Upgrade Culvert	NA
24	GH-110B	R2UB1H	23	320	320	Perennial	Upgrade Culvert	NA
25	GH-109	R4SB5C	661	1,980	1,980	Intermittent	Upgrade Culvert	NA
26	WA-1	PFO1B	0	4,180	4,180	Wetland	West Access Road	NA
27	GH-108	R3UB1H	15	190	190	Perennial	Upgrade Culvert	NA
28	GH-14	PEM1C	0	150	150	Wetland	Road Widening	NA
29	GH-107	R4SB5G	16	110	110	Intermittent	Upgrade Culvert	NA
30	GH-106 A	R4SB5E	230	710	710	Intermittent	Upgrade Culvert	NA
31	GH-106 B	R4SB5E	108	220	220	Intermittent	Upgrade Culvert	NA
32	GH-105	R3RB2H	12	100	100	Perennial	Upgrade Culvert	NA
33	GH-10	PFO1E	0	260	260	Wetland	Road Widening	NA
34	GH-104	R4SB5C	185	370	370	Intermittent	Upgrade Culvert	NA
35	GH-8	PFO1E	0	420	420	Wetland	Road Widening	NA
36	GH-7	PSS1C	0	900	900	Wetland	Road Widening	NA
37A	GH103C	R2UB1H	20	320	320	Perennial	Upgrade Bridge[4]	NA
37B	GH-4	PSS1C	0	1,380	1,380	Wetland	Road Widening	NA
38	EA-103	R2UB1H	40	610	610	Perennial	Upgrade Culvert	NA
39	EA-6	PUBE	0	650	650	Wetland	East Access Road	NA
40	EA-104	R4SB5E	54	110	110	Intermittent	New Culvert	NA
41	EA-10	PFO1C	0	1,230	1,230	Wetland	East Access Road	NA
42	EA-105	R4SB3E	193	390	390	Intermittent	New Culvert	NA
43	EA-106	R4SB3E	95	190	190	Intermittent	New Culvert	NA
44	EA-107	R3UB1H	63	810	810	Perennial	New Culvert	NA
45	EA-16	PEM2E	0	80	80	Wetland	East Access Road	NA
46	EA-108	R3UB1H	40	350	350	Perennial	New Culvert	NA
47	EA-109	R4SB7F	54	160	160	Intermittent	New Culvert	NA
48	EA-110-B	R4SB7E	65	250	250	Intermittent	New Culvert	NA
49	EA-110-A	R4SB7E	16	130	130	Intermittent	New Culvert	NA
50	EA-17	PEM2E	0	320	320	Wetland	East Access Road	NA
51	EA-18	PFO1C	0	550	550	Wetland	East Access Road	NA
52	EA-111	R3UB1H	105	1,410	1,410	Perennial	New Culvert	NA
53	EA-19	PSS1C	0	690	690	Wetland	East Access Road	NA
54	EA-21	PSS1C	0	560	560	Wetland	East Access Road	NA
55	EA-22	PSS1E	0	3,210	3,210	Wetland	East Access Road	NA
56	EA-24	PSS1E	0	2,700	2,700	Wetland	East Access Road	NA
57	EA-114	R3RB2H	75	640	640	Perennial	New Culvert	NA
58	EA-25	PSS1B	0	2,840	2,840	Wetland	East Access Road	NA
59	EA-26	PFO1E	0	1,600	1,600	Wetland	East Access Road	NA
60	EA-116	R4SB5E	30	120	120	Intermittent	New Culvert	NA
61	EA-28	PSS1B	0	250	250	Wetland	East Access Road	NA
62	EA-117	R4SB5E	91	360	360	Intermittent	New Culvert	NA
63	EA-118	R4SB1E	91	720	720	Intermittent	New Culvert	NA
64	EA-119	R4SB3E	60	480	480	Intermittent	New Culvert	NA
65	EA-30	PSS1C	0	100	100	Wetland	East Access Road	NA
66	EA-120	R4SB2E	62	250	250	Intermittent	New Culvert	NA
67	EA-33	PSS1E	0	70	70	Wetland	East Access Road	NA
68	EA-122	R4SB7E	91	360	360	Intermittent	New Culvert	NA
69	ER-107 A	R4SB5E	159	480	480	Intermittent	New Culvert	NA
70	ER-33	PFO1E	0	210	210	Wetland	East Ridge Road	NA
71	ER-107 B	R4SB5E	73	150	150	Intermittent	New Culvert	NA
72	ER-35	PFO1E	0	1,040	1,040	Wetland	East Ridge Road	NA

Total Impacts to Aquatic Resources
(Includes VP Upland Buffer Impacts)

November 2011 Submittal

Impact Area ID[1]	Wetland ID	NWI Code	Crossing Length	2011 Impact Area (SF)[2]	2010 Permitted Impact Area (SF)[3]	Type of Resource	Type of Impact	Reason for Change
73	ER-38	PFO1E	0	470	820	Wetland	East Ridge Road[6]	Reduction of 350 sq ft due to reconfiguration of East Ridge Access Road
74	ER-39A	PFO1E	0	2,200	2,200	Wetland	East Ridge Road	NA
75	ER-39B	PFO1E	0	2,070	2,070	Wetland	Clearing for Turbine[5]	NA
76	ER-109	R4SB5F	56	220	220	Intermittent	New Culvert	NA
77	ER-42	PFO4E	0	1,370	1,370	Wetland	East Ridge Road	NA
80	ERVP1	NA	0	20,200	10,320	VP Buffer	Upland Buffer Clearing[6,7]	Minor relocation of Turbine E-3 in order to facilitate reduction in cut/fill slopes; VP Buffer clearing increases from 10,320 to 20,200
82	ER-21	PSS1E	0	1,060	1,060	Wetland	East Ridge Road	NA
83	ER-100	R4SB5E	75	170	170	Intermittent	New Culvert	NA
84	ER-101	R4SB3E	117	230	230	Intermittent	New Culvert	NA
85	ER-13	PFO1C	0	5,810	5,810	Clearing	Clearing for Turbine[5]	NA
86	ER-14	PFO1C	0	1,290	1,290	Clearing	Clearing for Turbine[5]	NA
87	ER-14	PEM1B	0	410	410	Wetland	East Ridge Road	NA
88	ER-102	R4SB5E	35	140	140	Intermittent	New Culvert	NA
89	ER-16	PFO4C	0	1,240	1,240	Wetland	Crane Pad	NA
90	ER-17	PFO4C	0	1,070	1,070	Wetland	Crane Pad	NA
91	ER-18	PSS1C	0	950	950	Clearing	Clearing for Turbine[5]	NA
92	WA-2	PSS1E	0	270	270	Wetland	West Access Road	NA
93	WR-100	R4SB2F	80	500	500	Intermittent	New Culvert	NA
94	WA-4	PSS1E	0	60	60	Wetland	West Access Road	NA
95	WR-101	R4SB5E	60	120	120	Intermittent	New Culvert	NA
96	WR-102	R2RB2H	52	830	830	Perennial	New Culvert	NA
97	WR-103	R4SB2C	171	490	490	Intermittent	New Culvert	NA
98	NWA-1	PSS1E	0	150	150	Wetland	West Access Road	NA
99	WR-104 A	R2UB1H	85	1,730	1,730	Perennial	New Culvert	NA
100	WR-104B	R2UB1H	85	1,010	1,010	Perennial	New Culvert	NA
101	WR-3	PSS1E	0	660	660	Wetland	West Ridge Road	NA
102	WR-4	PSS1E	0	310	310	Wetland	West Ridge Road	NA
103	WR-106A	R4SB3C	99	260	260	Intermittent	New Culvert	NA
104	WR-106B	R4SB3C	160	320	240	Intermittent	New Culvert[6]	Regrading required to ensure Turbine W-2 foundation is on bedrock increased impact to intermittent stream
105	ER-10	PFO1C	0	1,670	1,670	Wetland	Clearing for Turbine[5]	NA
106	WR-22	PFO1E	0	1,970	1,970	Wetland	West Ridge Road	NA
107	WR-21	PFO1E	0	960	960	Wetland	Clearing for Turbine[5]	NA
108	NWA-100	R4SB3C	87	170	170	Intermittent	New Culvert	NA
109	NWA-101	R4SB2F	71	140	140	Intermittent	New Culvert	NA
110	NWA-102	R3UB1H	80	1,280	1,280	Perennial	New Culvert	NA
111	WA-11A	PSS1A	0	160	160	Wetland	West Access Road	NA
112	NWA-103	R4SB2G	81	190	190	Intermittent	New Culvert	NA
113	NWA-105	R4SB1F	54	140	140	Intermittent	New Culvert	NA
114	NWA-106A	R4SB2F	70	140	140	Intermittent	New Culvert	NA
115	NWA-106B	R4SB2F	70	140	140	Intermittent	New Culvert	NA
116	NWA-104	R2UB3H	130	2,450	2,450	Perennial	New Culvert	NA
117	NWA-107	R4SB3C	115	230	230	Intermittent	New Culvert	NA
118	NWR-3	PFO1E	0	40	40	Wetland	Clearing for Turbine[5]	NA
119	NWR-8	PFO1E	0	5,500	5,500	Wetland	Northwest Access Road	NA
120	NWR-11	PFO1E	0	790	740	Wetland	Northwest Access Road[6]	Replaced stone mattress with culvert, required additional fill to obtain minimum cover over culvert
121	NWA-110	R4SB1E	75	220	220	Intermittent	New Culvert	NA
122	WR-5	PSS1C	0	0	0	Wetland	Clearing for Overhead Lines[5,6]	NA
123	NWA-2	PEM1E	0	70	70	Wetland	Northwest Access Road	NA
124	WR-1A	NA	0	21,290	21,290	VP Buffer	Upland Buffer Clearing	NA
125	OHW-2	PEM1E	0	690	690	Wetland	Clearing for Overhead Lines	NA
126	EA-123	R4SB5E	70	140	140	Intermittent	New Culvert[8]	NA
127	WR-108	R4SB2C	100	300	300	Intermittent	New Culvert[8]	NA
128	GH-47	PEM2C	0	500	0	Wetland	Groton Hollow Road[6]	Wetland discovered after permitting plans were completed.
129	IC-6	PFO1E/F	0	1,440	1,440	Wetland	Clearing for Overhead Lines[6]	Revised OHE Interconnect Alignment
130	IC-8	PFO1C	0	180	180	Wetland	Clearing for Overhead Lines[6]	Revised OHE Interconnect Alignment
131	IC-1	PSS1F	0	1,430	1,430	Wetland	Clearing for Overhead Lines[6]	Revised OHE Interconnect Alignment
				129,980	119,820			

Notes:

Shaded rows represent changes since July 2010.

1 See Impact IDs as shown on the project plans.

2 As shown on plans dated October 28, 2011, Issued for Construction.

3 As shown on plans dated July 9, 2010, Issued for Permitting.

4 Temporary impact to remove existing log bridge and replace with a 17.3-foot by 3.8-foot steel box that spans the stream and banks.

5 Includes temporary wetland impacts due to clearing within the 150-foot turning radius for the proposed turbines and clearing along the footprint for proposed overhead lines.

6 These impact areas were changed since July, 2010 in response to design changes and the revised location of the overhead line to NH Route 25.

7 This table includes two upland impacts for clearing in the 100-foot vernal pool buffer that total 41,490 square feet. Direct impacts are listed separately.

8 These impact areas were added to the plan set in July, 2010 in response to NHDES Comments.

Drainage Report: Addendum No. 01

Proposed Groton Wind Farm

Groton Hollow Road
Groton, New Hampshire

Prepared for **Groton Wind, LLC**
Concord, New Haampshire

Prepared by ***VHB***/**Vanasse Hangen Brustlin, Inc.**
Bedford, New Hampshire 03110

October 2011

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Summary

The following calculations are provided to supplement the Drainage Report for the Proposed Groton Wind Farm Project in Groton, New Hampshire. The updated calculations are associated with the following revisions that have been modified as part of the design and development of the project:

- Relocation of the proposed Operations & Maintenance Facility.
- Revised layout of the proposed overhead electric transmission interconnect line.
- Revised layout of the East Ridge overhead electric collector line.
- Revised layout of the East Ridge Access Road.
- Realignment of Groton Hollow Road (Sta. 168+00 to 174+00).
- Turbine W2 Elevation Change.
- Revised layout of the West Ridge overhead electric transmission line.
- Stone mattress revisions/adjustments.

The above changes help to reduce the overall footprint of the project from 115.6 acres to 103.6 acres (approximately 12 acres).

Storm Water Quantity Mitigation

A peak runoff rate comparison for existing and proposed conditions was included in the original Drainage Report for the project and concluded that the proposed project was not anticipated to significantly change the peak runoff rates for the study area. It should be noted that the changes result in a 12 acre reduction in the overall project footprint. The majority of which occur within Subcatchment Area 101 (refer to Figure 4 – Drainage Area Map (Proposed) in the original Drainage Report). Additionally, none of the revisions significantly alter the Time of Concentration (Tc), Curve Number (CN) or size of the Subcatchment Areas previously analyzed. As such, the changes did not require that the hydrologic calculations be recomputed. A copy of Table 4 (Peak Storm Water Runoff Rate Summary) from the Drainage Report is provided below:

Table 4:
Peak Storm Water Runoff Rate Summary

Discharge Point		Condition	Peak Flow for Given Storm (cfs) 2-yr	10-yr	50-yr
D1	Clark Brook	Existing	105.7	761.7	1583.8
		Proposed	105.7	762.0	1584.4
			0.0	0.3	0.6
D2	Halls Brook/box culvert under Route 25	Existing	25.5	327.4	763.8
		Proposed	25.5	327.3	763.5
			0.0	-0.1	-0.3
D3	Pond/96" CMP under Route 25	Existing	6.6	128.7	336.2
		Proposed	6.6	128.5	335.7
			0.0	-0.2	-0.5
D4	Unnamed Stream/66" RCP Culvert under Route 25	Existing	3.6	88.3	245.5
		Proposed	3.6	88.3	245.5
			0.0	0.0	0.0
D5	Unnamed Stream/11' wide bridge under Route 3A	Existing	26.5	280.9	632.7
		Proposed	26.5	280.9	632.7
			0.0	0.0	0.3
D6	Unnamed Stream/15' wide bridge under route 3A	Existing	29.5	220.6	458.8
		Proposed	29.5	220.6	458.8
			0.0	0.0	0.0
D7	Wise Brook	Existing	18.8	102.2	194.5
		Proposed	18.8	102.1	194.3
			0.0	-0.1	-0.2

Operations & Maintenance Facility

The O&M building was moved from the east side of Clark Brook to the west side of Groton Hollow Road to a location where a fenced in switch yard was previously proposed. In addition, the total area for the O&M building and adjacent storage area has been reduced. Refer to Drawing C-3.1 for a plan showing the revised layout of the O&M area. This change has several environmental advantages:

- Eliminates the need for crossing Clark Brook to access the O&M area,
- Reduces the required land disturbance for the O&M area by approximately 0.7 acre, and
- Pursuant to AoT Condition 19, reduces the proposed clearing within a 50 ft buffer to two perennial streams (i.e., Clark Brook and Stream OM100) by approximately 8,150 sq ft (July 9, 2010 plans show approximately 12,400 sq ft of clearing within the buffer, while the revised plans require only 4,250 sq ft).

The stormwater management design for the relocated O&M building is based on the stormwater BMP's that were proposed for the original location and approved by the NHDES through New Hampshire's SEC process. Stormwater treatment will continue to be provided by a filtration basin (with sediment forebay) as previously proposed. The filtration basin will also serve to help maintain peak runoff flow rates from the O&M building area.

Culvert Sizing Summary

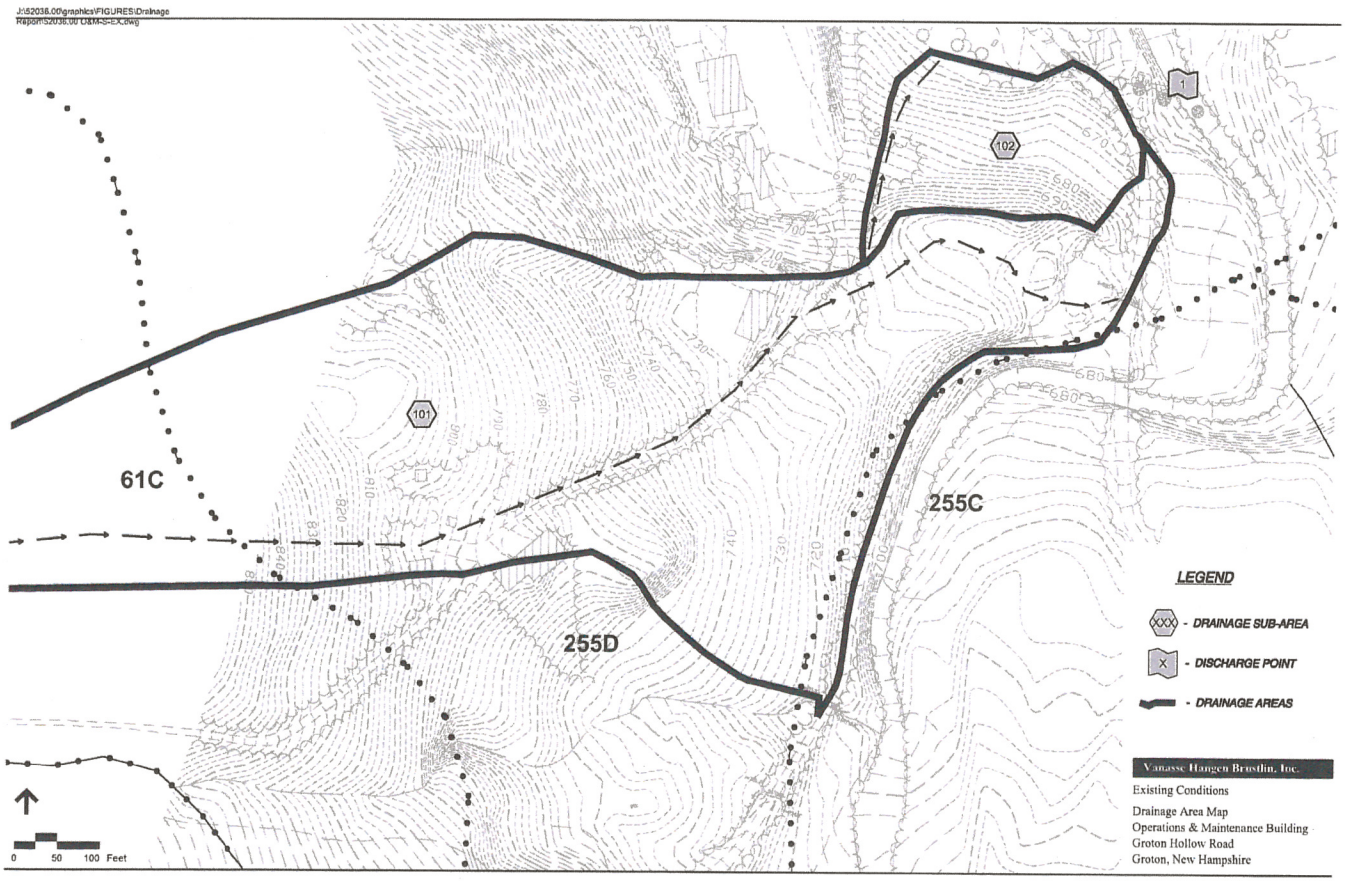
Several of the stone mattress locations have been adjusted. Stone mattresses at roadway low points have been replaced with culverts and stone mattresses have been removed in areas where very little flow was being conveyed. The Culvert Sizing Summary (included with the original Drainage Report) has been updated to reflect these, and other, minor changes and is included in this addendum.

VHB *Computations*

Project #: 52036.00
Project: Groton Wind Farm
Location: Groton, New Hampshire
Calculated by: B. Anderson Date: 11/1/11
Checked by: Date:
Title: Pre- vs Post-Development Peak Runoff Rate Comparison (O&M Building Area)

Operations & Maintenance Area

	Peak Runoff Rate (cfs)			
Condition	1-yr	2-yr	10-yr	50-yr
Existing	0.18	0.53	6.65	14.94
Proposed	0.18	0.28	4.26	14.80
Net Change	0.00	-0.25	-2.39	-0.14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101
61C
255C
255D
LEGEND
XXX - DRAINAGE SUB-AREA
X - DISCHARGE POINT
- DRAINAGE AREAS
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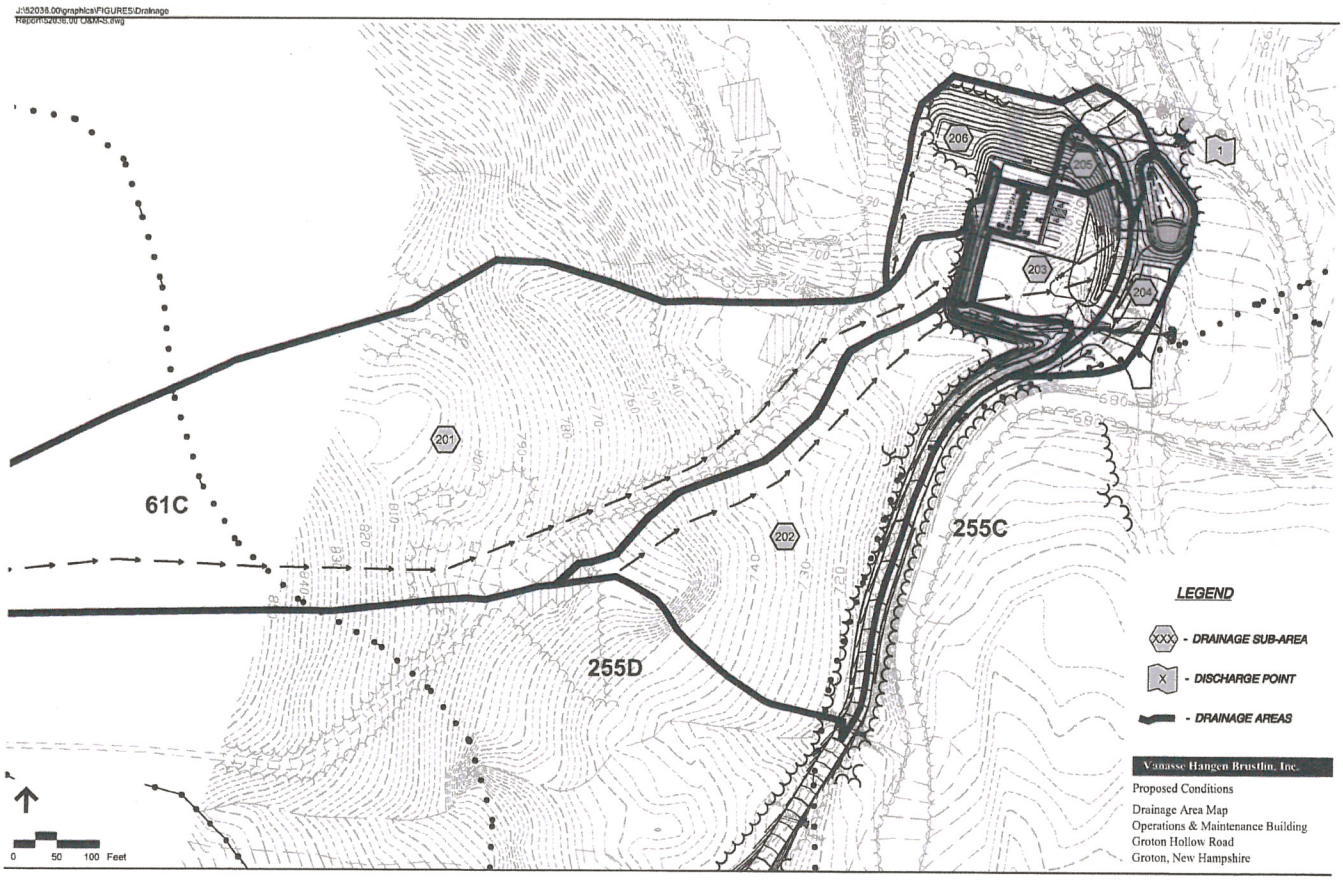
Vanasse Hangen Brustlin, Inc.
Existing Conditions
Drainage Area Map
Operations & Maintenance Building
Groton Hollow Road
Groton, New Hampshire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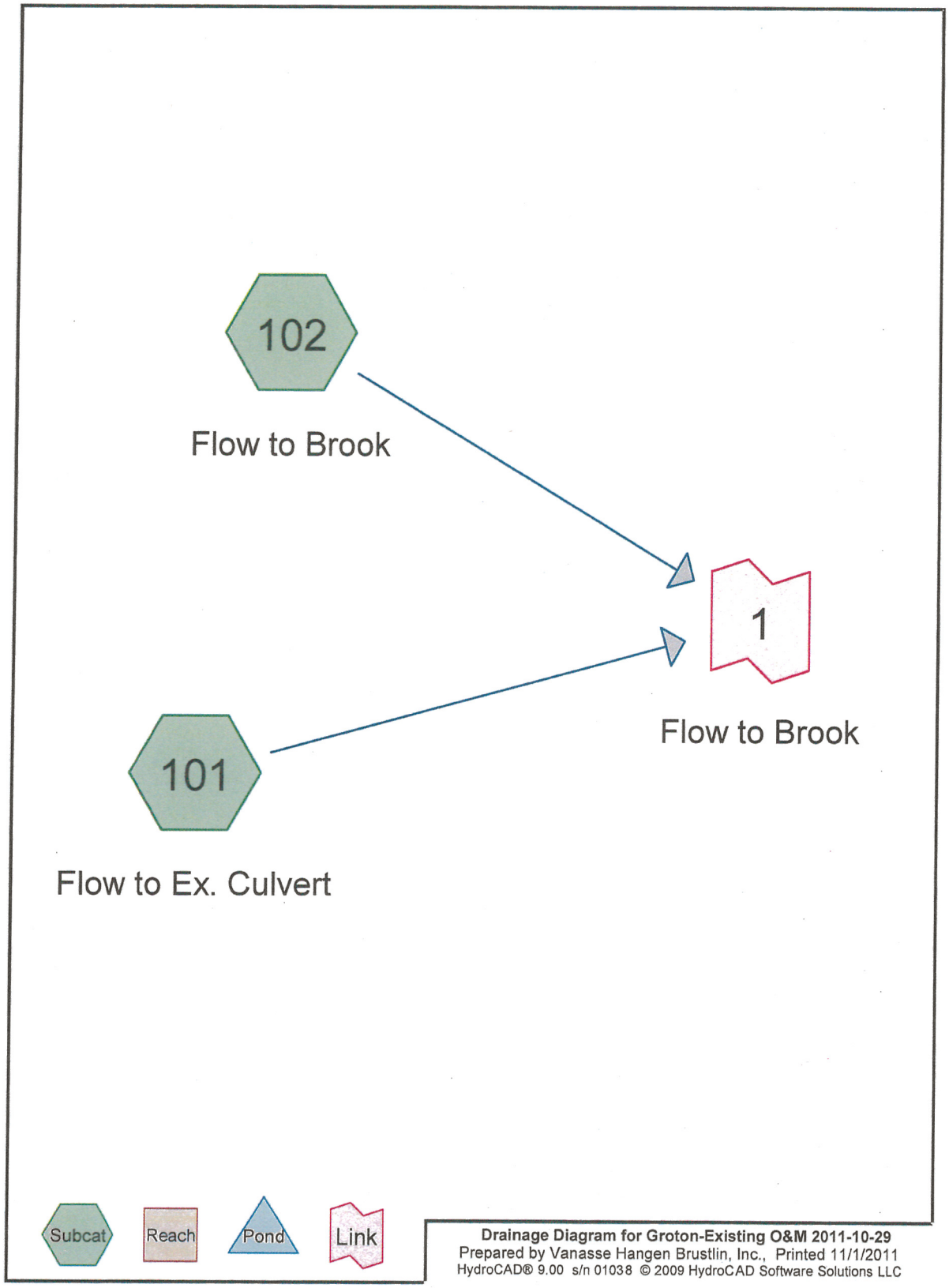
255D
LEGEND
- DRAINAGE SUB-AREA
- DISCHARGE POINT
- DRAINAGE AREAS
0 50 100 Feet
Vanasse Hangen Brustlin, Inc.
Proposed Conditions
Drainage Area Map
Operations & Maintenance Building
Groton Hollow Road
Groton, New Hampshire



Drainage Diagram for Groton-Existing O&M 2011-10-29
Prepared by Vanasse Hangen Brustlin, Inc., Printed 11/1/2011
HydroCAD® 9.00 s/n 01038 © 2009 HydroCAD Software Solutions LLC

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
1.046	55	Woods, Good, HSG B (102)
0.085	61	>75% Grass cover, Good, HSG B (102)
10.627	67	Based on CN for E101 (101)
0.064	85	Gravel roads, HSG B (102)
11.822		**TOTAL AREA**

Time span=5.00-30.00 hrs, dt=0.05 hrs, 501 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment 101: Flow to Ex. Culvert Runoff Area=10.627 ac 0.00% Impervious Runoff Depth=0.12"
Flow Length=1,690' Tc=28.5 min CN=67 Runoff=0.18 cfs 0.104 af

Subcatchment 102: Flow to Brook Runoff Area=1.195 ac 0.00% Impervious Runoff Depth=0.00"
Flow Length=240' Tc=18.2 min CN=57 Runoff=0.00 cfs 0.000 af

Link 1: Flow to Brook Inflow=0.18 cfs 0.104 af
Primary=0.18 cfs 0.104 af

Total Runoff Area = 11.822 ac Runoff Volume = 0.104 af Average Runoff Depth = 0.11"
100.00% Pervious = 11.822 ac 0.00% Impervious = 0.000 ac

Time span=5.00-30.00 hrs, dt=0.05 hrs, 501 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment 101: Flow to Ex. Culvert Runoff Area=10.627 ac 0.00% Impervious Runoff Depth=0.21"
Flow Length=1,690' Tc=28.5 min CN=67 Runoff=0.53 cfs 0.184 af

Subcatchment 102: Flow to Brook Runoff Area=1.195 ac 0.00% Impervious Runoff Depth=0.01"
Flow Length=240' Tc=18.2 min CN=57 Runoff=0.00 cfs 0.001 af

Link 1: Flow to Brook Inflow=0.53 cfs 0.186 af
Primary=0.53 cfs 0.186 af

Total Runoff Area = 11.822 ac Runoff Volume = 0.186 af Average Runoff Depth = 0.19"
100.00% Pervious = 11.822 ac 0.00% Impervious = 0.000 ac

Time span=5.00-30.00 hrs, dt=0.05 hrs, 501 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment 101: Flow to Ex. Culvert Runoff Area=10.627 ac 0.00% Impervious Runoff Depth=0.91"
Flow Length=1,690' Tc=28.5 min CN=67 Runoff=6.52 cfs 0.807 af

Subcatchment 102: Flow to Brook Runoff Area=1.195 ac 0.00% Impervious Runoff Depth=0.36"
Flow Length=240' Tc=18.2 min CN=57 Runoff=0.14 cfs 0.036 af

Link 1: Flow to Brook Inflow=6.65 cfs 0.843 af
Primary=6.65 cfs 0.843 af

Total Runoff Area = 11.822 ac Runoff Volume = 0.843 af Average Runoff Depth = 0.86"
100.00% Pervious = 11.822 ac 0.00% Impervious = 0.000 ac

Time span=5.00-30.00 hrs, dt=0.05 hrs, 501 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment 101: Flow to Ex. Culvert Runoff Area=10.627 ac 0.00% Impervious Runoff Depth=1.67"
Flow Length=1,690' Tc=28.5 min CN=67 Runoff=14.32 cfs 1.479 af

Subcatchment 102: Flow to Brook Runoff Area=1.195 ac 0.00% Impervious Runoff Depth=0.87"
Flow Length=240' Tc=18.2 min CN=57 Runoff=0.77 cfs 0.087 af

Link 1: Flow to Brook Inflow=14.94 cfs 1.566 af
Primary=14.94 cfs 1.566 af

Total Runoff Area = 11.822 ac Runoff Volume = 1.566 af Average Runoff Depth = 1.59"
100.00% Pervious = 11.822 ac 0.00% Impervious = 0.000 ac

Summary for Subcatchment 101: Flow to Ex. Culvert

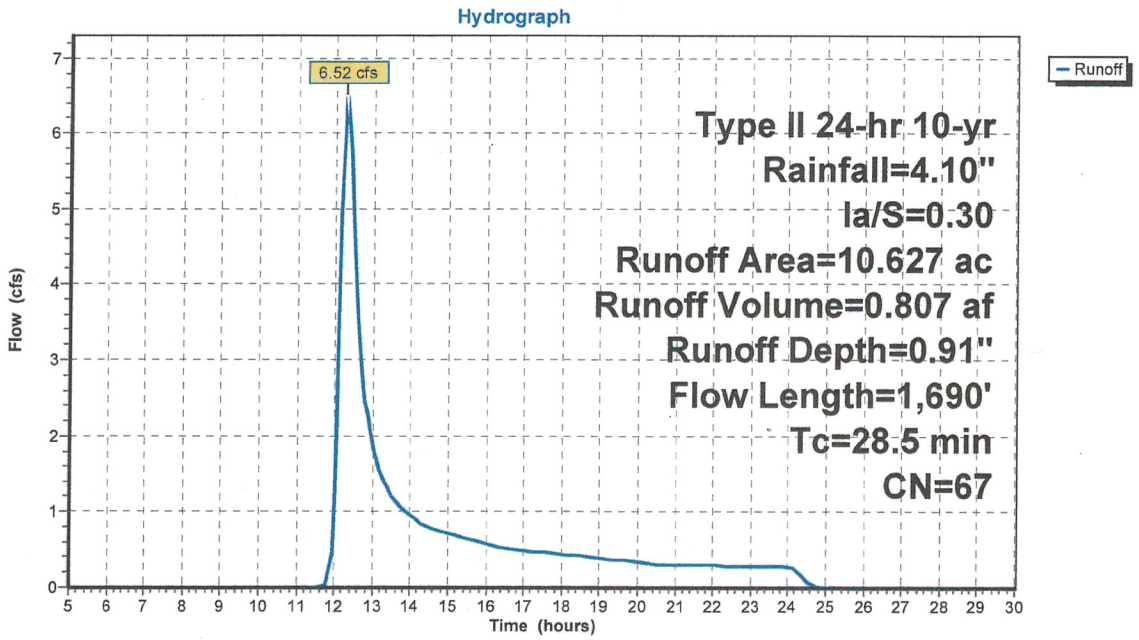
Runoff = 6.52 cfs @ 12.28 hrs, Volume= 0.807 af, Depth= 0.91"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr 10-yr Rainfall=4.10", Ia/S=0.30

	Area (ac)	CN	Description
*	10.627	67	Based on CN for E101
	10.627		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
18.5	100	0.1500	0.09		**Sheet Flow, Woods** Woods: Dense underbrush n= 0.800 P2= 2.60"
9.3	1,400	0.2500	2.50		**Shallow Concentrated Flow, Woods** Woodland Kv= 5.0 fps
0.7	190	0.1200	4.77	14.31	**Trap/Vee/Rect Channel Flow, Drainage Way** Bot.W=5.00' D=0.50' Z= 2.0 '/' Top.W=7.00' n= 0.060
28.5	1,690	Total			

Subcatchment 101: Flow to Ex. Culvert



Summary for Subcatchment 102: Flow to Brook

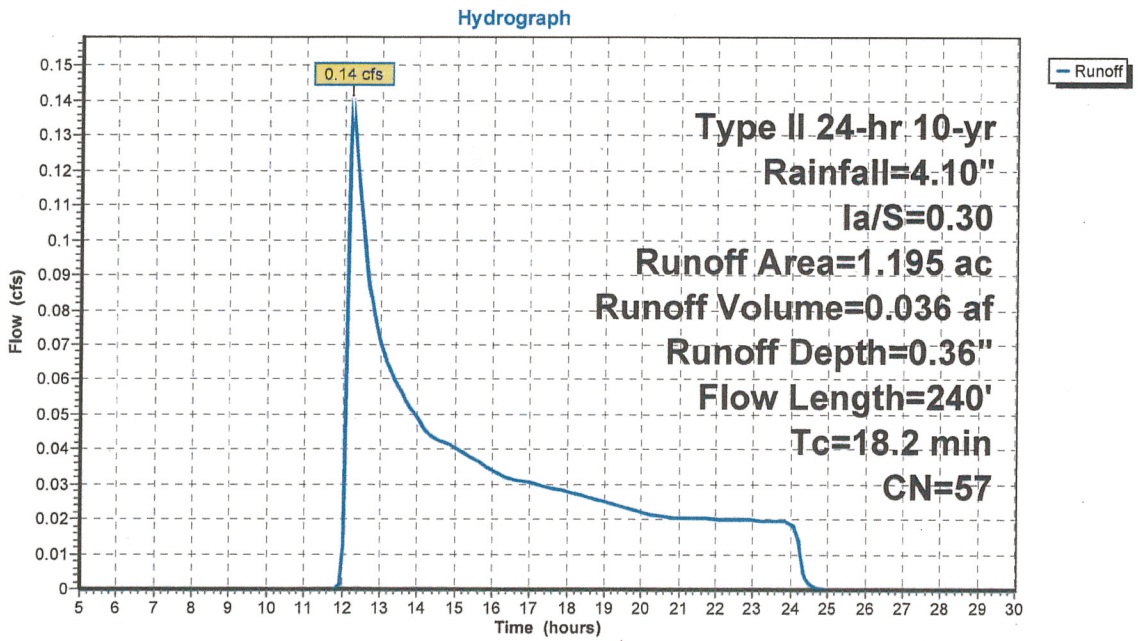
Runoff = 0.14 cfs @ 12.23 hrs, Volume= 0.036 af, Depth= 0.36"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr 10-yr Rainfall=4.10", Ia/S=0.30

Area (ac)	CN	Description
0.064	85	Gravel roads, HSG B
0.085	61	>75% Grass cover, Good, HSG B
1.046	55	Woods, Good, HSG B
1.195	57	Weighted Average
1.195		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
17.2	100	0.1800	0.10		**Sheet Flow,** Woods: Dense underbrush n= 0.800 P2= 2.60"
1.0	140	0.2000	2.24		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
18.2	240	Total			

Subcatchment 102: Flow to Brook

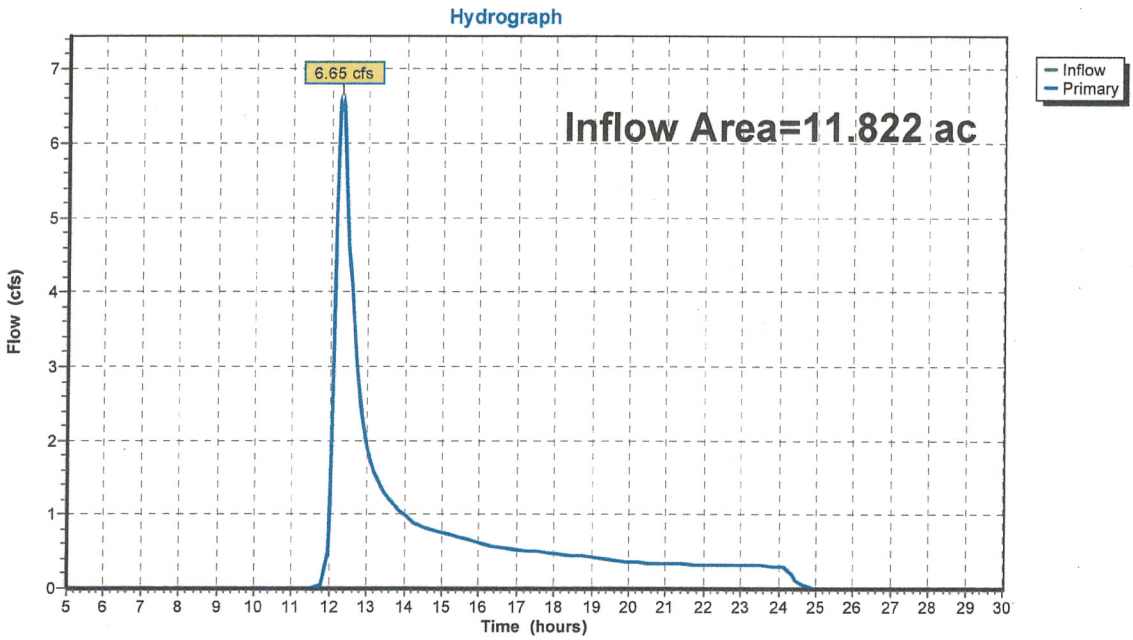


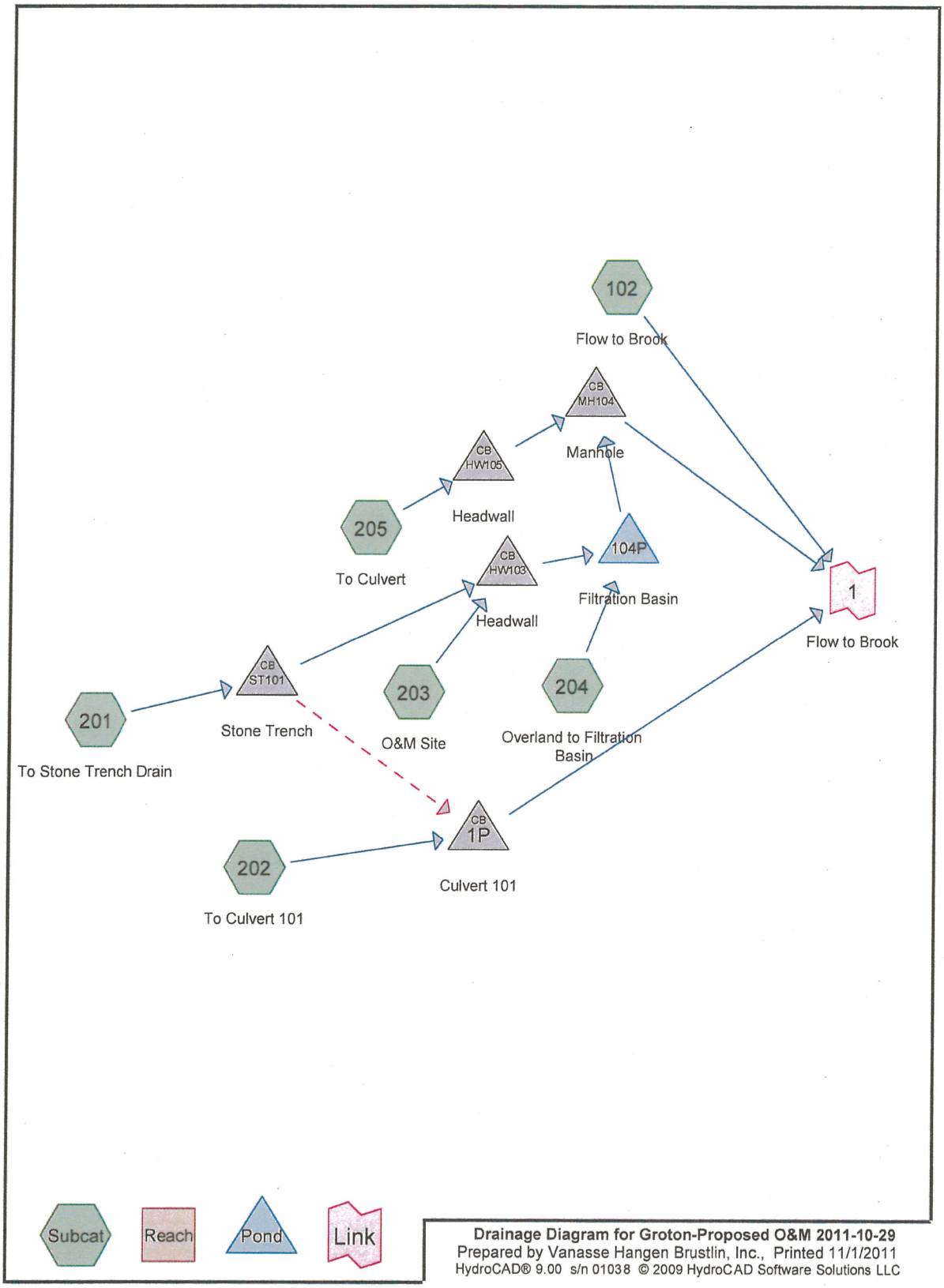
Summary for Link 1: Flow to Brook

Inflow Area = 11.822 ac, 0.00% Impervious, Inflow Depth = 0.86" for 10-yr event
Inflow = 6.65 cfs @ 12.28 hrs, Volume= 0.843 af
Primary = 6.65 cfs @ 12.28 hrs, Volume= 0.843 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 5.00-30.00 hrs, dt= 0.05 hrs

Link 1: Flow to Brook





Drainage Diagram for Groton-Proposed O&M 2011-10-29
Prepared by Vanasse Hangen Brustlin, Inc., Printed 11/1/2011
HydroCAD® 9.00 s/n 01038 © 2009 HydroCAD Software Solutions LLC

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
0.209	55	Woods, Good, HSG B (102)
0.891	61	>75% Grass cover, Good, HSG B (102, 203, 204, 205)
9.980	67	Based on CN for P101 (201, 202)
0.543	85	Gravel parking/roads, HSG B (203, 204, 205)
0.107	85	Gravel roads, HSG B (102)
0.092	98	Roof (201, 203)
11.822		**TOTAL AREA**

Time span=5.00-30.00 hrs, dt=0.05 hrs, 501 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment 102: Flow to Brook Runoff Area=0.768 ac 0.00% Impervious Runoff Depth=0.05"
Flow Length=206' Tc=18.0 min CN=63 Runoff=0.00 cfs 0.003 af

Subcatchment 201: To Stone Trench Drain Runoff Area=7.511 ac 0.61% Impervious Runoff Depth=0.12"
Flow Length=1,500' Tc=27.8 min CN=67 Runoff=0.13 cfs 0.074 af

Subcatchment 202: To Culvert 101 Runoff Area=2.515 ac 0.00% Impervious Runoff Depth=0.12"
Flow Length=635' Tc=22.5 min CN=67 Runoff=0.04 cfs 0.025 af

Subcatchment 203: O&M Site Runoff Area=0.546 ac 8.42% Impervious Runoff Depth=0.59"
Tc=6.0 min CN=80 Runoff=0.54 cfs 0.027 af

Subcatchment 204: Overland to Filtration Runoff Area=0.377 ac 0.00% Impervious Runoff Depth=0.26"
Tc=6.0 min CN=72 Runoff=0.09 cfs 0.008 af

Subcatchment 205: To Culvert Runoff Area=0.105 ac 0.00% Impervious Runoff Depth=0.12"
Tc=6.0 min CN=67 Runoff=0.00 cfs 0.001 af

Pond 1P: Culvert 101 Peak Elev=682.09' Inflow=0.04 cfs 0.025 af
18.0" Round Culvert n=0.013 L=115.0' S=0.0200 '/' Outflow=0.04 cfs 0.025 af

Pond 104P: Filtration Basin Peak Elev=666.20' Storage=470 cf Inflow=0.62 cfs 0.109 af
Outflow=0.14 cfs 0.109 af

Pond HW103: Headwall Peak Elev=670.37' Inflow=0.54 cfs 0.101 af
12.0" Round Culvert n=0.013 L=40.0' S=0.0500 '/' Outflow=0.54 cfs 0.101 af

Pond HW105: Headwall Peak Elev=659.53' Inflow=0.00 cfs 0.001 af
12.0" Round Culvert n=0.013 L=82.0' S=0.0085 '/' Outflow=0.00 cfs 0.001 af

Pond MH104: Manhole Peak Elev=658.90' Inflow=0.14 cfs 0.110 af
12.0" Round Culvert n=0.013 L=29.0' S=0.0069 '/' Outflow=0.14 cfs 0.110 af

Pond ST101: Stone Trench Peak Elev=680.69' Inflow=0.13 cfs 0.074 af
Primary=0.13 cfs 0.074 af Secondary=0.00 cfs 0.000 af Outflow=0.13 cfs 0.074 af

Link 1: Flow to Brook Inflow=0.18 cfs 0.137 af
Primary=0.18 cfs 0.137 af

Total Runoff Area = 11.822 ac Runoff Volume = 0.137 af Average Runoff Depth = 0.14"
99.22% Pervious = 11.730 ac 0.78% Impervious = 0.092 ac

Time span=5.00-30.00 hrs, dt=0.05 hrs, 501 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment 102: Flow to Brook Runoff Area=0.768 ac 0.00% Impervious Runoff Depth=0.10"
Flow Length=206' Tc=18.0 min CN=63 Runoff=0.01 cfs 0.007 af

Subcatchment 201: To Stone Trench Drain Runoff Area=7.511 ac 0.61% Impervious Runoff Depth=0.21"
Flow Length=1,500' Tc=27.8 min CN=67 Runoff=0.38 cfs 0.130 af

Subcatchment 202: To Culvert 101 Runoff Area=2.515 ac 0.00% Impervious Runoff Depth=0.21"
Flow Length=635' Tc=22.5 min CN=67 Runoff=0.13 cfs 0.044 af

Subcatchment 203: O&M Site Runoff Area=0.546 ac 8.42% Impervious Runoff Depth=0.79"
Tc=6.0 min CN=80 Runoff=0.74 cfs 0.036 af

Subcatchment 204: Overland to Filtration Runoff Area=0.377 ac 0.00% Impervious Runoff Depth=0.39"
Tc=6.0 min CN=72 Runoff=0.18 cfs 0.012 af

Subcatchment 205: To Culvert Runoff Area=0.105 ac 0.00% Impervious Runoff Depth=0.21"
Tc=6.0 min CN=67 Runoff=0.01 cfs 0.002 af

Pond 1P: Culvert 101 Peak Elev=682.16' Inflow=0.13 cfs 0.044 af
18.0" Round Culvert n=0.013 L=115.0' S=0.0200 '/' Outflow=0.13 cfs 0.044 af

Pond 104P: Filtration Basin Peak Elev=666.82' Storage=2,056 cf Inflow=0.92 cfs 0.178 af
Outflow=0.16 cfs 0.178 af

Pond HW103: Headwall Peak Elev=670.44' Inflow=0.74 cfs 0.166 af
12.0" Round Culvert n=0.013 L=40.0' S=0.0500 '/' Outflow=0.74 cfs 0.166 af

Pond HW105: Headwall Peak Elev=659.56' Inflow=0.01 cfs 0.002 af
12.0" Round Culvert n=0.013 L=82.0' S=0.0085 '/' Outflow=0.01 cfs 0.002 af

Pond MH104: Manhole Peak Elev=658.92' Inflow=0.16 cfs 0.180 af
12.0" Round Culvert n=0.013 L=29.0' S=0.0069 '/' Outflow=0.16 cfs 0.180 af

Pond ST101: Stone Trench Peak Elev=680.85' Inflow=0.38 cfs 0.130 af
Primary=0.38 cfs 0.130 af Secondary=0.00 cfs 0.000 af Outflow=0.38 cfs 0.130 af

Link 1: Flow to Brook Inflow=0.28 cfs 0.231 af
Primary=0.28 cfs 0.231 af

Total Runoff Area = 11.822 ac Runoff Volume = 0.230 af Average Runoff Depth = 0.23"
99.22% Pervious = 11.730 ac 0.78% Impervious = 0.092 ac

Time span=5.00-30.00 hrs, dt=0.05 hrs, 501 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment 102: Flow to Brook Runoff Area=0.768 ac 0.00% Impervious Runoff Depth=0.67"
Flow Length=206' Tc=18.0 min CN=63 Runoff=0.38 cfs 0.043 af

Subcatchment 201: To Stone Trench Drain Runoff Area=7.511 ac 0.61% Impervious Runoff Depth=0.91"
Flow Length=1,500' Tc=27.8 min CN=67 Runoff=4.70 cfs 0.570 af

Subcatchment 202: To Culvert 101 Runoff Area=2.515 ac 0.00% Impervious Runoff Depth=0.91"
Flow Length=635' Tc=22.5 min CN=67 Runoff=1.83 cfs 0.191 af

Subcatchment 203: O&M Site Runoff Area=0.546 ac 8.42% Impervious Runoff Depth=1.92"
Tc=6.0 min CN=80 Runoff=1.85 cfs 0.087 af

Subcatchment 204: Overland to Filtration Runoff Area=0.377 ac 0.00% Impervious Runoff Depth=1.26"
Tc=6.0 min CN=72 Runoff=0.82 cfs 0.040 af

Subcatchment 205: To Culvert Runoff Area=0.105 ac 0.00% Impervious Runoff Depth=0.91"
Tc=6.0 min CN=67 Runoff=0.15 cfs 0.008 af

Pond 1P: Culvert 101 Peak Elev=682.92' Inflow=3.73 cfs 0.236 af
18.0" Round Culvert n=0.013 L=115.0' S=0.0200 '/' Outflow=3.73 cfs 0.236 af

Pond 104P: Filtration Basin Peak Elev=668.13' Storage=6,342 cf Inflow=3.53 cfs 0.652 af
Outflow=2.75 cfs 0.610 af

Pond HW103: Headwall Peak Elev=671.24' Inflow=3.25 cfs 0.612 af
12.0" Round Culvert n=0.013 L=40.0' S=0.0500 '/' Outflow=3.25 cfs 0.612 af

Pond HW105: Headwall Peak Elev=659.87' Inflow=0.15 cfs 0.008 af
12.0" Round Culvert n=0.013 L=82.0' S=0.0085 '/' Outflow=0.15 cfs 0.008 af

Pond MH104: Manhole Peak Elev=659.87' Inflow=2.77 cfs 0.618 af
12.0" Round Culvert n=0.013 L=29.0' S=0.0069 '/' Outflow=2.77 cfs 0.618 af

Pond ST101: Stone Trench Peak Elev=684.42' Inflow=4.70 cfs 0.570 af
Primary=2.68 cfs 0.525 af Secondary=2.02 cfs 0.045 af Outflow=4.70 cfs 0.570 af

Link 1: Flow to Brook Inflow=4.26 cfs 0.896 af
Primary=4.26 cfs 0.896 af

Total Runoff Area = 11.822 ac Runoff Volume = 0.939 af Average Runoff Depth = 0.95"
99.22% Pervious = 11.730 ac 0.78% Impervious = 0.092 ac

Time span=5.00-30.00 hrs, dt=0.05 hrs, 501 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment 102: Flow to Brook Runoff Area=0.768 ac 0.00% Impervious Runoff Depth=1.33"
Flow Length=206' Tc=18.0 min CN=63 Runoff=1.01 cfs 0.085 af

Subcatchment 201: To Stone Trench Drain Runoff Area=7.511 ac 0.61% Impervious Runoff Depth=1.67"
Flow Length=1,500' Tc=27.8 min CN=67 Runoff=10.30 cfs 1.045 af

Subcatchment 202: To Culvert 101 Runoff Area=2.515 ac 0.00% Impervious Runoff Depth=1.67"
Flow Length=635' Tc=22.5 min CN=67 Runoff=3.97 cfs 0.350 af

Subcatchment 203: O&M Site Runoff Area=0.546 ac 8.42% Impervious Runoff Depth=2.94"
Tc=6.0 min CN=80 Runoff=2.81 cfs 0.134 af

Subcatchment 204: Overland to Filtration Runoff Area=0.377 ac 0.00% Impervious Runoff Depth=2.13"
Tc=6.0 min CN=72 Runoff=1.43 cfs 0.067 af

Subcatchment 205: To Culvert Runoff Area=0.105 ac 0.00% Impervious Runoff Depth=1.67"
Tc=6.0 min CN=67 Runoff=0.30 cfs 0.015 af

Pond 1P: Culvert 101 Peak Elev=684.52' Inflow=11.32 cfs 0.612 af
18.0" Round Culvert n=0.013 L=115.0' S=0.0200 '/' Outflow=11.32 cfs 0.612 af

Pond 104P: Filtration Basin Peak Elev=668.16' Storage=6,440 cf Inflow=6.75 cfs 0.984 af
Outflow=3.19 cfs 0.940 af

Pond HW103: Headwall Peak Elev=672.50' Inflow=5.35 cfs 0.917 af
12.0" Round Culvert n=0.013 L=40.0' S=0.0500 '/' Outflow=5.35 cfs 0.917 af

Pond HW105: Headwall Peak Elev=660.14' Inflow=0.30 cfs 0.015 af
12.0" Round Culvert n=0.013 L=82.0' S=0.0085 '/' Outflow=0.30 cfs 0.015 af

Pond MH104: Manhole Peak Elev=660.13' Inflow=3.23 cfs 0.954 af
12.0" Round Culvert n=0.013 L=29.0' S=0.0069 '/' Outflow=3.23 cfs 0.954 af

Pond ST101: Stone Trench Peak Elev=684.77' Inflow=10.30 cfs 1.045 af
Primary=2.73 cfs 0.783 af Secondary=7.57 cfs 0.262 af Outflow=10.30 cfs 1.045 af

Link 1: Flow to Brook Inflow=14.80 cfs 1.652 af
Primary=14.80 cfs 1.652 af

Total Runoff Area = 11.822 ac Runoff Volume = 1.696 af Average Runoff Depth = 1.72"
99.22% Pervious = 11.730 ac 0.78% Impervious = 0.092 ac

Summary for Subcatchment 102: Flow to Brook

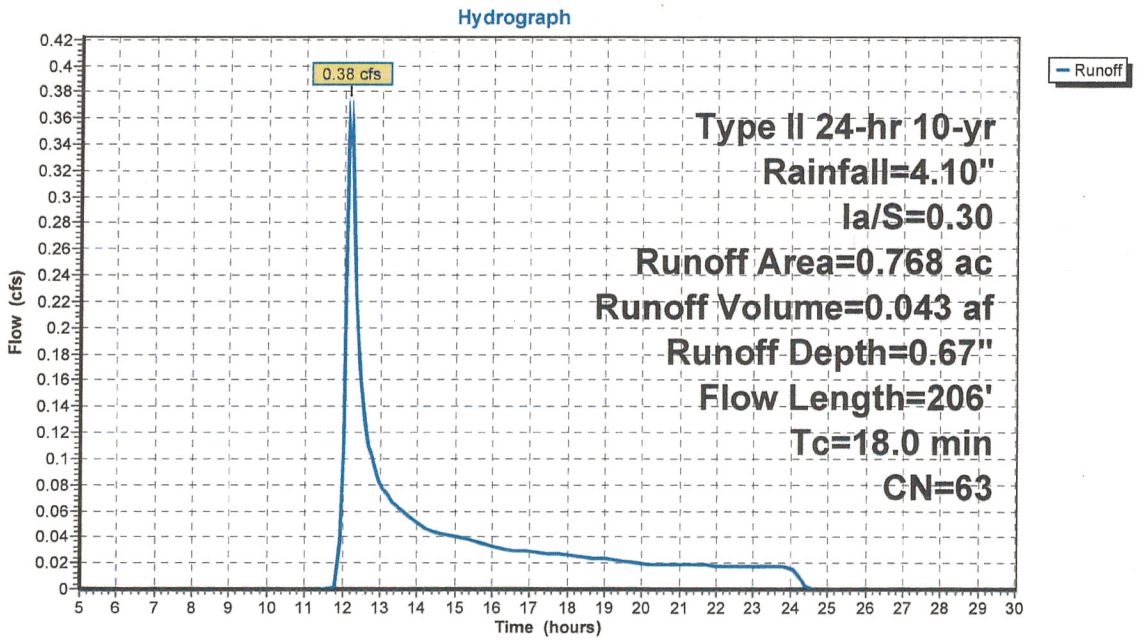
Runoff = 0.38 cfs @ 12.16 hrs, Volume= 0.043 af, Depth= 0.67"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr 10-yr Rainfall=4.10", Ia/S=0.30

Area (ac)	CN	Description
0.107	85	Gravel roads, HSG B
0.452	61	>75% Grass cover, Good, HSG B
0.209	55	Woods, Good, HSG B
0.768	63	Weighted Average
0.768		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
17.2	100	0.1800	0.10		**Sheet Flow,** Woods: Dense underbrush n= 0.800 P2= 2.60"
0.8	106	0.2000	2.24		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
18.0	206	Total			

Subcatchment 102: Flow to Brook



Summary for Subcatchment 201: To Stone Trench Drain

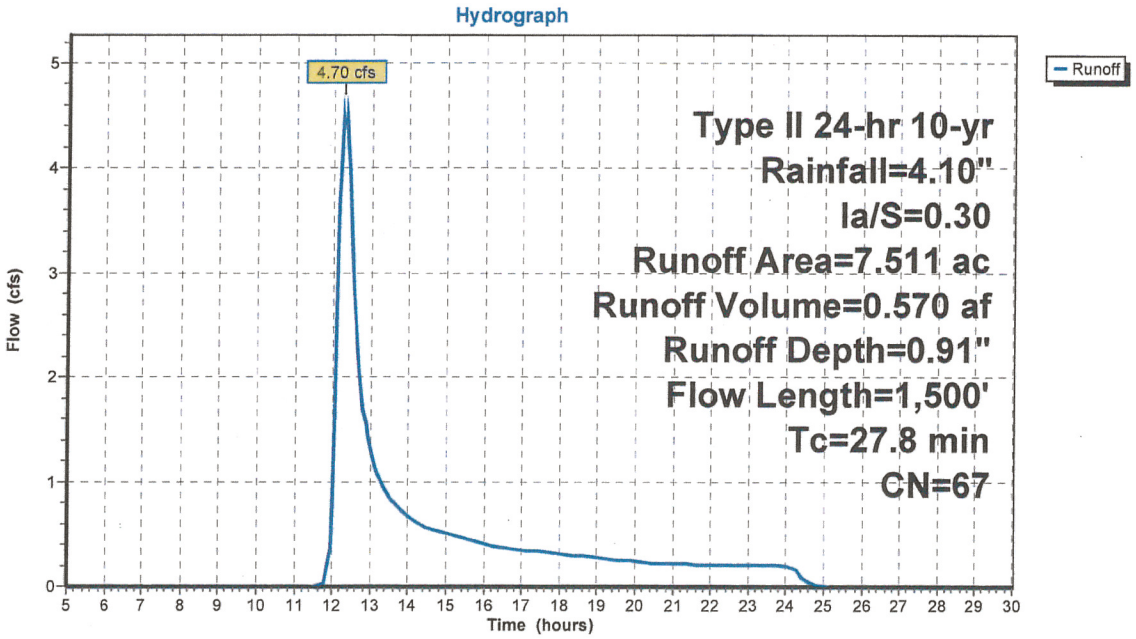
Runoff = 4.70 cfs @ 12.27 hrs, Volume= 0.570 af, Depth= 0.91"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr 10-yr Rainfall=4.10", Ia/S=0.30

	Area (ac)	CN	Description
*	7.465	67	Based on CN for P101
*	0.046	98	Roof
	7.511	67	Weighted Average
	7.465		99.39% Pervious Area
	0.046		0.61% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
18.5	100	0.1500	0.09		**Sheet Flow,** Woods: Dense underbrush n= 0.800 P2= 2.60"
9.3	1,400	0.2500	2.50		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
27.8	1,500	Total			

Subcatchment 201: To Stone Trench Drain



Summary for Subcatchment 202: To Culvert 101

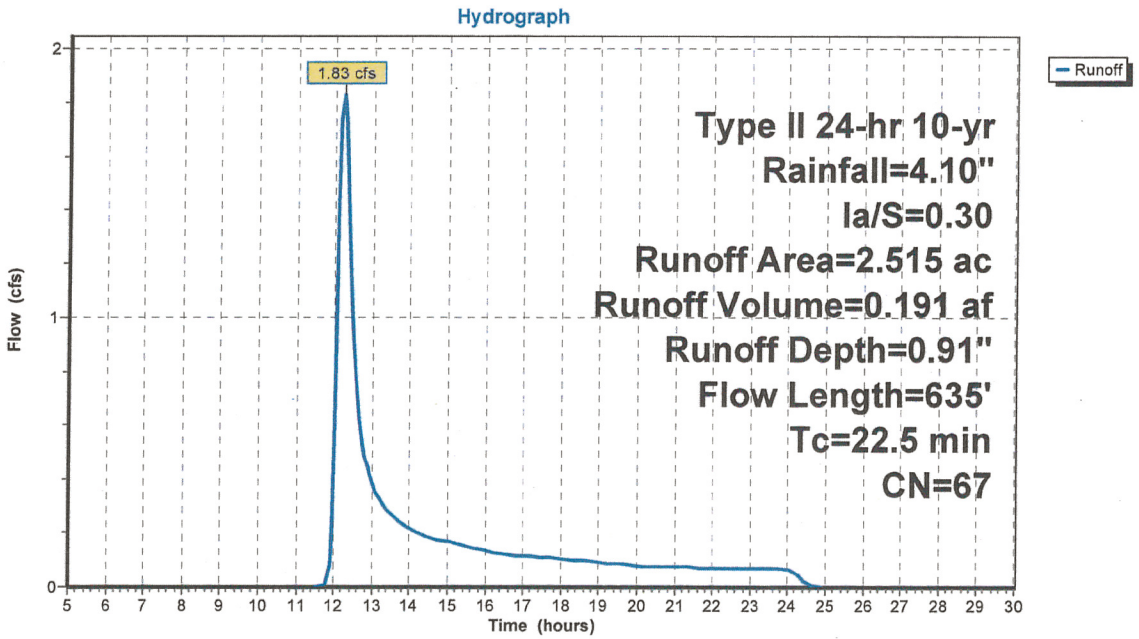
Runoff = 1.83 cfs @ 12.20 hrs, Volume= 0.191 af, Depth= 0.91"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr 10-yr Rainfall=4.10", Ia/S=0.30

	Area (ac)	CN	Description
*	2.515	67	Based on CN for P101
	2.515		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
17.6	100	0.1700	0.09		**Sheet Flow,** Woods: Dense underbrush n= 0.800 P2= 2.60"
4.9	535	0.1340	1.83		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
22.5	635	Total			

Subcatchment 202: To Culvert 101



Summary for Subcatchment 203: O&M Site

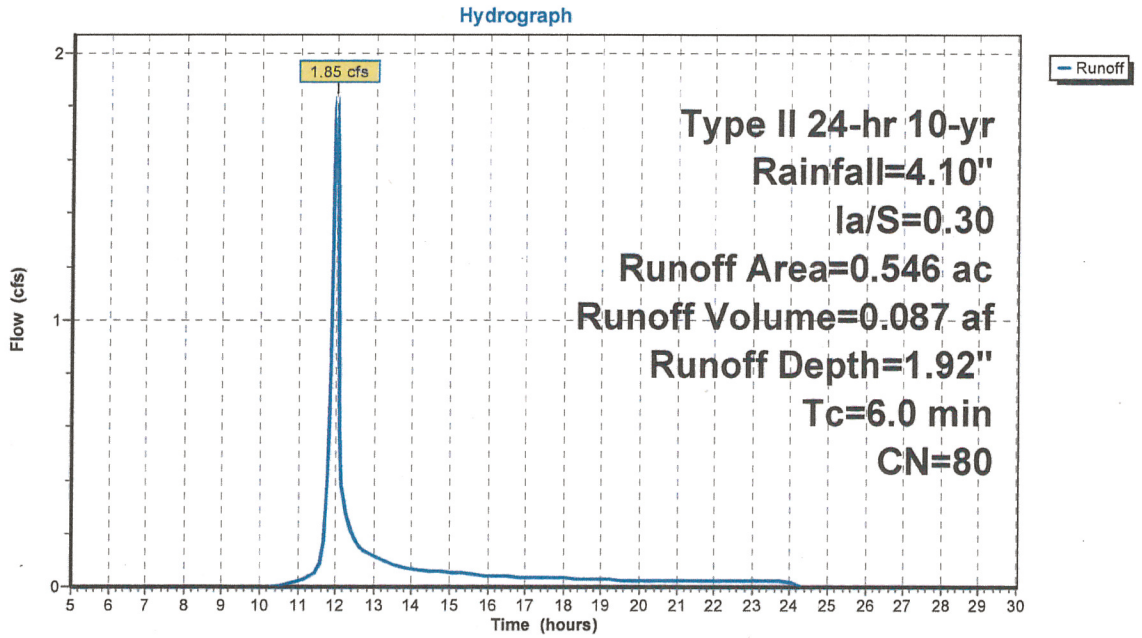
Runoff = 1.85 cfs @ 11.97 hrs, Volume= 0.087 af, Depth= 1.92"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr 10-yr Rainfall=4.10", Ia/S=0.30

	Area (ac)	CN	Description
	0.150	61	>75% Grass cover, Good, HSG B
*	0.350	85	Gravel parking/roads, HSG B
*	0.046	98	Roof
	0.546	80	Weighted Average
	0.500		91.58% Pervious Area
	0.046		8.42% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					**Direct Entry,**

Subcatchment 203: O&M Site



Summary for Subcatchment 204: Overland to Filtration Basin

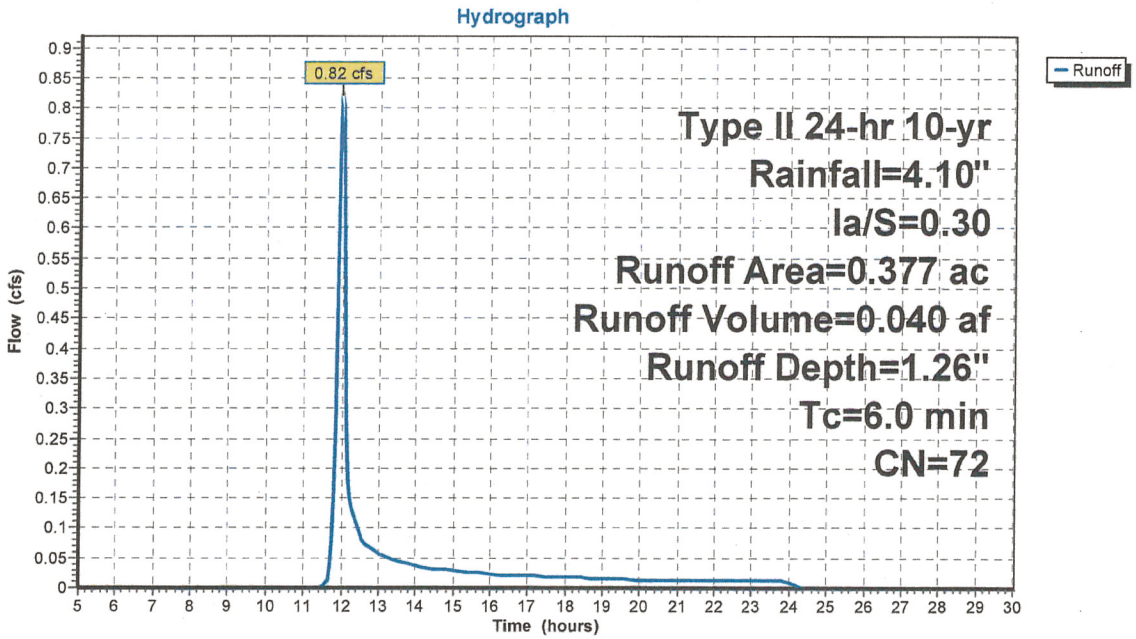
Runoff = 0.82 cfs @ 11.98 hrs, Volume= 0.040 af, Depth= 1.26"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr 10-yr Rainfall=4.10", Ia/S=0.30

	Area (ac)	CN	Description
	0.210	61	>75% Grass cover, Good, HSG B
*	0.167	85	Gravel parking/roads, HSG B
	0.377	72	Weighted Average
	0.377		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					**Direct Entry,**

Subcatchment 204: Overland to Filtration Basin



Summary for Subcatchment 205: To Culvert

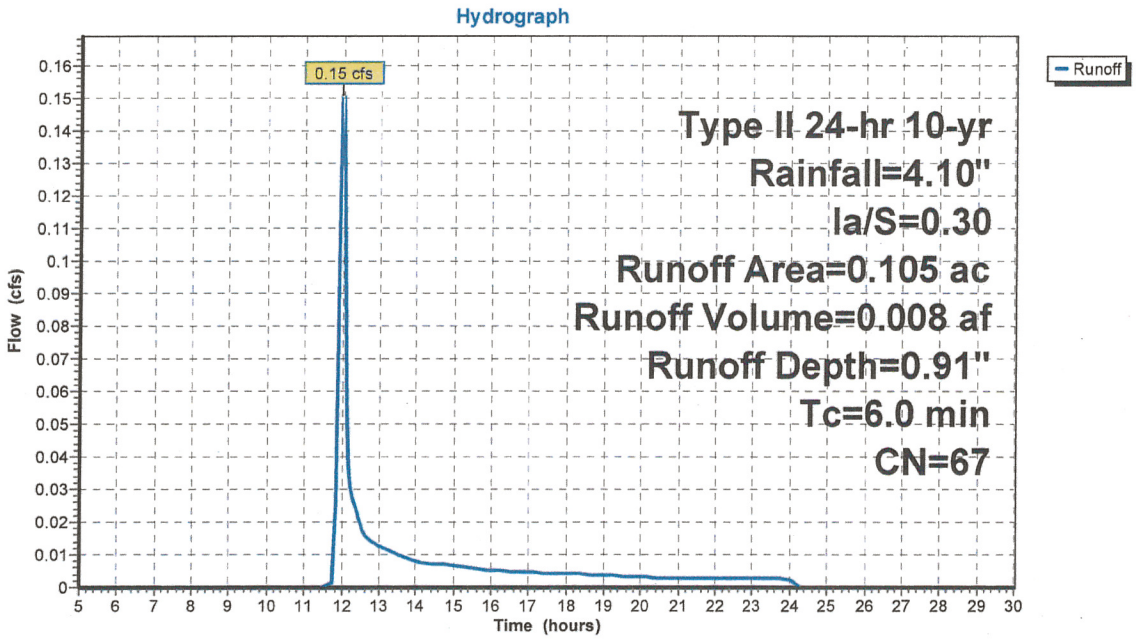
Runoff = 0.15 cfs @ 11.99 hrs, Volume= 0.008 af, Depth= 0.91"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-30.00 hrs, dt= 0.05 hrs
Type II 24-hr 10-yr Rainfall=4.10", Ia/S=0.30

	Area (ac)	CN	Description
	0.079	61	>75% Grass cover, Good, HSG B
*	0.026	85	Gravel parking/roads, HSG B
	0.105	67	Weighted Average
	0.105		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					**Direct Entry,**

Subcatchment 205: To Culvert



Summary for Pond 1P: Culvert 101

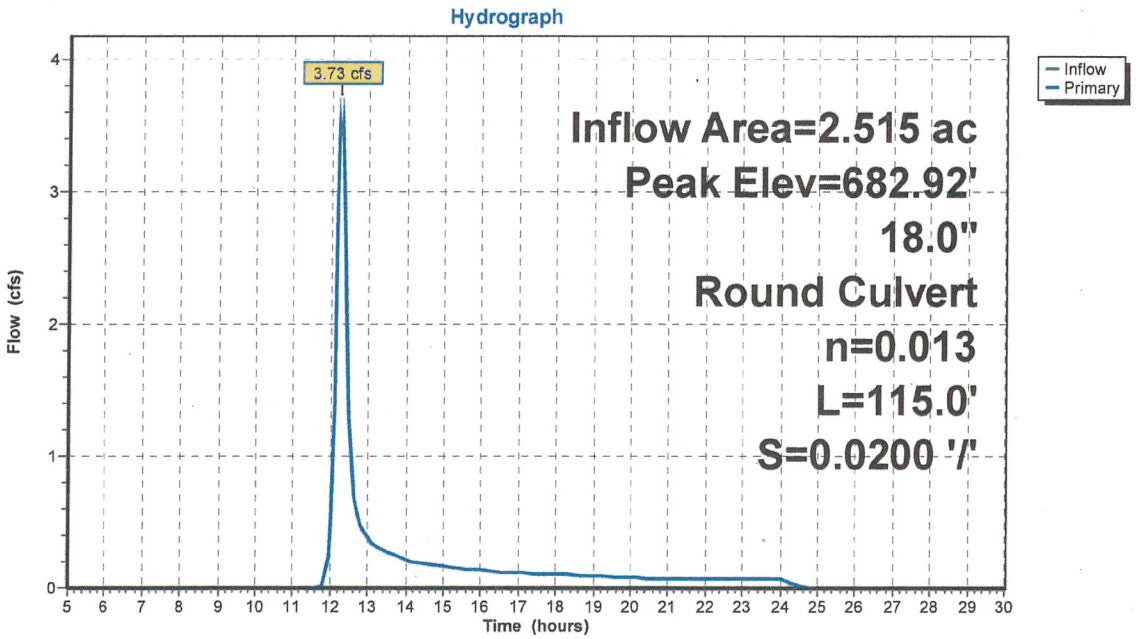
Inflow Area = 2.515 ac, 0.00% Impervious, Inflow Depth = 1.13" for 10-yr event
Inflow = 3.73 cfs @ 12.25 hrs, Volume= 0.236 af
Outflow = 3.73 cfs @ 12.25 hrs, Volume= 0.236 af, Atten= 0%, Lag= 0.0 min
Primary = 3.73 cfs @ 12.25 hrs, Volume= 0.236 af

Routing by Dyn-Stor-Ind method, Time Span= 5.00-30.00 hrs, dt= 0.05 hrs
Peak Elev= 682.92' @ 12.25 hrs
Flood Elev= 685.00'

Device	Routing	Invert	Outlet Devices
#1	Primary	682.00'	**18.0" Round Culvert** L= 115.0' CPP, square edge headwall, Ke= 0.500 Outlet Invert= 679.70' S= 0.0200 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior

Primary OutFlow Max=3.72 cfs @ 12.25 hrs HW=682.92' TW=0.00' (Dynamic Tailwater)
↑**1=Culvert** (Inlet Controls 3.72 cfs @ 3.27 fps)

Pond 1P: Culvert 101



Summary for Pond 104P: Filtration Basin

Inflow Area = 8.434 ac, 1.09% Impervious, Inflow Depth = 0.93" for 10-yr event
Inflow = 3.53 cfs @ 12.09 hrs, Volume= 0.652 af
Outflow = 2.75 cfs @ 12.60 hrs, Volume= 0.610 af, Atten= 22%, Lag= 30.1 min
Primary = 2.75 cfs @ 12.60 hrs, Volume= 0.610 af

Routing by Dyn-Stor-Ind method, Time Span= 5.00-30.00 hrs, dt= 0.05 hrs
Peak Elev= 668.13' @ 12.59 hrs Surf.Area= 3,734 sf Storage= 6,342 cf
Flood Elev= 669.20' Surf.Area= 4,690 sf Storage= 10,796 cf

Plug-Flow detention time= (not calculated: outflow precedes inflow)
Center-of-Mass det. time= 141.9 min (1,055.8 - 913.9)

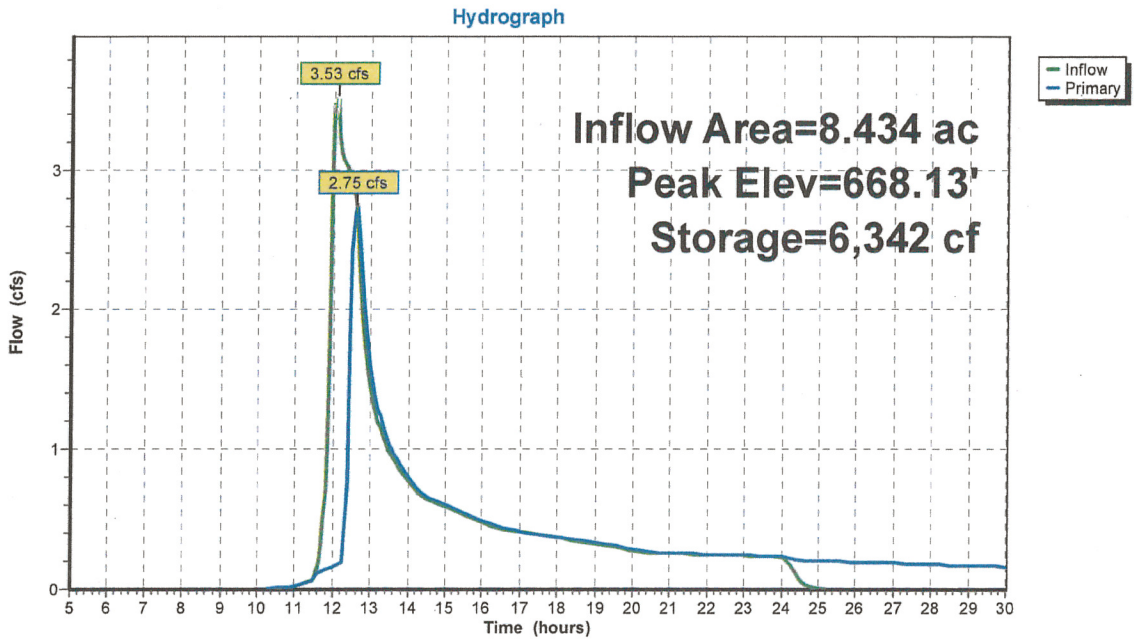
Volume	Invert	Avail.Storage	Storage Description
#1	666.00'	10,796 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
666.00	2,230	0	0
668.00	3,631	5,861	5,861
669.00	4,417	4,024	9,885
669.20	4,690	911	10,796

Device	Routing	Invert	Outlet Devices
#1	Primary	662.80'	**12.0" Round Culvert** L= 24.0' CPP, square edge headwall, Ke= 0.500 Outlet Invert= 662.00' S= 0.0333 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior
#2	Device 1	666.00'	**2.500 in/hr Exfiltration to UD's over Surface area**
#3	Device 1	667.90'	**2.3" x 4.6" Horiz. Orifice/Grate X 4.00 columns** X 8 rows C= 0.600 in 21.0" x 21.0" Grate Limited to weir flow at low heads

Primary OutFlow Max=2.74 cfs @ 12.60 hrs HW=668.13' TW=659.87' (Dynamic Tailwater)
└**1=Culvert** (Passes 2.74 cfs of 8.31 cfs potential flow)
└**2=Exfiltration to UD's** (Exfiltration Controls 0.22 cfs)
└**3=Orifice/Grate** (Weir Controls 2.53 cfs @ 1.57 fps)

Pond 104P: Filtration Basin



Summary for Pond HW103: Headwall

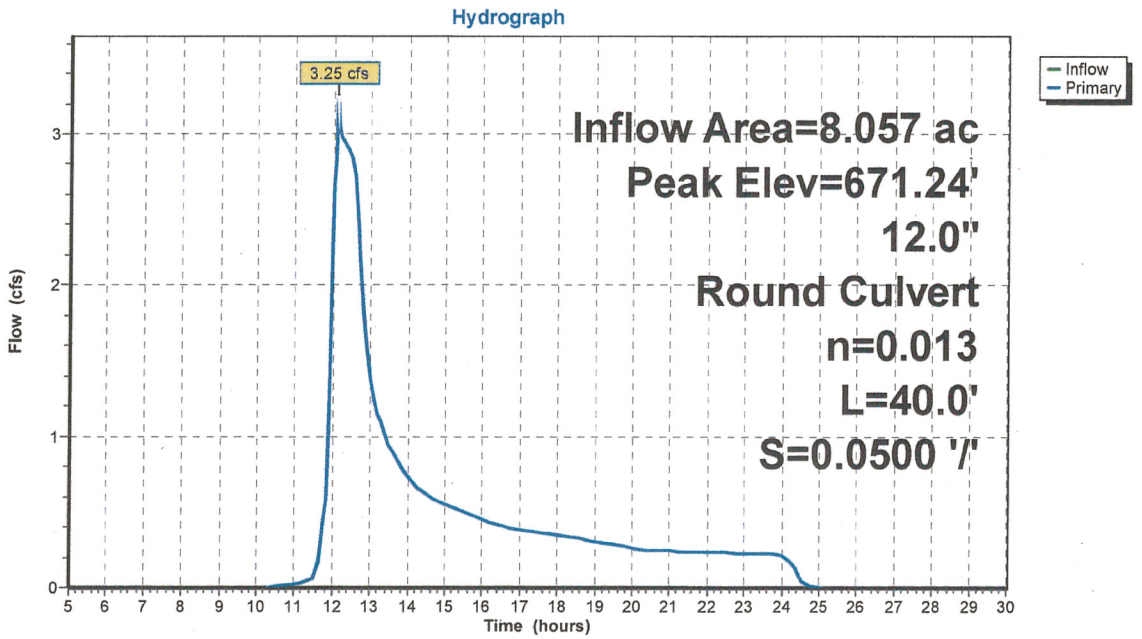
Inflow Area = 8.057 ac, 1.14% Impervious, Inflow Depth = 0.91" for 10-yr event
Inflow = 3.25 cfs @ 12.11 hrs, Volume= 0.612 af
Outflow = 3.25 cfs @ 12.11 hrs, Volume= 0.612 af, Atten= 0%, Lag= 0.0 min
Primary = 3.25 cfs @ 12.11 hrs, Volume= 0.612 af

Routing by Dyn-Stor-Ind method, Time Span= 5.00-30.00 hrs, dt= 0.05 hrs
Peak Elev= 671.24' @ 12.11 hrs
Flood Elev= 673.00'

Device	Routing	Invert	Outlet Devices
#1	Primary	670.00'	**12.0" Round Culvert** L= 40.0' CPP, square edge headwall, Ke= 0.500 Outlet Invert= 668.00' S= 0.0500 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior

Primary OutFlow Max=3.21 cfs @ 12.11 hrs HW=671.22' TW=667.07' (Dynamic Tailwater)
↑—**1=Culvert** (Inlet Controls 3.21 cfs @ 4.08 fps)

Pond HW103: Headwall



Summary for Pond HW105: Headwall

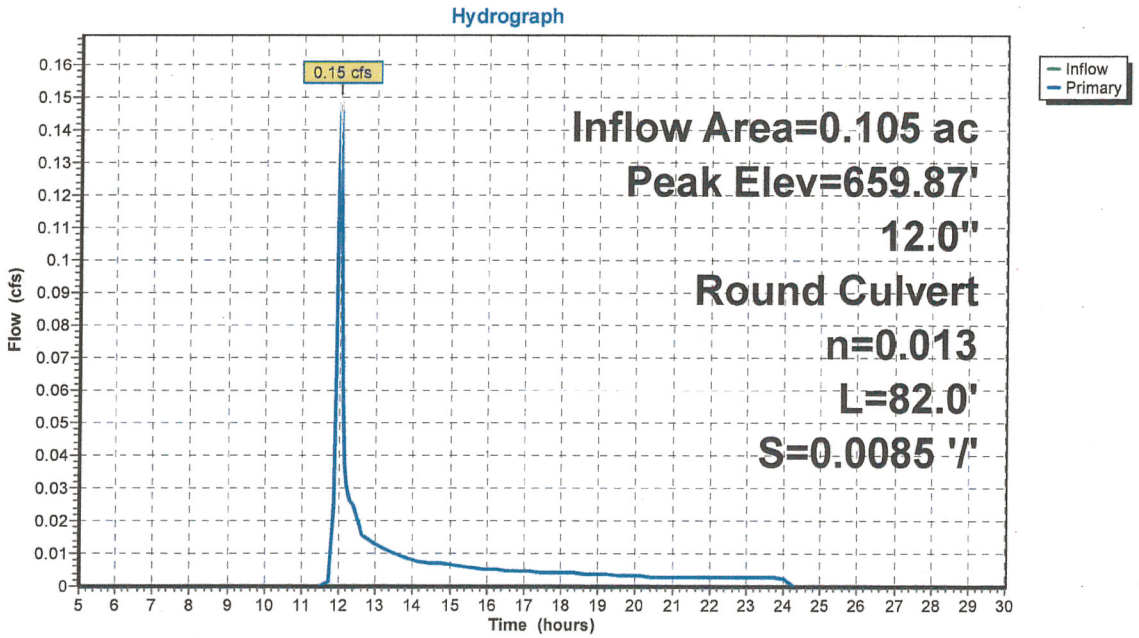
Inflow Area = 0.105 ac, 0.00% Impervious, Inflow Depth = 0.91" for 10-yr event
Inflow = 0.15 cfs @ 11.99 hrs, Volume= 0.008 af
Outflow = 0.15 cfs @ 11.99 hrs, Volume= 0.008 af, Atten= 0%, Lag= 0.0 min
Primary = 0.15 cfs @ 11.99 hrs, Volume= 0.008 af

Routing by Dyn-Stor-Ind method, Time Span= 5.00-30.00 hrs, dt= 0.05 hrs
Peak Elev= 659.87' @ 12.64 hrs
Flood Elev= 662.00'

Device	Routing	Invert	Outlet Devices
#1	Primary	659.50'	**12.0" Round Culvert** L= 82.0' CPP, square edge headwall, Ke= 0.500 Outlet Invert= 658.80' S= 0.0085 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior

Primary OutFlow Max=0.14 cfs @ 11.99 hrs HW=659.70' TW=659.00' (Dynamic Tailwater)
↑**1=Culvert** (Outlet Controls 0.14 cfs @ 1.99 fps)

Pond HW105: Headwall



Summary for Pond MH104: Manhole

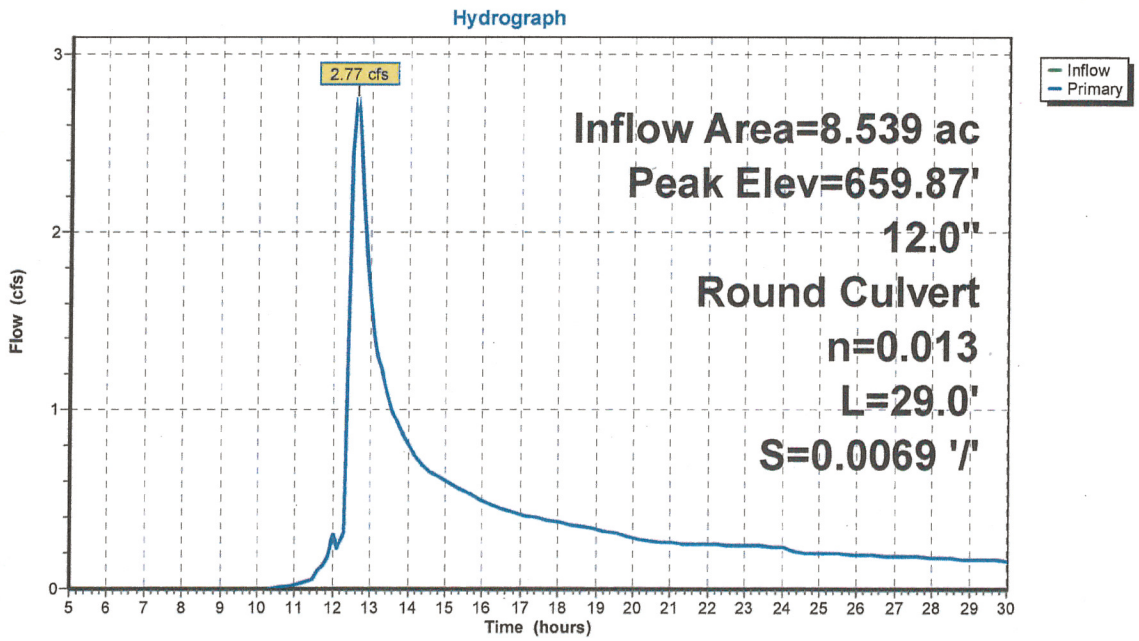
Inflow Area = 8.539 ac, 1.08% Impervious, Inflow Depth > 0.87" for 10-yr event
Inflow = 2.77 cfs @ 12.59 hrs, Volume= 0.618 af
Outflow = 2.77 cfs @ 12.59 hrs, Volume= 0.618 af, Atten= 0%, Lag= 0.0 min
Primary = 2.77 cfs @ 12.59 hrs, Volume= 0.618 af

Routing by Dyn-Stor-Ind method, Time Span= 5.00-30.00 hrs, dt= 0.05 hrs
Peak Elev= 659.87' @ 12.59 hrs
Flood Elev= 665.00'

Device	Routing	Invert	Outlet Devices
#1	Primary	658.70'	**12.0" Round Culvert** L= 29.0' CPP, square edge headwall, Ke= 0.500 Outlet Invert= 658.50' S= 0.0069 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior

Primary OutFlow Max=2.76 cfs @ 12.59 hrs HW=659.87' TW=0.00' (Dynamic Tailwater)
↑—**1=Culvert** (Barrel Controls 2.76 cfs @ 3.79 fps)

Pond MH104: Manhole



Summary for Pond ST101: Stone Trench

Inflow Area = 7.511 ac, 0.61% Impervious, Inflow Depth = 0.91" for 10-yr event
Inflow = 4.70 cfs @ 12.27 hrs, Volume= 0.570 af
Outflow = 4.70 cfs @ 12.27 hrs, Volume= 0.570 af, Atten= 0%, Lag= 0.0 min
Primary = 2.68 cfs @ 12.27 hrs, Volume= 0.525 af
Secondary = 2.02 cfs @ 12.27 hrs, Volume= 0.045 af

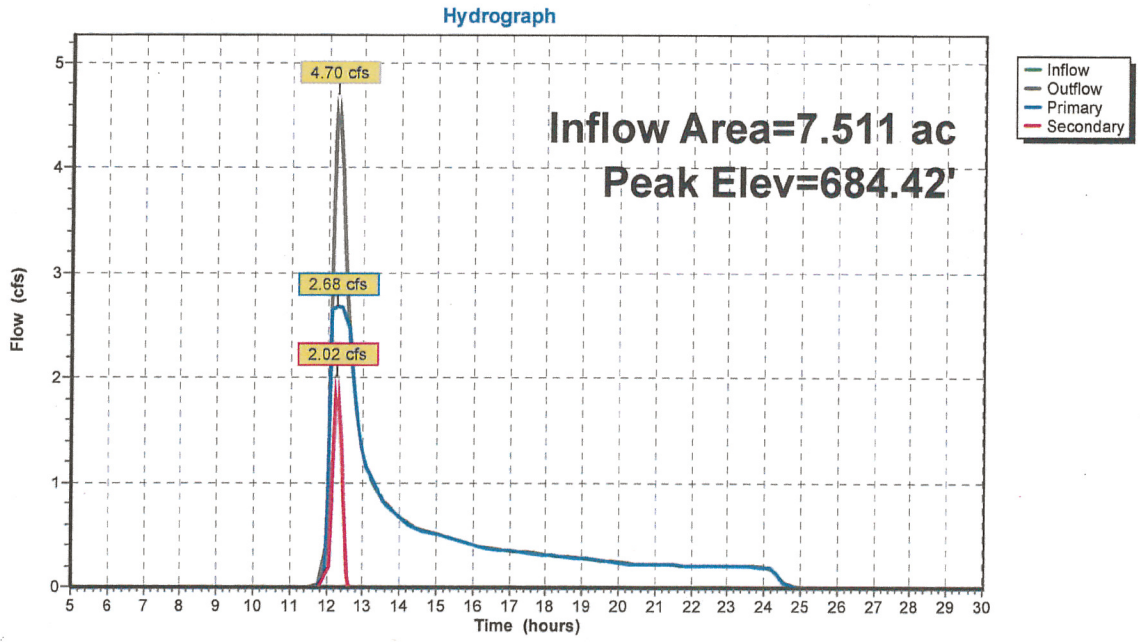
Routing by Dyn-Stor-Ind method, Time Span= 5.00-30.00 hrs, dt= 0.05 hrs
Peak Elev= 684.42' @ 12.27 hrs
Flood Elev= 685.00'

Device	Routing	Invert	Outlet Devices
#1	Primary	680.50'	**8.0" Round Culvert** L= 170.0' CPP, square edge headwall, Ke= 0.500 Outlet Invert= 674.00' S= 0.0382 '/' Cc= 0.900 n= 0.013
#2	Secondary	684.20'	**8.0' long x 4.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.38 2.54 2.69 2.68 2.67 2.67 2.65 2.66 2.66 2.68 2.72 2.73 2.76 2.79 2.88 3.07 3.32

Primary OutFlow Max=2.68 cfs @ 12.27 hrs HW=684.42' TW=671.10' (Dynamic Tailwater)
↑—**1=Culvert** (Barrel Controls 2.68 cfs @ 7.67 fps)

Secondary OutFlow Max=1.98 cfs @ 12.27 hrs HW=684.42' TW=682.91' (Dynamic Tailwater)
↑—**2=Broad-Crested Rectangular Weir** (Weir Controls 1.98 cfs @ 1.12 fps)

Pond ST101: Stone Trench

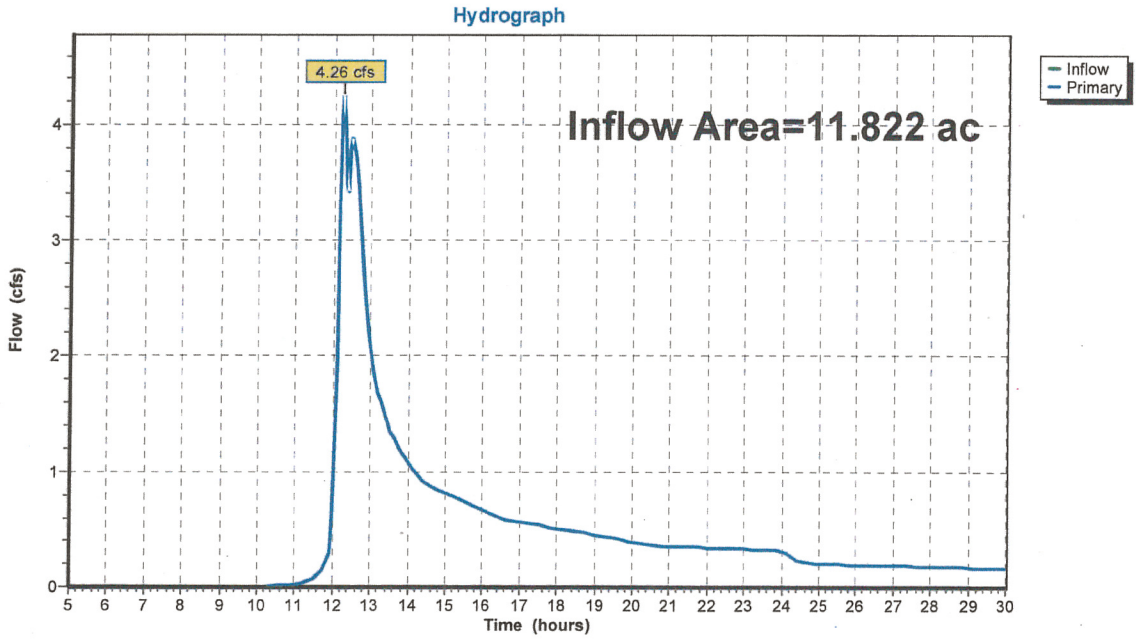


Summary for Link 1: Flow to Brook

Inflow Area = 11.822 ac, 0.78% Impervious, Inflow Depth > 0.91" for 10-yr event
Inflow = 4.26 cfs @ 12.25 hrs, Volume= 0.896 af
Primary = 4.26 cfs @ 12.25 hrs, Volume= 0.896 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 5.00-30.00 hrs, dt= 0.05 hrs

Link 1: Flow to Brook



General Calculations - WQV and WQF
(optional worksheet)

This worksheet may be useful when designing a BMP that does not fit into one of the specific worksheets already provided. For example, if proposing a new technology, which is not a stormwater wetland, infiltration practice, etc., then this worksheet may be useful.

Water Quality Volume (WQV)

8.44	ac	A = Area draining to the practice
0.62	ac	A_I = Impervious area draining to the practice
0.07	decimal	I = percent impervious area draining to the practice, in decimal form
0.12	unitless	Rv = Runoff coefficient = 0.05 + (0.9 x I)
0.98	ac-in	WQV= 1" x Rv x A
3,563	cf	WQV conversion (ac-in x 43,560 sf/ac x 1ft/12")

Water Quality Flow (WQF)

1	inches	P = amount of rainfall. For WQF in NH, P = 1".
0.12	inches	Q = water quality depth. Q = WQV/A
82	unitless	CN = unit peak discharge curve number. $CN = 1000/(10+5P+10Q-10*[Q^2 + 1.25*Q*P]^{0.5})$
2.2	inches	S = potential maximum retention. S = (1000/CN) - 10
0.435	inches	Ia = initial abstraction. Ia = 0.2S
6.0	minutes	T_c = Time of Concentration
280.0	$cfs/mi^2/in$	qu is the unit peak discharge. Obtain this value from TR-55 exhibits 4-II and 4-III
0.429	cfs	WQF = q_u x WQV. Conversion: to convert "$cfs/mi^2/in$ * ac-in" to "cfs" multiply by $1mi^2/640ac$

Designer's Notes:

For O&M Building Site Area

Filtration Basin has a cumulative storage of 10,796 cubic-feet

WQV in Basin set to 3,808 cubic-feet at elevation 667.4

Sediment forbay volume set to 25% of WQV or 952 cubic-feet

Impervious Area also includes gravel areas.

FILTRATION PRACTICE DESIGN CRITERIA (Env-Wq 1508.06)

Type/Node Name: **Proposed Filtration Basin**

Enter the type of filtration practice (e.g., bioretention system) and the node name in the drainage analysis, if applicable

YES	Have you reviewed the restrictions on unlined systems outlined in Env-Wq 1508.06(b)?	
8.44 ac	A = Area draining to the practice[1]	
0.62 ac	A_I = Impervious area draining to the practice	
0.07 decimal	I = percent impervious area draining to the practice, in decimal form	
0.12 unitless	Rv = Runoff coefficient = 0.05 + (0.9 x I)	
0.98 ac-in	WQV= 1" x Rv x A	
3,557 cf	WQV conversion (ac-in x 43,560 sf/ac x 1ft/12")	
889 cf	25% x WQV (check calc for sediment forebay volume)	
2,668 cf	75% x WQV (check calc for surface sand filter volume)	
Forebay	Method of Pretreatment? (not required for clean or roof runoff)	
952 cf	V_{SED} = sediment forebay volume, if used for pretreatment	← ≥ 25%WQV
2,230 sf	A_{SA} = surface area of the practice	
2.5 iph	I_{DESIGN} = design infiltration rate[2]	
YES Yes/No	If I_{DESIGN} is < 0.50 iph, has an underdrain been provided?	
2.0 hours	T_{DRAIN} = drain time = V_{PP} / (A_{SA} * I_{DESIGN})	← ≤ 72-hrs
664.25 feet	E_{FC} = elevation of the bottom of the filter course material	
663.00 feet	E_{UD} = invert elevation of the underdrain (UD), if applicable	
662.50 feet	E_{BTM} = elevation of the bottom of the practice (i.e., bottom of the stone reservoir).	
NA feet	E_{SHWT} = elevation of SHWT (if none found, enter the lowest elevation of the test pit)	
NA feet	E_{ROCK} = elevation of bedrock (if none found, enter the lowest elevation of the test pit)	
1.25 feet	$D_{FC\ to\ UD}$ = depth to UD from the bottom of the filter course[3]	← ≥ 1'
#VALUE! feet	$D_{FC\ to\ ROCK}$ = depth to bedrock from the bottom of the filter course[3]	← ≥ 1'
#VALUE! feet	$D_{FC\ to\ SHWT}$ = depth to SHWT from the bottom of the filter course[3]	← ≥ 1'
#VALUE! feet	$D_{BTM\ to\ SHWT}$ = depth to SHWT from the bottom of the practice[3]	← ≥ 2'
668.13 ft	Peak elevation of the 10-year storm event (infiltration can be used in analysis)	
669.20 ft	Elevation of the top of the practice	
YES	10 peak elevation ≤ Elevation of the top of the practice	← yes

If a surface sand filter is proposed:

YES ac	Drainage Area check.	← < 10 ac
10,796 cf	V = volume of storage[4,5] (attach a stage-storage table)	← ≥ 75%WQV
18.0 inches	D_{FC} = filter course thickness	← 18"
Sheet C-10.2	Note what sheet in the plan set contains the filter course specification	
NA Yes/No	Access grate provided?	← yes
Crushed Stone	The filter shall not be covered in grass. What is covering the filter?	

If an underground sand filter is proposed:

YES ac	Drainage Area check.	← < 10 ac
cf	V = volume of storage[4,5] (attach a stage-storage table)	← ≥ 75%WQV
inches	D_{FC} = filter course thickness	← 24"
Sheet	Note what sheet in the plan set contains the filter course specification	
Yes/No	Access grate provided?	← yes

If a bioretention area is proposed:

NO	ac	Drainage Area no larger than 5 ac?	← yes
	cf	V = volume of storage[4, 5] (attach a stage-storage table)	← ≥ WQV
	inches	D_{FC} = filter course thickness	← 18"
Sheet		Note what sheet in the plan set contains the filter course specification	
	:1	Pond side slopes	← ≥2:1
Sheet		Note what sheet in the plan set contains the planting plans and surface cover	

If porous pavement is proposed:

		Type of pavement proposed (concrete? Asphalt? Pavers? Etc)	
	sf	A_{SA} = surface area of the pervious pavement	
-	:1	ratio of the contributing area to the pervious surface area	← 5:1
	inches	D_{FC} = filter course thickness	← 12"
Sheet		Note what sheet in the plan set contains the filter course spec.	← 304.1 sand

1. If the practice is a tree box filter, the drainage area shall be < 0.1 acre

2. Rate of the limiting layer (either the filter course or the underlying soil). See Vol. 2 of the NH Stormwater Manual, Ch. 2-4, for guidance on determining the infiltration rate.

3. If not within a GPA or WSIPA: SHWT/Bedrock must be at least 1 foot below the filter course material (or an underdrain must drain the SHWT to at least one foot below the filter course material). If within a GPA or WSIPA: SHWT must be at least two feet below the bottom of the practice OR the filter course material must be at least twice as thick as required and the SHWT must be at least one foot below the filter course material.

4. Volume without depending on infiltration. The storage above the filter media shall not include the volume above the outlet structure, if any.

5. The volume includes the storage above the filter but below the invert of the outlet structure (if any), the filter media voids, and the pretreatment area.

Designer's Notes:

The entire water quality volume is being filtered and outleted by the underdrain.

See HydroCAD printouts for stage-storage chart/table

Computations

Project #: 52036.00
Project: Wind Farm
Location: Groton, New Hampshire
Calculated by: B. Anderson Date: 11/9/2011
Checked by: Date:
Title: Culvert Sizing Summary

Culvert	Location	Station	Size	Material	Design Storm	Flow (CFS)	Drainage Area (Ac)	Comments
100	Groton Hollow Road	59+00	12"	CPP	25-year	0.3	0.2	
101	Groton Hollow Road	61+46	18"	CPP	25-year	10.5	10.3	Shifted location to accommodate new O&M bldg. layout
102	Groton Hollow Road	67+31	**49"x33" ***	CMP Arch	50-year	38.5	30.0	
103	Groton Hollow Road	68+56	35"x24"	CMP Arch	25-year	15.1	13.9	
104	Groton Hollow Road	73+44	35"x24"	CMP Arch	25-year	13.9	13.6	
105	Groton Hollow Road	78+55	18"	CPP	25-year	9.3	7.1	
106	Groton Hollow Road	85+04	15"	CPP	25-year	4.1	2.9	
107	Groton Hollow Road	87+85	18"	CPP	25-year	6.4	5.3	
108	Groton Hollow Road	89+71	18"	CPP	25-year	5.7	5.5	
109	Groton Hollow Road	95+38	42"x29"	CMP Arch	50-year	43.5	26.5	
110	Groton Hollow Road	100+20	18"	CPP	25-year	6.9	6.5	
111	Groton Hollow Road	107+02	28"x20"	CMP Arch	25-year	3.6	3.5	
112	Groton Hollow Road	109+30	9'x2'	Steel Box	50-year	58.8	47.5	9'x3' size corrected to reflect calculations and plans.
113	Groton Hollow Road	126+45	12"	CPP	25-year	0.8	0.6	
114	Groton Hollow Road	127+78	9'x2'	Steel Box	50-year	64.1	57.2	9'x3' size corrected to reflect calculations and plans.
114A	Groton Hollow Road	135+08	15"	CPP	25-year	2.0	1.4	
115	Groton Hollow Road	137+65	35"x24"	CMP Arch	50-year	27.4	22.2	
116	Groton Hollow Road	142+31	**83"x57" ***	CMP Arch	50-year	161.4	110.6	
117	Groton Hollow Road	143+11	18"	CPP	25-year	6.4	5.8	
118	Groton Hollow Road	148+71	12"	CPP	25-year	1.6	1.0	
119	Groton Hollow Road	150+89	12"	CPP	25-year	1.5	1.0	
217A	Groton Hollow Road	178+00	15"	CPP	25-year	1.2	0.5	Added additional culvert along road
218	Groton Hollow Road	167+61	Ex. 6'x9'	Stone Box	NA	NA	562.4	
219	Groton Hollow Road	163+23	9'x3'	Steel Box	50-year	105.1	81.9	
220	Groton Hollow Road	157+72	21"x15"	CMP Arch	25-year	11.5	16.8	
221	Groton Hollow Road	154+15	9'x2'	Steel Box	50-year	101.5	125.6	9'x3' size corrected to reflect calculations and plans.
222	Groton Hollow Road	±169+00	18'x3.5'	Steel Box	100-year	423.1	298.4	17.3'x3.8' size revised, revised drainage area/flow
201	East Access Road	82+91	17"x13"	CMP Arch	25-year	6.5	7.0	
202	East Access Road	67+37	24"x18"	CMP Arch	25-year	8.5	13.8	Revised drainage area/flow
202A	East Access Road	72+50	15"	CMP	25-year	3.7	4.5	Replaced stone mattress with culvert

VHB *Computations*

Project #: 52036.00
Project: Wind Farm
Location: Groton, New Hampshire
Calculated by: B. Anderson Date: 11/9/2011
Checked by: Date:
Title: Culvert Sizing Summary

Culvert	Location	Station	Size	Material	Design Storm	Flow (CFS)	Drainage Area (Ac)	Comments
202B	East Access Road	76+55	15"	CMP	25-year	1.3	3.1	Replaced stone mattress with culvert
203	East Access Road	60+50	57"x38"	CMP Arch	50-year	43.6	45.6	Revised drainage area/flow
204	East Access Road	59+87	24"x18"	CMP Arch	25-year	3.9	3.2	
205	East Access Road	53+96	42"x29"	CMP Arch	50-year	49.3	36.2	Revised drainage area/flow
206	East Access Road	53+56	24"x18"	CMP Arch	25-year	22.2	16.0	
207	East Access Road	47+23	24"x18"	CMP Arch	25-year	8.5	5.3	Revised drainage area/flow
208	East Access Road	41+67	64"x43" *	CMP Arch	50-year	66.5	54.9	Revised drainage area/flow
208A	East Access Road	35+52	15"	CMP	25-year	2.1	1.4	Replaced stone mattress with culvert
209	East Access Road	32+29	71"x47" *	CMP Arch	50-year	71.0	58.7	
210	East Access Road	31+88	24"x18"	CMP Arch	25-year	1.2	0.8	Revised drainage area/flow
211	East Access Road	30+69	24"x18"	CMP Arch	25-year	1.3	1.0	
212	East Access Road	26+92	35"x24" *	CMP Arch	25-year	12.5	11.4	Increased 28"x20" culvert size to lower HW depth.
213	East Access Road	26+12	64"x43" *	CMP Arch	50-year	85.7	67.4	
213A	East Access Road	22+86	15"	CMP	25-year	1.4	1.0	Replaced stone mattress with culvert
214	East Access Road	20+74	24"x18"	CMP Arch	25-year	3.2	2.4	
214A	East Access Road	15+09	24"x18"	CMP Arch	25-year	6.0	5.0	Replaced stone mattress with culvert
215	East Access Road	13+15	24"	RCP	25-year	10.4	5.2	
216	East Access Road	11+41	24"x18"	CMP Arch	25-year	2.8	2.2	
217	East Access Road	6+24	18'x3.5'	Steel Box	100-year	364.0	251.3	17.3'x3.8' size revised, revised drainage area/flow
201A	Northeast Access Rd.	2+32	18"	CMP	25-year	9.1	12.4	Replaced stone mattress with culvert (at low point)
201B	Northeast Access Rd.	20+60	24"	CMP	25-year	2.2	1.4	Added culvert at low point (new road alignment)
501	Southeast Access Rd.	30+88	42"x29"	CMP Arch	50-year	33.4	23.4	
502	Southeast Access Rd.	37+64	17"x13"	CMP Arch	25-year	3.2	2.6	
503	Southeast Access Rd.	38+58	17"x13"	CMP Arch	25-year	4.3	3.4	
504	Southeast Access Rd.	39+55	24"x18"	CMP Arch	25-year	9.7	6.4	
505	Southeast Access Rd.	41+00	17"x13"	CMP Arch	25-year	5.5	2.6	
601	West Access Road	9+47	15"	CPP	25-year	2.2	3.4	Replaced stone mattress with culvert
601A	West Access Road	15+9	24"	CPP	25-year	14.4	10.7	Replaced stone mattress with culvert
602	West Access Road	19+29	21"x15"	CMP Arch	25-year	7.7	7.3	
603	West Access Road	20+76	17"x13"	CMP Arch	25-year	2.4	1.7	

Project #: 52036.00
Project: Wind Farm
Location: Groton, New Hampshire
Calculated by: B. Anderson Date: 11/9/2011
Checked by: Date:
Title: Culvert Sizing Summary

Culvert	Location	Station	Size	Material	Design Storm	Flow (CFS)	Drainage Area (Ac)	Comments
604	West Access Road	21+35	**57"x38" ***	CMP Arch	50-year	100.0	62.7	Revised drainage area/flow
605	West Access Road	23+84	35"x24"	CMP Arch	25-year	10.1	11.3	Revised drainage area/flow
605A	West Access Road	27+00	15"	CPP	25-year	0.6	3.6	Replaced stone mattress with culvert
606	West Access Road	31+51	12"	CPP	25-year	4.2	8.2	Replaced stone mattress with culvert
607	West Access Road	39+43	12"	CPP	25-year	2.8	2.8	Replaced stone mattress with culvert
607A	West Access Road	44+25	15"	CPP	25-year	2.4	1.2	Replaced stone mattress with culvert (at low point)
701	West Ridge Road	51+56	**49"x33" ***	CMP Arch	50-year	33.1	24.7	Revised drainage area/flow
701A	West Ridge Road	57+50	15"	CPP	25-year	1.9	2.1	Replaced stone mattress with culvert
702	West Ridge Road	62+13	17"x13"	CMP Arch	25-year	2.2	2.0	
702A	West Ridge Road	3+75	12"	CPP	25-year	5.8	6.6	Replaced stone mattress with culvert (at low point)
702B	West Ridge Road	64+64	12"	CPP	25-year	6.4	7.0	Replaced stone mattress with culvert (at low point)
703	West Ridge Road	5+16	17"x13"	CMP Arch	25-year	2.1	1.9	Added culvert due to regrading of turbine pad
704	West Ridge Road	69+29	21"x15"	CMP Arch	25-year	10.0	4.9	Replaced stone mattress with culvert
705	West Ridge Road	78+15	18"	CPP	25-year	7.3	4.1	Replaced stone mattress with culvert (at low point)
706	West Ridge Road	80+25	15"	CPP	25-year	2.8	3.8	Replaced stone mattress with culvert
707	West Ridge Road	111+75	12"	CPP	25-year	2.9	1.6	Replaced stone mattress with culvert (at low point)
708	West Ridge Road	101+17	12"	CPP	25-year	2.9	4.7	Replaced stone mattress with culvert (at low point)
801	North Access Road	4+42	**49"x33" ***	CMP Arch	50-year	47.5	33.1	35"x24" size increased, revised drainage area/flow
801A	North Access Road	10+30	15"	CMP	25-year	2.0	1.4	Replaced stone mattress with culvert
802	North Access Road	13+50	17"x13"	CMP Arch	25-year	8.9	6.7	
802A	North Access Road	18+07	17"x13"	CMP Arch	25-year	3.2	2.1	Replaced stone mattress with culvert
803	North Access Road	21+42	24"x18"	CMP Arch	25-year	14.3	15.3	17"x13" size increased, revised drainage area/flow
803A	North Access Road	25+50	18"	CMP	25-year	2.5	1.5	Replaced stone mattress with culvert
804	North Access Road	29.88	**49"x33" ***	CMP Arch	50-year	46.6	34.1	Revised drainage area/flow
804A	North Access Road	31+85	15"	CMP	25-year	4.3	4.0	Replaced stone mattress with culvert
804B	North Access Road	38+35	18"	CMP	25-year	9.5	17.6	Replaced stone mattress with culvert
805	North Access Road	43+53	21"x15"	CMP Arch	25-year	10.2	13.0	17"x13" size increased, revised drainage area/flow
806	North Access Road	45+41	12"	CPP	25-year	4.0	5.2	Revised drainage area/flow
807	North Access Road	46+42	28"x20"	CMP Arch	50-year	28.1	20.5	
808	North Access Road	46+90	17"x13"	CMP Arch	25-year	1.2	2.4	Revised drainage area/flow

Project #: 52036.00
Project: Wind Farm
Location: Groton, New Hampshire
Calculated by: B. Anderson Date: 11/9/2011
Checked by: Date:
Title: Culvert Sizing Summary

Culvert	Location	Station	Size	Material	Design Storm	Flow (CFS)	Drainage Area (Ac)	Comments
809	North Access Road	48+80	49"x33" *	CMP Arch	50-year	49.5	30.6	42"x29" size increased to reduce HW depth
810	North Access Road	48+50	12"	CMP	25-year	2.2	2.3	Added cluvert under ex. road/path
811	North Access Road	53+35	15"	CMP	25-year	4.5	6.1	Replaced stone mattress with culvert
901	North Ridge Road	72+55	12"	CPP	25-year	7.0	8.8	Revised drainage area/flow
902	North Ridge Road	79+16	12"	CPP	25-year	0.8	0.7	
902	North Ridge Road	79+00	12"	CPP	25-year	1.3	4.2	
902A	North Ridge Road	77+13	15"	CPP	25-year	6.9	8.3	
903	North Ridge Road	83+50	24"x18"	CMP Arch	25-year	7.3	13.5	Revised drainage area/flow
903A	North Ridge Road	88+12	15"	CPP	25-year	3.4	7.3	Replaced stone mattress with culvert
904	North Ridge Road	110+50	12"	CPP	25-year	2.6	3.0	Replaced stone mattress with culvert (at low point)

* Pipe calculation and sizing based on the next smaller nominal pipe size than currently shown. Perennial Stream crossings shall have pipe dimensions as shown on this chart with 8" of gravel placed within it to act as a natural bottom for the stream

Shaded cells indicate revisions from the permit plans and shaded rows indicate culvert additions to the permit plans.

Geiger, Susan S.

From: Rennie, Craig [Craig.Rennie@des.nh.gov]
Sent: Monday, December 05, 2011 1:49 PM
To: Walker, Peter
Cc: Emmett, Doren; Cherian, Ed; Revell, Kelly; KWilkes@VHB.com; Clayton, Michael
Subject: Revised Plans/Amended Permits for Groton Wind Farm, Wetland File #2010-00745, AoT File #100325-033
Attachments: GROTON WIND POWER_WETLAND AMENDMENT_CDR.pdf; AoT_GROTON WIND_AMENDED_CDR.pdf

Peter,
The Department of Environmental Services (DES) has reviewed the revised grading and wetland impact plans (showing minor roadway modifications, relocation of the O&M building, minor transmission line relocations, and a reduction in stone mattresses) that further reduce the overall disturbance by 12 acres, and increases the wetland impact by 280 square feet, and has determined that these minor modifications are acceptable as presented. Attached please find the amended approvals for the Wetland and Alteration of Terrain Permits. The attached amended permits shall serve as confirmation to proceed with the minor modifications as depicted on the revised plans by VHB dated October 28, 2011. Please call if you have any questions.
Thanks,
Craig

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Craig D. Rennie, CWS, CWB
Land Resource Specialist
NH Department of Environmental Services
Water Division
29 Hazen Drive, PO Box 95
Concord, NH 03302-0095
ph: (603) 271-0676 fax: (603) 271-6588
email: craig.rennie@des.nh.gov
~~~~~~~~~~~~~~~~~~~~~~

Attachment 3

Turbine ID	Move Distance (m)
E10	0.019
E11	0.013
E12	0.013
E13	0.010
E2	12.604
E3	40.973
E4	17.210
E5	0.007
E6	0.004
E7	0.016
E8	0.005
E9	0.013
N1	0.014
N2	3.048
N3	3.410
N4	2.307
N5	0.015
N6	27.780
W1	0.012
W2	0.012
W3	0.016
W4	9.027
W5	0.013
W6	0.015

Legend

- As-Built Locations
- Permitted Locations

N

0 100 200 300 400 500 600

Meters

Turbine Locations

Groton Wind Project

IBERDROLA RENEWABLES

Path: \\Forgis01\065 Data\Projects\NH\Groton\MapDocuments\Misc\Turbine Locations - AsBuilt vs Permitted (2013-12-02).mxd

Modified Date: 12/2/2013

THE STATE OF NEW HAMPSHIRE
BEFORE THE
SITE EVALUATION COMMITTEE

DOCKET NO. 2010-01

GROTON WIND, LLC

PREFILED TESTIMONY OF PETER J. WALKER ON BEHALF OF GROTON WIND, LLC

December 4, 2013

Qualifications

Q. Please state your name and business address.

A. My name is Peter J. Walker. My business address is 6 Bedford Farms Drive, Suite 607, Bedford, New Hampshire, 03110.

Q. Who is your current employer and what position do you hold?

A. I am employed by Vanasse Hangen Brustlin, Inc. ("VHB"). I hold the position of Director of Environmental Services.

Q. Please summarize your educational background and work experience.

A. I am a New Hampshire native with more than 20 years of experience in the environmental matters. I hold a Bachelor's Degree from Williams College in Biology and Environmental Studies and a Master's Degree in Ecology and Evolutionary Biology from the University of Vermont. Prior to joining VHB in 2002, I was an administrator for the Permitting and Resources Sections of the Wetlands Bureau of the New Hampshire Department of Environmental Services ("DES"). At VHB, I am

responsible for environmental analysis for VHB's projects in northern New England including natural resources, water quality, air and noise engineering, oil and hazardous materials and cultural resources. Outside of VHB, I have served on the Board of Directors of the New Hampshire Association of Natural Resource Scientists and was a Director of the New Hampshire Corporate Wetlands Restoration Partnership and a representative on the New Hampshire General Court's Commission to Study Issues Relating to Land Development in New Hampshire.

Q. Please describe your involvement with the Groton Wind Project.

A. I was the Project Manager for VHB's engineering and environmental consulting work on the Project. In this role, my responsibilities included overseeing the engineering and environmental teams to ensure that VHB's work was conducted thoroughly and competently and that the teams had the resources they needed to conduct their technical work. Because of my background as a natural resource scientist, I also assisted with the natural resource and regulatory technical analysis including the development of the wetland mitigation package for the Project. I also testified at the adjudicative hearings in this docket. As the Project moved from the permitting phase to the construction phase, I assisted with the development of revised site plans which were submitted to DES under a cover letter from me dated November 10, 2011.

Purpose of Testimony

Q. What is the purpose of this prefiled testimony?

A. I am submitting this testimony in support of a motion by Groton Wind to amend its Certificate of Site and Facility to incorporate changes to the Project reflected in the revised site plans referred to above. My testimony describes the changes and provides supporting justification for each.

Description of Site Plan Revisions

Q. Please list the revisions to the original site plans for the Groton Wind Project that DES has approved.

A. **Revision 1. Operations and Maintenance Facility.** The location of the O&M building was moved from the east side of Clark Brook to the west side of Groton Hollow Road to a location where a fenced in switch yard was previously proposed.

Revision 2. Overhead Electric Transmission Interconnect. The overhead line from the Project to Route 25 was originally proposed to run north along Groton Hollow Road. During the adjudicative phase of the SEC proceedings, Groton Wind revised this route in response to concerns expressed by a few residents of Groton Hollow Road and the New Hampshire Electric Cooperative (regarding its lack of complete easement documentation). *See* Second Supplemental Prefiled Testimony of Edward J. Cherian (Nov. 19, 2010) at 3. The revised route for the interconnection line from the Project to Route 25 runs along private property. The Certificate (at pages 1-2) reflects the fact that the SEC has already considered and approved this revision.

Revision 3. East Ridge Overhead Electric Collector Line. The overhead transmission line from Turbine E-2 to the O&M building was adjusted.

Revision 4. East Ridge Access Road. The access road and overhead electric line on the East Ridge of the Project was revised to eliminate separate access roads to Turbines E4 and E5, and to Turbines E2 and E3. Turbines E2 through E4 were relocated slightly. Based on information compiled by Groton Wind, the as-built location of Turbine E2 moved approximately 41 ft to the southwest, Turbine E3 moved approximately 134 ft to the southwest and Turbine E4 moved approximately 56 ft to the south/southwest. These changes were made to decrease the overall length of new roadway needed to access these turbine locations with the intent of reducing the footprint of the roadway and therefore eliminating construction impacts and construction costs. Changes in the turbine locations were partly a function of the new roadway design, but the minor adjustments were also made in part to optimize the turbines' efficiency based on information provided by Groton Wind.

Revision 5. Groton Hollow Road from Sta. 168+ to 174+00. Approximately 600 linear feet of Groton Hollow Road was realigned to avoid an archeologically sensitive area. This change was presented to the SEC during the adjudicative phase of the proceedings. *See* Supplemental Prefiled Testimony of Michael J. Leo (Oct. 12, 2010) at 2.

Revision 6. Turbine W2 Elevation Change. The elevation of Turbine W2 was lowered approximately 9 feet.

Revision 7. West Ridge Overhead Electric Transmission Line. Approximately 700 linear feet of overhead transmission line was relocated east of Turbine W1.

Revision 8. Stone Mattress Revisions. Adjustments to several stone mattress locations were made. Stone mattresses at roadway low points were replaced with culverts and were removed from areas of little flow.

Q. Please describe the benefits of the above-mentioned revisions.

A. **Revision 1**: The total area of the O&M building and adjacent storage area was reduced. This revision had several environmental advantages, including: elimination of the need to cross Clark Brook to access the building; reduction of the building's land disturbance by approximately 0.7 acres; and reduction in proposed clearing within a 50' buffer to two perennial streams from 12,400 square feet to only 4,250 square feet.

Revision 2: The revised route of the interconnection line from the Project to Route 25 avoids Groton Hollow Road and therefore decreased the impacts along the residential section of that road. This revision addressed concerns expressed by residents in that area. It has the added benefit of reducing the length of the originally proposed overhead line to Route 25 by nearly 1.5 miles.

Revision 3: The revised route of the East Ridge overhead collector line is shorter than the proposed route and has the benefit of decreasing the amount of clearing originally proposed for the East Ridge.

Revision 4: The East Ridge Access Road revision eliminates the need to construct separate roads to Turbines E4 and E5 and to Turbines E2 and E3. This results in a single road which reduces the length of access roadways for these turbines. The new location of Turbine E3 and the revised roadway layout reduced the overall Project footprint in this area, and changes in the access road around Turbine E6 reduced impacts to a wetland from 820 square feet to 470 square feet.

Revision 5: The benefit of the realigned portion of Groton Hollow Road is that it avoided an archaeologically sensitive area, i.e. an existing old stone foundation. The change did not result in any additional disturbance area and did not change previously assessed wetland impacts. This change was presented to the Committee during the adjudicative phase of the proceedings. *See* Supplemental Prefiled Testimony of Michael J. Leo (Oct. 12, 2010) at 2.

Revision 6: The 9 foot decrease in the elevation of Turbine W2 occurred to provide a more stable base for the turbine foundation (i.e. to ensure that it would be on bedrock.)

Revision 7: The benefit of the relocation of the West Ridge Overhead Transmission is that it moved the line further away from the location of Turbine W1 and completely eliminated a clearing impact of 830 square feet to a wetland.

Revision 8: The stone mattresses that were at low points in the road were replaced with culverts to reduce the risk of potential roadway flooding in the event of heavy rain. The stone mattress or culvert changes represent improvements to the original plans and do not affect overall runoff (pre vs. post) discharge rates from the site. The

concept of maintaining existing flow patterns in the post development condition was retained.

Q. Are there any negative impacts associated with the site plan revisions?

A. Overall, the revisions to the Project's site plans constitute improvements over the originally submitted plans and therefore provide a net benefit. Some very minor impacts associated with the revisions are as follows: The rerouted interconnection line (Revision 2) resulted in three clearing impacts of 3,050 square feet to wetlands. However, this change was presented to and approved by the Committee previously. The new location of Turbine E3 and revised road layout (Revision 4) increased clearing within a vernal pool and its buffer from 10,320 square feet to 20,200 square feet. The revision to the elevation of Turbine W2 (Revision 6) required a minor change in the profile of a short segment of the access road which resulted in an additional impact (38 linear feet/80 square feet) to an intermittent stream. Only one of the many stone mattress or culvert adjustments resulted in an additional wetland impact. The revised plans also identified a 500 square foot impact to a wetland area that had not been identified in the original site plans. This new small wetland area was previously obscured by some previous land use and wasn't identified until after the SEC hearing. The net effect of the revisions increase direct wetland impacts by 280 square feet. However that increase is negligible when one considers that the originally proposed impacts were 71,680 square feet. Also, given that the revisions reduce the overall area disturbance by approximately 12 acres, it is reasonable to conclude that, as a whole, the revisions do not constitute a negative impact.

Q. Are you familiar with the findings made by the Site Evaluation Committee with respect to the Groton Wind Project's impacts on the orderly development of the region, aesthetics, historic sites, air and water quality, the natural environment and public health and safety?

A. Yes. I am familiar with the Committee's Decision on these issues.

Q. Do you believe that the Project changes reflected in the revised site plans dated October 28, 2011 undermine the initial findings of the Committee?

A. No. I do not believe that the Project revisions reflected in the October 28, 2011 site plans that DES has reviewed and approved undermine the Committee's initial findings. All of the revisions are relatively minor changes to the site plans that the Committee reviewed and approved, and therefore cannot be viewed as undermining the Committee's initial determinations concerning the Groton Wind Project. My opinion regarding each specific revision is set forth below.

Revision 1: With respect to the issues of aesthetics, historic sites, air and water quality, natural environment, and public health and safety, the Committee made no specific findings regarding the impacts of the O&M facility on a standalone basis. However, because the O&M building was constructed in the same general vicinity within the Project area as originally proposed, it is reasonable to conclude that the Committee's original determinations are not undermined by the revised location. Note that the revised O&M facility was reduced in size relative to its original location: the parking area was reduced in size from 13 spaces to 5, as was the gravel storage area (0.7 acres+/-). Additionally, moving the location away from Clark

Brook represents a benefit to that important resource. In view of the foregoing and given the benefits of the revised location of the O&M building noted in my testimony, this change does not undermine the Committee's initial findings.

Revision 2: As indicated above, the Committee has already reviewed and approved the revised location of the interconnection line running along private property to Route 25.

Revision 3: This revision reduced the amount of clearing and grading on the East Ridge. It therefore does not undermine the Committee's original findings.

Revision 4: The revisions to the East Ridge road and overhead electric line did increase an indirect impact associated with clearing within a vernal pool and its buffer, but reduced the overall Project footprint in this area and resulted in decreased direct wetland impacts. Thus, these changes have no impact on the Committee's original findings. Because the relocation of Turbines E2 through E4 were very small relative to the overall size and scope of the project (these changes were on the order of 50 to 150 ft for a project spread over thousands of acres of land), these changes do not undermine the Committee's original findings relative to the wind turbines.

Revision 5: The realignment of Groton Hollow Road to avoid an archaeologically sensitive area has already been reviewed and approved by the Committee.

Revision 6: Lowering the elevation of Turbine W2 by 9 feet does not undermine any of the Committee's findings regarding the wind turbines. Although a minor change in the profile of a short segment of access road in this area has an impact to an

intermittent stream, that impact is very minor, was approved by DES, and therefore does not undermine the Committee's findings with respect to the Project's roadways.

Revision 7: The revised location of 700 feet of overhead line entirely eliminated the clearing impact to a wetland (i.e. 830 square feet). In addition, this line was constructed in the same general vicinity of the original overhead line route near Turbine W1. Given the proximity of the new location of this line to the proposed location, and the revised location's improved wetland impacts, the revised location does not undermine the Committee's findings.

Revision 8: The stone mattress and culvert revisions did not affect overall runoff discharge rates from the site and resulted in only one wetland being impacted. These changes do not undermine the Committee's findings relative to the stone mattresses and culverts that were approved as part of the original filing.

Q. Do you believe that the Project changes reflected in the revised site plans dated October 28, 2011 are reasonable?

A. Yes. The changes are reasonable for several reasons. First, each change constitutes an improvement in the original site plans for the reasons discussed above. Second, the changes reduced the Project's overall area of disturbance by approximately 12 acres (i.e. from 115.6 acres to 103.6 acres). Third, none of the revisions significantly altered VHB's original determinations regarding potential effects on site drainage, and the conclusions in VHB's original Drainage Report remain valid. Lastly, and perhaps most importantly, DES has reviewed all of the revisions, determined that they were minor modifications, and has approved them.

Q. Does this conclude your prefiled testimony?

A. Yes.

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