



LEBANON CONSERVATION COMMISSION
JUNE 8, 2023 - 6:30 PM
COUNCIL CHAMBERS, CITY HALL OR
REMOTE VIA VIRTUAL PLATFORM
LEBANONNH.GOV/LIVE

-
- 1. Call to Order**
 - 2. Approval of Minutes**
 - A. May 11, 2023
 - 3. Open to the Public**
 - 4. Permit Review**
 - A. None
 - 5. Study Items**
 - A. Boston Lot - Property Review
 - B. Alternative Drinking Water Source - Review & Discussion
 - 6. Committee Reports**
 - A. Biodiversity Group (Invasives)
 - B. Stewardship
 - Ranger
 - Trail Coordinator
 - Monitors and Stewards
 - C. Wild about Lebanon
 - D. Amphibian Crossings
 - E. LUCT/Current Use
 - F. Other Subcommittees
 - 7. Other Business**
 - A. FYIs
 - B. Follow Up
 - C. Workshops and Educational Opportunities
 - 8. Future Agenda Items**
 - 9. Adjournment**

The order of agenda items is subject to change.

Meetings are open for in-person and remote attendance. Members of the public that wish to attend remotely may do so by going to LebanonNH.gov/Live where you will find instructions on how to enter the meeting. Members of the public will be able to participate and ask questions through the City's virtual platform or by phone. Please note: Should technical difficulties occur during the meeting that disrupts virtual or phone connection(s), the meeting will continue without remote access capabilities.

DRAFT

**LEBANON CONSERVATION COMMISSION
CITY COUNCIL CHAMBERS, CITY HALL OR
REMOTE VIA VIRTUAL PLATFORM
6:30PM WEDNESDAY MAY 11, 2023**

MEMBERS PRESENT: Sarah Riley (Chair), Bruce James (Vice Chair), Chris Johnson, Ernst Oidtman, Erling Heistad (City Council Rep.), Donald Lacey, Susan Almy, Barbara Hirai (Alt.)

MEMBERS ABSENT: Sean Dittrich (Alt.)

STAFF PRESENT: Mark Goodwin (GIS Coordinator)

1. CALL TO ORDER

Chair Riley called the meeting to order at 6:33pm.

2. APPROVAL OF MINUTES: April 13, 2023

Amendments: Page 1, Line 1: Change “Chair Riley” to “Vice Chair Bruce James”

Page 2, Line 27: Change “limit” to “affect”

Page 3, Line 4: Add “and Sarah Riley” after “she” and add “and East Wilder Conservation Area” after “property”

A MOTION was made by Mr. Heistad to approve the April 13, 2023 minutes as amended. The Motion was seconded by Ms. Almay.

** The Vote on the MOTION was approved (7-0).*

3. OPEN TO THE PUBLIC

No members of the public were present.

4. PERMIT REVIEW

None

5. STUDY ITEMS

A. 2023 Goals Review

Mr. Goodwin explained that the Commission members had identified three lists of Action Items:

1. Projects to undertake from the City’s Master Plan
2. Strategic Plan – Department work plans – actions proposed to happen over a 2-3 year window
3. List of goals for the year – list of brainstormed ideas developed at the start of each year

1 He said a list of desired goals for the group were identified in the February 2023 meeting.
2 Mr. Goodwin said he compiled that list from the meeting minutes and developed a
3 DRAFT copy of the Goals for 2023 and cross-checked it with the three lists of projects
4 identified. He said this meeting's goal was to focus on the Goals for 2023. He said he
5 noted the bulleted items on the list where a "who" and/or "when" needed to be identified.
6 Mr. Goodwin shared a DRAFT copy of the Goals for 2023, which included the following
7 sections:

- 8 • Property Stewardship
- 9 • Education/Outreach
- 10 • Land Conservation
- 11 • Miscellaneous

12 13 **Property Stewardship**

14 Ms. Hirai said the bulleted goal item related to signs/kiosks/maps should be moved to a
15 fairly high priority. She also said maps are pretty unclear and need to be updated. She
16 said they needed to create signs to communicate "closure due to restoration" and "no
17 harvesting/forestry."

18
19 There was discussion about wildlife cameras on public properties and what regulations
20 are in place to govern their use. Mr. Oidtmann said there's a camera that's been up for a
21 few weeks overlooking the vernal pool on Farnum Hill. Ms. Hirai said Lebanon's new
22 Ranger, John Tietjen, does have a camera installed. Chair Riley said she had not learned
23 that cameras were installed until the Wild About Lebanon and she'd be interested to see
24 what the cameras have captured. Mr. Heistad said he's seen cameras on Signal Hill. Chair
25 Riley said she would email Ranger Tietjen and ask him if he has installed wildlife
26 cameras and what he's been seeing.

27
28 Mr. Heistad said there was a question about whether residents who are allowed to walk
29 on private property are now allowed to install cameras as well. Ms. Almay said the
30 current regulations are vague as to whether people can put up cameras. She said it is
31 being discussed in the State Senate. She said some hunters have been using cameras to
32 hunt deer and this practice has not been appreciated by landowners and others. She said
33 there is a proposed bill to require residents to put their names and telephone numbers on
34 wildlife cameras, and, if they want to install them on private property, they will need the
35 permission of the landowner before installation. Mr. Oidtmann said anyone who wants to
36 install a camera on public land should also have to let the Commission know. Chair Riley
37 asked if the City could enforce that kind of requirement.

38
39 Mr. Heistad said the NH Fish and Game Department may regulate this activity, as
40 opposed to the state. Ms. Almay said all such regulations come through Joint Legislative
41 Committee Administrative Roles (JLCAR). Chair Riley asked if any member of the
42 Commission would contact the NH Fish and Game Department to clarify regulations so
43 they can communicate them with residents and Mr. Oidtmann volunteered to contact
44 them. Ms. Almay noted that the bill doesn't become law unless the Governor signs it, so
45 it is not yet law. Mr. Johnson asked if someone could remove a camera from a property,

1 like someone might remove litter. Mr. Lacey said the cameras are not necessarily
2 nefarious and the Commission may consider a more general way of educating the public.
3 Mr. Johnson suggested language be added to the kiosks that residents need to notify the
4 City before installing cameras. Mr. Goodwin noted that some wildlife cameras have been
5 installed by the US Fish and Wildlife Service that has asked permission from the City. He
6 said is not aware of the locations of these cameras and they may be moved around. Ms.
7 Almay reminded the group that the law is being reviewed and the group should hold off
8 on making any changes to regulations until that review is completed.
9

10 Mr. Goodwin noted the only item in the Property Stewardship section that still he
11 identified as needing “Who” / “When” designations is related to Forest Management
12 Plans. He said there is a current inventory of properties with management plans and the
13 Commission needs to decide how much effort it wants to put into developing additional
14 management plans. He said it should also look at the list of recommendations for the
15 current management plans and see what it can accomplish. Mr. Goodwin said these plans
16 are on the City’s website on the Conservation Commission / Properties page.
17

18 Ms. Almay asked Mr. Goodwin whether he, as GIS Coordinator, has control over
19 updating the trail maps. Mr. Goodwin said he knows most maps had been updated as
20 recently as two years ago and said every property on the map has an updated trail. Ms.
21 Hirai said there are some discontinued trails that should be removed. Mr. Lacey said he
22 used a LIDAR map for Two Rivers and it was hard to know what was there because it
23 does not include trees. He said it’s nice when the trails on the kiosk could match what’s
24 on the ground. Mr. Goodwin said more and more people using the trails are using
25 interactive maps so it’s an on-going process to keep the maps up-to-date.
26

27 Chair Riley suggested a small working group be created to work with Mr. Goodwin to
28 update the trail maps. Mr. Goodwin noted he has many projects and he often must
29 prioritize them based on urgency. Mr. Johnson said he may be able to help with GIS
30 projects because he knows people at Dartmouth College who also have GIS experience.
31

32 **Education/Outreach**

33 Chair Riley said she’d like to prioritize the bullet item related to aquifer/water resource.
34 Ms. Almay suggested that the person at the state level in charge of Hydrogeology be
35 contacted to provide information to the Commission. She said the members need to
36 educate themselves before they try to educate others. Mr. Lacy said Mr. James was an
37 expert on water issues. Mr. James said Hydrogeology is a complex topic but he may
38 know someone who could conduct a day-long workshop about the City’s water resources,
39 its rivers and wetlands, and groundwater, etc. Mr. Johnson said he could see if anyone at
40 Dartmouth College could also be an educational resource on Hydrogeology. Ms. Hirai
41 said perhaps the topic of outreach awareness should be the responsibility of someone
42 working for the City instead of the Conservation Commission. Mr. Goodwin said
43 outreach is typically an action item for the DPW. He said DPW Deputy Director Jim
44 Anger used to work with businesses to educate them about potential pollution in the
45 drinking water watershed.
46

1 Ms. Almay said there's a huge aquifer that was found near the water treatment plant. Mr.
2 Goodwin noted that the location of the proposed well is in the floodway, but the City is
3 working on moving it. Chair Riley said she would like to see the City's report on that
4 aquifer. Mr. Goodwin suggested Chair Riley ask the City Manager to get a copy of that
5 report, which he said was likely developed by the consultant who presented it to the City
6 Council.

7
8 Mr. Oidtmann said a Mascoma River Cleanup is being organized for Saturday, July 22,
9 2023. He said the following groups will participate: Lebanon Rotary Club, Hanover
10 Rotary Club, Boy Scouts, Girl Scouts, High Schoolers, Young Professionals. He said the
11 Commission can help by organizing volunteers and email the contact information to him.
12 Chair Riley said the CRC website will probably not be ready in time to list the event and
13 Mr. Oidtmann suggested it be included on listserv, and Mr. Goodwin said the Planning
14 Board could disseminate a poster or other information about the event to its various
15 sources.

16
17 Ms. Hirai asked that this bullet item be rewritten that the Commission "supports the
18 efforts of the Rotary for the Mascoma Greenway Cleanup," instead of the Commission
19 will "host" the event. She also asked that the work related to invasives be added to the
20 Outreach section.

21 22 **Land Conservation**

23 Mr. Goodwin said the Commission should review the list of proposed action items from
24 the Wildlife study because a major grant is available. Ms. Hirai said if they are looking at
25 applying for grants for Wildlife Corridor projects in the Route 120 area, they could also
26 look at other properties in the area to protect. Mr. Goodwin noted that Rte. 120 roadway
27 is pretty high up and slopes down on both sides and there are wetlands to the west. He
28 said to the east, several critters, like the snapping turtles, are always crossing Rte. 120.
29 He suggested that a box culvert (which he said was one of the top recommendations from
30 the Wildlife Corridor study) could be created but it would be a massive, disruptive
31 project because Route 120 would have to be shut down during construction. He said the
32 project might have a better chance if it could be added to a replacement project for an
33 existing culvert. He said the Nicole Cormen Nature Preserve on one side of Rte. 120 and
34 landmark properties on the other side with some of the highest value wetlands. He said, if
35 it were able to be done, the project could also assist amphibian and small mammal
36 connectivity and be almost a flagship project. Mr. Goodwin said the state may also say it
37 within its control to do such a project, so there are many unknowns. Chair Riley said
38 maybe the Commission could work with other Boards to work on grant writing for these
39 types of projects.

40
41 Ms. Almay said she brought this item to the Planning Department last year: she said there
42 is a parcel of about 17 acres of land near Baker's Crossing on the edge of Mascoma River
43 that includes a wet meadow area. She said it gets dry enough that people picnic in the
44 area and leave litter and debris. She said it is owned by the people who live in the new
45 development next to Baker's Crossing. She said the owners have no interest in it. She
46 said it is not sellable but she suggested the City could offer to take this parcel off the

1 owners' hands in order to make it more protected. Chair Riley said she knows this area
2 but said she did not know how to protect it. She suggested a sign or Wildlife camera be
3 added as a warning about leaving trash. Ms. Hirai said the Upper Valley Land Trust has
4 more interest in protecting easements on land that is not currently being protected and if
5 the land area could be expanded around Baker's Crossing, the UV Land Trust might be
6 more interested in helping to put an easement on it. Chair Riley said the undeveloped
7 land around Baker's Crossing is not contiguous with this parcel being discussed, but there
8 are other undeveloped land between Baker's Crossing and the water. Ms. Hirai said it
9 would be very desirable if those could all be connected. Mr. Oidtmann said he has a
10 meeting with the Upper Valley Land Trust tomorrow (he is a trustee) and that group is
11 working on many projects and is working on getting more land areas conserved in
12 Lebanon. Chair Riley asked if he would discuss the parcel that Ms. Almay mentioned
13 with the UV Land Trust. He said he would ask them if there's a possibility of preserving
14 more land upstream from Baker's Crossing, but he said would need an accurate map
15 when he talks to them.

16
17 Chair Riley said the Commission had talked about expanding steep slope regulations to
18 all zones in the City. Mr. Goodwin confirmed there is no reason the regulations could not
19 be expanded to all zones. He said the Commission members could start by identifying the
20 issues the City may be experiencing on steep slopes and how adequate the current
21 regulations are and then research what has been done in other communities. He said
22 vernal pool research of other communities could be started now and may be a better
23 choice of priority because it is an on-going concern, as opposed to steep slope
24 regulations, which has not really been an issue for eight years or more. Ms. Hirai
25 suggested the work they want to do with vernal pools could be tied to other conservation
26 areas for grant applications. Mr. Goodwin also said the state came up with a number of
27 template regulations that could also be a good starting point.

28 29 **Miscellaneous**

30 The group had a discussion about the regulations governing the LOST fund and whether
31 all or some of the funds could be invested. Mr. Goodwin said he doesn't know the
32 regulations, but he has gotten no real answers related to whether interest can be earned on
33 the funds. He also said he did not know how to become a member of the governing group
34 of the LOST fund (called the Trustees of the Trust Funds). Mr. Lacey noted the group
35 was fortunate to have the funds and 100% access to it. Mr. Goodwin said the account is
36 safe, but it might not get future funding. Ms. Hirai said she liked the idea of looking at
37 lands to acquire and use the money wisely. Chair Riley said it could also be used for
38 lands to protect.

39
40 Ms. Almay asked what LID techniques were, as included in the bullet related to
41 communication with DPW regarding maintenance activities. Mr. Goodwin said LID
42 stands for Low Impact Development. Chair Riley said when they were developing goals,
43 she was trying to be more forward-thinking in terms of storm water management and
44 replacing culverts to find solutions that would also be more wildlife friendly. She said
45 that is why it is important to collaborate with DPW efforts so these ideas could be
46 incorporated into planned projects. She mentioned the improvements planned for West

1 Lebanon and the drainages that will be coming off the hill above Main Street. She said
2 there may be opportunities to make those drainages more like streams and make that area
3 more wildlife friendly. Mr. Heistad said it would be wonderful for kids in downtown
4 West Lebanon to see amphibians. Chair Riley said if the City does acquire the property at
5 the base of Church Street West there is a stream in a yard that no one knows is there. She
6 said it could be turned into a beautiful and functional pedestrian and/or bike park/corridor
7 with the stream.
8

9 Mr. Goodwin said culvert replacement is a great opportunity to integrate these design
10 ideas. He said they've had a report for about six years from the RPC that's an assessment
11 of about 120 priority culverts that need replacement. He said usually culvert replacement
12 has been more crisis-based but the City has hired a dedicated Asset Management person
13 to get these projects done more proactively.
14

15 6. COMMITTEE REPORTS

16 A. Biodiversity Group (Invasives)

17 Workshop: Ms. Hirai said two foresters gave a talk (workshop) at 2 Rivers which was
18 attended by about 25 people who seemed to enjoy it. She said people seemed to be
19 interested in the most common invasives. Chair Riley noted that, since it has not been
20 mowed in some time, some native floodplain species, like silver maples, are starting to
21 grow in the meadow. Chair Riley said the foresters said to consider the area a recovering
22 floodplain forest instead of a meadow and maintain it that way.
23

24 Garlic Mustard: Chair Riley said the garlic mustard has been pulled for the last three
25 weeks. She said she and Ms. Hirai pulled garlic mustard at 2 Rivers three weeks ago. She
26 noted that the garlic mustard was less dense where pulling had taken place two years ago.
27 Mr. Lacey said he'd been pulling invasives from Baker's Crossing and, in the area of
28 mile marker 135-8, there were eight flowering plants.
29
30

31 B. Stewardship 32 - Ranger

33 Mr. Lacey said Ranger Tietjen has been appointed and has been working at Baker's
34 Crossing, but he is not an experienced chainsaw operator. He suggested he be sent for
35 chainsaw safety training. Mr. Goodwin confirmed the new Ranger has been onboarded
36 but is involved in the Science Olympiad and his science class is going to the national
37 competition, so he will have a delayed start this season. In the meantime, Ron, the now-
38 retired Ranger, is filling in. Mr. Goodwin said he receives weekly reports from Ron that
39 he has been hitting the properties and trails. He said Ron gives his time as well as some
40 money because he has to pay for gas and other supplies to go to all the trails. Ms. Hirai
41 suggested a thank-you send-off be held for Ron. Mr. Oidtmann said he worked with
42 Ranger Tietjen on Farnum Hill and he noted he should wear a helmet and face protection.
43

- Trail Coordinator

Mr. James said he contacted stewards and set times to go out to trails and see what they think needs to be done. He said a few stewards have decided not to continue. He said Mr. Craig Sanborn, head of the Cardigan Highlanders Volunteer Trail Crew, has offered his expertise and assistance to the Commission. He said Mr. Sanborn is an expert related to building waterbars, treadway work, etc. He said he gave him a field book called *Maintenance and Rehab Guidelines for Volunteers* written by the Appalachian Trail Conference. He said it's a good resource on layout of different trails, drainage issues, treadway, safety. Mr. James suggested Mr. Sanborn could supervise a specific project (like building a waterbar) and a donation could be made to the Cardigan Highlanders Trail Crew. Ms. Almay asked if he might have some ideas about how to stabilize the staircase as the edge of Cole and Mr. James said he might. Chair Riley said it would be interesting to see what he'd say about some of the troublesome trails.

Mr. Heistad said as of 10 days ago, Signal Hill trail was clear around the pond, and as of three days ago, the road coming off Ben Hudson Parkway was clear also. Mr. James and Mr. Heistad said they would put up signs that Mark created.

Chair Riley said she heard there was some draining of a vernal pool at Signal Hill. Mr. James said someone cut drainage channels to drain the trail but also drained the vernal pool. Chair Riley said it is illegal to drain vernal pools. Mr. James said it was a wet area that should remain wet because it is part of the vernal pool system. Chair Riley asked if there could be another sign added that says it is illegal to drain a wetland.

- Monitors and Stewards

Ms. Hirai said she and Mr. James went to 2 Rivers and cleared the nexus of the pathways, which worked well for the workshop that was held there. Mr. Lacey said it was unclear how much more mowing needs to be done. Chair Riley suggested mowing the main path and then the trail cutting across diagonally (which is the short-cut trail that the fishermen use). She said this would fall in nicely with the idea of letting this be a forest and not so much a meadow, as the forester at the workshop suggested.

Ms. Hirai suggested the Commission conduct a site visit to determine exactly what should be maintained. Mr. Goodwin said those on the site visit should consider the two management approaches: let this be a natural area with one maintained trail or maintain the entire trail system (which takes a lot of effort). Ms. Hirai said if the trails are not maintained, residents are less likely to want to walk them. Chair Riley suggested the group may want to meet and review and set management goals for this area, considering the management approaches Mr. Goodwin suggested. Mr. Heistad noted that people of all ages/mobility levels should be considered when maintaining these trails. The group set a meeting date of Thursday, May 18 at 4:00pm for the site visit and said it would be open to the members of the community.

1 Ms. Hirai said something needs to be done about people who are harvesting plants. She
2 said ramps were being dug up and said postings are needed, if not formal signs.

3
4 Chair Riley asked if the group should brainstorm events for Rotarian trail work. She said
5 the Young Professionals are planning a cleanup on May 20 or 21. Mr. Johnson said he
6 could attend.

7
8 **C. Wild About Lebanon**

9 Chair Riley said the April 22 Earth Day Walk was successful. She said it was attended by
10 Land Trust Volunteer Coordinator, Cassie Bernik. She said hopefully the Commission
11 will have many more collaborations with her.

12
13 **D. Amphibian Crossings**

14 Chair Riley reported that the Lions Club produced and collaborated with the DPW to post
15 four amphibian signs at Heater Road by Hypertherm and Old Pine Tree Cemetery Road.
16 Mr. Lacey said he saw the one on Heater Road was attached to the speed limit sign, so it
17 is getting noticed.

18
19 **E. LUCT/Current Use**

20 No update
21

22 **F. Other Subcommittees**

23 Mr. Oidtmann said he is looking for apprentices for the Mascoma River Cleanup to
24 eventually take over that effort. Ms. Hirai offered to help him make a binder of the
25 guidelines so the transition to the next leader is easier. Mr. Oidtmann said he needs
26 people at headquarters (at the Pavilion) to coordinate pickup trucks, etc.

27
28 Chair Riley noted that the Tree Board has been working on a tree ordinance and applying
29 for an IRA grant to plant trees where less advantaged folks might need them (for
30 example, planting shade trees around bus stops). Mr. Lacey said there are many parking
31 lots that need trees for shade for dogs. Chair Riley said the Planning Board has provisions
32 for many new proposed parking lots for the inclusion of shade trees that shade 30% of the
33 lot within ten years. Chair Riley said the tree ordinance also has a goal to require the City
34 to post any tree it wants to cut down on its property.

35
36
37 **7. OTHER BUSINESS**

38 **A. FYIs**

39 Chair Riley said there are no new FYIs, but she noted that the deadline for Pike Industries
40 is May 18 but DES can give them another extension. She said she would contact DES on
41 May 18 to determine status.
42

B. Follow Up

Mr. Lacey said last year, a woman had wanted to subdivide her property on Hardy Hill Road to sell it more easily. He said she had assured the Commission she was not subdividing so a development could be put there. He said Dana Key bought it and his son, Andy, is building a house on it. He said Dana said Andy is very excited about spending time in the 18 acres of woods there. He said there will not be a development there.

Chair Riley said Master Plan Chapter 5 Natural Resources will be discussed at the May 22 Planning Board meeting / Public Hearing. She asked if the actual draft text of the chapter could be added to the website so residents can review it prior to the meeting.

C. Workshops and Educational Opportunities

Mr. Johnson said the Upper Valley Young Professionals asked if the Commission would run a conservation workshop to discuss the issues that face the Commission and how people can get involved. He said it seems like it would be a good way to encourage interest from this group. Chair Riley said she could reach out to the new volunteer steward (Cassie Bernik) at the Upper Valley Land Trust to give the workshop.

Chair Riley said she sent an email to the group about two upcoming training sessions on the last Friday in May and the last Friday in June. Chair Riley said she and Ms. Hirai would be attending the June 2 training in Concord that will help the Commission be more effective in reviewing wetland permits.

Mr. Heistad noted that the kiosk at Jackson is in parts and is awaiting assembly. Mr. Goodwin said that is a job on Ranger Teitjen's list. Ms. Hirai asked if the Upper Valley Young Professionals could help with that project. Mr. Johnson said he would ask if the group were interested. Chair Riley said the Jackson property could be a good one for the next Wild About Lebanon and said there has been interest in walks up there to see the trails, meadows, and the blueberries. Mr. Heistad said the blueberry plants need pruning, so a blueberry pruning workshop may be needed. Chair Riley said if there's enough interest, they could get a group together and give training and then have a pruning event.

8. FUTURE AGENDA ITEMS**9. ADJOURNMENT**

A MOTION was made by Mr. Lacey to adjourn the meeting at 9:02pm. The Motion was seconded by Ms. Almay.

** The vote on the Motion was approved 7-0.*

The meeting was adjourned at 9:02pm.

- 1 Respectfully submitted,
- 2 Paula Roux
- 3 Recording Secretary

**FOREST OBSERVATIONS, DESCRIPTIONS
AND PRESCRIPTIONS**
for
THE BOSTON LOT and SIGNAL HILL
owned by
The City of Lebanon
located in
Lebanon, Grafton County
New Hampshire



Prepared by:
FULL CIRCLE FORESTRY
6078 Route 113
Thetford Center, Vermont 05075
(802) 785-4749

Ehrhard Frost, Certified Ecoforester, NH LPF # 103
Caitlin Cusack, Forester

December 2011

**FOREST OBSERVATIONS, DESCRIPTIONS
AND PRESCRIPTIONS**
for
THE BOSTON LOT and SIGNAL HILL
owned by
The City of Lebanon
located in
Lebanon, Grafton County
New Hampshire

Prepared by:
FULL CIRCLE FORESTRY
6078 Route 113
Thetford Center, Vermont 05075
(802) 785-4749

Ehrhard Frost, Certified Ecoforester, NH LPF # 103
Caitlin Cusack, Forester

20 December 2011

TABLE OF CONTENTS

	<i>Page</i>
Locus Map	
I. Introduction	1
II. The Landscape Setting	2
III. Forest Ecosystem Components & Stand Development	5
IV. Multiple Use Features	12
V. Examination Method and Forest Type & Natural Community Classification	17
VI. Management Objectives	20
VII. Adaptive Forest Management and Ecological Forestry	22
VIII. Guiding Principles	26
IX. Tract Descriptions	28
<u>The Boston Lot</u>	28
Location	28
Boundary & Survey Information	29
Covenants & Restrictions	30
Access	32
Tract Description	32
Topography (Topographic Map)	33
Soils (Soil Map)	34
Water & Wetlands	37
Land Use History	38
Forest Types: Descriptions & Prescriptions (Forest Type Map)	40
Tract Summary	69
<u>Signal Hill Tract</u>	72
Location	72
Boundary & Survey Information	72
Covenants & Restrictions	73
Access	75
Tract Description	75
Topography (Topographic Map)	75
Soils (Soil Map)	76
Land Use History	77
Forest Types: Descriptions & Prescriptions (Forest Type Map)	79
Open Land: Descriptions & Prescriptions	90
Tract Summary	92
X. Conclusion and Summary	94

APPENDIX

Works Consulted

Glossary

Partial Botanical List for the Boston Lot & Signal Hill Tract

A Table of Maturities and/or Expected Ages & Maximum Ages of
Selected Trees of Northern New England

Species Abbreviation

Key to Forest Stand Coding

THE BOSTON LOT and SIGNAL HILL TRACT

I. INTRODUCTION

Two properties, Boston Lot and Signal Hill, encompassing 656 acres and owned by the City of Lebanon, New Hampshire are the subject of this report. Both properties are found in Lebanon, Grafton County, New Hampshire. The 439 acre Boston Lot is located in the northwest quadrant of the City of Lebanon.

Signal Hill was purchased by the City of Lebanon on December 21, 2001. This tract occupies 217 acres, is located just north of down town Lebanon in the Northeast quadrant of town.

The locus map depicts the each parcels' physical location within the city and their geographic relationship to each other.

Both tracts are protected by conservation easements. The Society for the Protection of New Hampshire Forests (SPNHF) holds the easement on the Boston Lot (both the original tract and the addition). The easement on the Signal Hill tract is held by the Upper Valley Land Trust (UVLT).

The forest inventory of the properties was conducted between August and October 2010. This plan was developed for, and funded by, the City of Lebanon Conservation Commission. The document is intended to describe the current condition of the forest, to identify resource concerns and to incorporate the landowner's objectives into management recommendations and prescriptions.

We are grateful to Tracey Thibault, former Associate Planner for the City of Lebanon, for initiating the project and coordinating it until her departure from the Planning Office in December 2010. Additionally, we would like to thank Mark Goodwin for mapping support and research assistance and for assuming coordination of the project when Tracey departed; Mark created the Locus Map, Soil Map and topographic Map for the properties. Many thanks to the Conservation Commission for allowing us time to present proposals and preliminary findings and for reviewing this document. Special thanks to those members who were able to attend either or both of the field tours of the Boston Lot and Signal Hill. We benefited from your input and insight into both of these properties and that insight greatly contributed to our ability to develop the recommendations included in this plan.

II. THE LANDSCAPE SETTING

Landscape Context

The City of Lebanon falls within the Northern Connecticut River Valley subsection of the VT-NH Upland ecoregion. The region is characterized by valleys of glacial outwash and glacial lake deposits, lower slopes of glacial till and metamorphic bedrock (Sperduto and Nichols 2004). Boston Lot is contiguous with the Indian Ridge Conservation Easement and the Landmark Lands, which together make up a significant tract of unfragmented forest important for large-ranging wildlife species such as black bear and moose. These species can require from 1,200 to 11,000 acres for their home range depending on the quality of the habitat (Keeping Track 2000).

Hydrology

Average annual precipitation in southwestern New Hampshire is approximately 38" that is evenly distributed during the course of the year. Snowfall typically occurs during the latter part of November through March, and sometimes into April. Average annual snowfall is around 65".

Geology and Soils

The site productivity, hydrology and vegetation of Boston Lot and Signal Hill are significantly influenced by the underlying bedrock. The bedrock of this region originated as sediments deposited during the early Devonian Period, approximately 400 million years ago, when an inland sea covered this region. Subsequent episodes of mountain building events metamorphosed these sedimentary rocks to create a magma dome, later known as the Oliverian granite gneiss pluton, on the north side of Lebanon. The Bedrock Geology Map of New Hampshire (Lyons et al. 1997) indicates that this bedrock is mainly quartz-bearing igneous rocks: Oliverian biotite granite and granodiorite, which are fairly weather-resistant. Partridge mica schist, a metamorphic rock, is found underlying the Boston Lot addition at the lower elevations along Route 10; this rock is much less resistant to weathering than quartz.



At Signal Hill quartz is a component of the stone walls.

After the mountain building events, the landscape underwent many years of erosion that substantially reduced the size of these previously Himalayan-like mountains. Continental glaciers then covered the region, cycling through various periods of advance and retreat, the last one, the Wisconsin Glacier,

receding about 13,500 years ago. The glaciers affected the topography, water features, and soil of the Boston Lot and Signal Hill tracts by rounding hilltops, removing soil, and littering the terrain with glacial debris: glacial till, glacial outwash and lacustrine sediments. Glacial till, unstratified mixtures of silts, sands, gravels, stones, and boulders deposited by ice, overlies the majority of the Boston Lot and all of Signal Hill. These glacial deposits provided the parent materials for the formation of soil (Van de Poll 2010). Soils derived from glacial till that underlie the Boston Lot and Signal Hill properties include the Cardigan, Kearsage, Charlton, Bernardston, Stissing and Pittstown series.

A small percentage of the soil on the Boston Lot was formed from water-deposited parent materials, either glacial outwash or lacustrine sediments. These lake deposits are found at the lower elevations along the western boundary of the Addition. Outwash soils are found in valleys and on plains where the sediments were deposited according to size by streams flowing out of melting glaciers. The coarser stones and gravels were deposited first followed by finer sands and silts. The Rippowam and Quonset soils formed in outwash material and underlie the lower slopes of the Boston Lot addition.

Where glacial lakes formed, sediments were deposited along the shore or on the lake bottom. Finer silts and clay were deposited in the deeper and calmer waters of the lake center while coarse materials were deposited along the shore. The Hitchcock soil series is found along the western boundary of the Boston Lot Addition along Route 10 and in the southwestern corner of the tract. These areas were inundated by glacial Lake Hitchcock, which formed a long narrow lake as a result of damming by glacial debris in what is now Rocky Hill, CT and extending North to about present day Haverhill, NH and Wells River, VT.

High quality agricultural soils are classified by the Natural Resource Conservation Service (NRCS) based on their ability to produce food, feed, forage, fiber, and oilseed crops. Soils are classified in descending order of productivity as prime agricultural soils, soils of statewide importance or soils of local importance. Prime agricultural soils do not occur on either the Boston Lot or Signal Hill. Soils of statewide importance are less productive than prime soils but are still considered important for producing the above mentioned crops. The productivity of these soils is also impacted by factors such as steepness and erodibility. Soils of statewide importance include about 9 acres of Bernardston silt loam at Boston Lot, which is forested, and 2 open acres of Pittstown loam at Signal Hill.

Soils of local importance are less productive than soils of statewide importance and are further compromised by surface stones, water, steepness, and soil depth. Many of the stony phases of soil series ranked as of statewide importance fall into this category. A stony phase is indicated in these series when .5 - 3% of the soil surface is covered by stones >3" and < 24" in diameter (Van de Poll 2010). Additionally, soils ranked in this category that are poorly drained, or hydric, must have artificial drainage established and be actively farmed. Locally important farmland soils found on Signal Hill include about 4

acres of the very stony Pittstown loam and approximately 15 acres of the Cardigan-Kearsage complex. The Pittstown soil is forested. All but 2 acres of the Cardigan-Kearsage series, occupied by the South meadow summit is forested. Rippowam soils, found on about 3 acres East of and adjacent to the powerline junction of the Boston Lot Addition, is the only soil that could be considered locally important on that tract. However, Rippowam soils are considered hydric, or wetland soils. The area underlain with this soil is not artificially drained and is not actively farmed; and therefore, does not qualify as locally important farmland. Drainage installation for fields or pastures occupying hydric soils, though at one time common and recommended by the Soil Conservation Service (SCS), the predecessor to NRCS, is now prohibited by wetland regulations.

Soils of statewide or local importance represent 2% of the Boston Lot area; these soils are all forested. On Signal Hill approximately 10% of the area is underlain with soils of statewide or local importance; about 20% of this area is open and the remaining 80% is forested. Soils of statewide and local importance, though compromised somewhat for agricultural use as described above, are also very productive forest sites.

Land Use History

Regionally, much of the forests were cleared in the past to make way for farms and subsequent agricultural uses. These past land uses impacted and altered the landscape of the region. For example, heavy pasturing negatively affected soil and water resources by destroying native vegetation, compacting and/or eroding the soil and creating conditions conducive for the colonization of non-native invasive plants. Shallow soils are more susceptible to damage than deeper soils, though deep, heavy soils are also subject to severe damage, especially when wet (e.g. rutting and compaction). Past timber harvests were typically conducted with little regard for forest resources other than the commercial value afforded by timber extraction. Frequently, high-grade or heavy harvests were, and continue to be, the precursor to development or significant land use change. Unfortunately, the long-term consequences of such land use practices are not fully understood. However, evidence suggests that soil productivity is reduced for at least decades and probably a century or more by exploitive timber harvesting and inappropriate farming practices. Despite these abuses on a landscape level, forests quickly reclaimed abandoned agricultural land and today, seemingly thrive.

These historic regional land use patterns were replicated at Boston Lot and Signal Hill as evidenced by features described in the “Cultural Resources” section. Both properties, like many of the highlands of Lebanon, were most likely used as pasture. Agriculture was abandoned at Boston Lot much earlier than its river valley counterparts due to the harsher climate and poorer soils. The shift to mill trades also aided the demise of hilltop agriculture and allowed for the gradual return of forests to the highlands (Van de Poll 2010). Agricultural abandonment occurred much later at Signal Hill. Aerial photos

from 1955 indicate that much of the Signal Hill ridge was open or semi-open. Stand #4, white pine, was also punctuated by semi-open patches.

As agricultural land was abandoned, white pine colonized the old fields; the forest once again reclaimed the landscape. When the pine forests matured, they were frequently logged heavily. Remnant white pines and old stumps occur commonly throughout much of the Boston Lot. Evidence of past harvesting is largely absent at Signal Hill, probably due to the relatively young age of the forest. The Boston Lot was heavily cut by Peannie Goodwin in the 1960s. Peannie's typical practice was to harvest all commercial timber 12" DBH and greater that yielded sawlogs. Smaller trees and poor quality stems not suitable for logs were retained. A combination of thinnings, improvement cuts and group selection harvests were implemented as remedial treatments in 1987-88.

III. FOREST ECOSYSTEM COMPONENTS and STAND DEVELOPMENT

Ecosystem Components

The variation in forest ecosystem components between Boston Lot and Signal Hill is largely due to differences in the age and successional stage of the forest and management histories. These ecosystem components provide a myriad of wildlife habitats and support a variety of forest processes which in turn are necessary to provide forest function. A diverse composition and age structure provides the greatest degree of resiliency to climate change, diseases, and invasive pests and plants.

Diversity

Vertical diversity refers to complexity and variation of the vegetative layers within the forest. A forest stand with high vertical diversity exhibits multiple, well-developed layers comprised of understory herbs and ferns, shrubs, understory trees and saplings, a mid canopy layer and mature canopy trees. The Boston Lot forest exhibits moderate to high vertical diversity, while the forest occupying Signal Hill is low in vertical diversity and somewhat simple in structure.

Horizontal diversity refers to the distribution and abundance of forest developmental stages and habitats across the landscape. Within forest stands horizontal diversity refers to patchiness: areas of mature trees punctuated by canopy openings, interspersed with dense sapling regeneration, sections of varying density and composition. The greater the vegetative diversity, the greater the habitat diversity and the greater the wildlife diversity. The diversity of vegetative layers, from small seedlings and shrubs through tall, dominant, canopy trees, as well as species composition, are influenced and determined by available light.

Structural Components

Large trees, cavity trees and hollow trees are scattered throughout Boston Lot and Signal Hill. Areas of blowdown are found on both properties, though historic wind damage occurs at the Boston Lot and is recent in nature at Signal Hill. Wind events and single tree fall create down woody material. All of these features add structural complexity to the landscape. Although both properties have a similar geological foundation, the forest of the Boston Lot is older, and as such more vertically and horizontally diverse. This forest also supports an abundance of mast trees (defined below), higher species and age class diversity, and larger amounts of retained organic material such as downed logs and snags. Again, these features contribute to complexity and diversity of the forest.

Mast refers to the fruit and seed of trees that is typically utilized by wildlife as a food source. Mast take the form of either soft mast (black cherry, Juneberry, apple) or hard mast (the nuts of oaks, hickories, butternut and hophornbeam and the seeds of softwoods).

Native Plants

Native plants are vital ecological components, and in many ways define the ecosystem. A botanical inventory was performed at Boston Lot and Signal Hill by the inventory team of Ehrhard Frost and Caitlin Cusack; Rick van de Poll documented the flora and natural communities as part of the Lebanon Natural Resources Inventory (Van de Poll 2010). Plants were observed, identified to the extent of the inventory crew's ability, and recorded along transects and at inventory points from August to October 2010. (See the section, "Examination Method and Forest Type Classification", for a description of the inventory method.) Every acre was not visited or observed. The inventory timing precluded many plants, especially spring ephemerals. A total of 82 vascular plant species and 9 genera were noted during the inventory. The observed plants included 22 trees, 11 shrubs and vines, 34 flowers, 12 ferns, and 3 club mosses. The Partial Plant List is included in the Appendix. Consider this list initial baseline data that can be enhanced over time; plant diversity is far greater than the plant list implies.

Rick Van de Poll has mapped most of the Boston Lot as a Hemlock/Hardwood/Pine Natural Community. A small community of Appalachian Oak/Pine was designated on Honeysuckle Ridge. Signal Hill was classified as a Hemlock/Hardwood/Pine Natural Community.

Observations of plant diversity and abundance greatly aid the delineation of both the forest stands and the natural communities found on the property. Specific plants that occupy and indicate specific habitats, such as wet or enriched soils, provide a better understanding of the site. These plants provide insight into growth potential, site limitations, operability constraints and successional tendencies that relate to compositional changes over time.

Rich site indicators, like basswood, are found at very low abundance levels and their occurrence is extremely localized. Five rich site species were observed at Boston Lot and seven were observed at Signal Hill. Rich site species are indicated by bold italics in the stand species lists and partial plant list in the appendix. Enrichment is localized and limited. The low populations indicate low and localized enrichment throughout portions of each property.

Six state-listed plants are known to occur on the Boston Lot. Wild ginger (*Asarum canadense*) and wild leeks (*Allium tricoccum*) are species of “special concern” because they are somewhat uncommon in New Hampshire and are at risk of decline due to over-collection. Sharp-lobed hepatica (*Anemone acutiloba*), dwarf scouring rush (*Equisetum scirpoides*) and butternut (*Juglans cinerea*) are listed as watch species. State watch plants are vulnerable to becoming threatened because of low population size (21-100 natural occurrences in the state observed within the last 20 years), or plants that are, in the judgement of experts, vulnerable to becoming threatened due to other important considerations. Butternut and wild ginger were observed during the fall 2010 inventory. Wild leeks, dwarf scouring rush and sharp-lobed hepatica were observed by Van de Poll.

One state-listed species is known to occur at Signal Hill: barren strawberry (*Geum fragarioides*), a S2 species known to occur in only seven other locations in New Hampshire.

Species of several plant genera found on the property are on the 2010 New Hampshire Natural Heritage Bureau Rare Plant List. The following genera found on the property have species listed as S1, S2 or S3: numerous *Carex* (sedge) species, *Allium* (onion) *Galium* (bedstraw) and *Solidago* (goldenrod). State listed species in these genera, and other species not observed or recognized by the inventory crew may also be found on the property. Again, the partial plant list is only an initial record of the plant life found on the Boston Lot and Signal Hill properties; add additional species to the list as they are discovered or identified.

An ever increasing knowledge and appreciation of plants and the rudimentary ability to identify them and to recognize their significance has become an essential and critical forest assessment tool. Plant assemblages provide insight into successional tendencies, soil and site characteristics, nutrient availability, and natural communities. Continual monitoring of stand development and plant populations will provide greater insights into the plant communities of this tract and thereby guide future management decisions. In fact, this knowledge may provide the foundation for preserving the intricacies and dynamics of fully functioning native forests.

Stand Development

Forest development is influenced by bedrock, soil, water, climate and disturbance. Shade tolerant species such as hemlock, beech and sugar maple can reproduce and survive under low light levels. Intolerant species, such as paper birch or aspen require full sunlight to reproduce and thrive. The complex dynamic of forest succession occurs at different rates within stands on the property and across the landscape. These shifts are affected by past management practices and the environmental factors mentioned above. Natural disturbance, such as wind events and ice storms, further influence or interrupt what may otherwise appear to be an orderly stand progression from early successional to “old growth” stands. Some stand transitions or progressions are readily apparent, while others are more challenging to predict. These successional tendencies are important to identify; they impact the future forest composition and structure and heavily influence stand prescriptions. These are specifically discussed in the “Stand Descriptions” and “Prescriptions” section of this plan.

Disturbance

Natural and human disturbances play an integral role in stand development. These disturbances manifest themselves in many forms: ice and snow damage, wind and rain events (tropical storms and hurricanes), herbivory, invasive plants and insects and biotic and abiotic pathogens.

Forests are subject to many natural disturbances, some small and frequent in occurrence and others extensive and infrequent. Single tree fall is the most common disturbance both in the region's forests and on the Boston Lot and Signal Hill. This form of disturbance is caused primarily by wind, ice loading and natural mortality, expressing itself in canopy gaps created by single trees or small groups of trees. Pit and mound architecture on the forest floor was frequently observed in some stands, particularly on the Boston Lot, indicating past wind events. At Signal Hill a recent wind event tipped over approximately 2 acres of white pine in one area and also blew over trees in smaller groups and individually within stand #4. Windthrow and other disturbances allow greater light levels to reach the forest floor, frequently expose mineral soil, providing a seedbed for plants, and modify micro-climate. Disturbances, visualized as waves impacting the forest over time, encourage stand complexity and diversity. Human disturbances, in the form of silvicultural treatments, both pre-commercial and commercial (timber harvesting) can mimic natural disturbances.

Large-scale wind events or ice storms generally occur at intervals that transcend human life-spans. Return intervals for large-scale disturbances are typically 100 to 150 years or greater. Fire is not a primary disturbance factor in our portion of the Northeast due to the humid climate and the species

composition of the region; Northern Hardwood stands are not fire prone. Fire plays a greater role in the boreal forest than it does in the Northern Hardwood forest. However, prior to the “Smokey the Bear” fire suppression era, lightning-caused fires on softwood ridge tops were more common in this region. The most notable local example was the 1953 fire on the Grantham Mountain ridge. That fire is a fine example of the impact of fire on high elevation forests; bare ledge still dominates that ridge 58 years later.

Herbivory

Herbivory, particularly by white-tail deer is a significant disturbance at both Boston Lot and Signal Hill. Deer browse is particularly heavy on hardwood species and can significantly impact seedling survival and thus the future species composition of the forest. The 1987-88 harvesting at the Boston Lot successfully established a new tree generation, or cohort. Deer populations were lower at that time. Since then, development of hardwood seedlings has been arrested by heavy browsing. The migration of moose southward also has negative implications for hardwood regeneration, saplings and pole-sized trees of some species. At Signal Hill hardwoods have not successfully developed under the main canopy. The inability of hardwoods to naturally develop because of herbivory is creating an age class void in our forests as well as allowing invasive species to more readily proliferate.

Invasive Plants

Invasive plants are another disturbance factor with significant negative consequences. The implications for the forest as these plants seem to become increasingly common are discussed below in the section devoted to invasive plants.

Many invasive alien plants were intentionally introduced from Europe or Asia for ornamental plantings, erosion control, and wildlife food. The SCS was a strong proponent of planting many of these species, which are now known to create more harm than good. The fruits of these plants are consumed by various wildlife species, most notably birds, who then transport and spread seeds throughout the landscape. Invasive plants displace native species, suppress forest succession, and create localized monocultures if left unchecked. These alien plants and their continued spread are a threat to the composition and functionality of the forest ecosystem throughout the region. Invasive plants are typically prevalent adjacent to agricultural areas, in young forests that originated from fields and other areas of heavy disturbance.

Four species of non-native invasive plants were observed at Boston Lot and Signal Hill: Japanese barberry, bush honeysuckle, glossy buckthorn and common buckthorn. Glossy buckthorn is by far the most common on both properties, though Honeysuckle Ridge on the Boston Lot is aptly named.

Invasive plants at Boston Lot are confined to areas along the reservoir, in and on the edge of the power line R-O-Ws, along recreational trails, particularly Honeysuckle Loop, and limited areas of stands #1, #2, #3, #7, #8 & #12.

Signal Hill is heavily infested with invasives, primarily glossy buckthorn; common buckthorn, barberry and honeysuckle are also present at varying levels. Stand #4 and the upper field support the highest concentrations.

A specific invasive inventory was not conducted at either tract, though the presence and abundance levels of invasives was noted during all field site visits. Additional invasive species could be present in areas that were not observed during the inventory and populations could also vary from those observed. Invasive alien plants can, and do, displace native woody species. Disturbance, in any form, including silvicultural treatments improves conditions for invasives and promote their spread. The preference by deer for browsing native species provides an additional advantage to these alien plants.

Recommendations

- Conduct a thorough inventory and mapping of non-native invasive plants.
- Develop an integrated invasive plant treatment program that utilizes non-chemical and chemical control methods as recommended by a Licensed Herbicide Applicator in conjunction with forester input.
- Implement control practices prior to implementing silvicultural treatments.
- Implement follow-up treatments as needed.
- Monitor stands containing invasives, as well as adjacent stands.

Pathogens and disease

Ash decline or ash yellows disease, butternut canker, white pine canker and beech bark disease are forest health concerns that were noted on the subject properties. Each are described below:

- Butternut canker is a disease that affects butternut and is thought to be primarily caused by the fungus *Sirococcus clavigignenti-juglandacearum*. Symptoms of the disease include dying branches and stems. Spores from the dying branches are spread by rainwater to tree stems and eventually lead to death (Burns and Honkala 1990). Remedies or control mechanisms are not available.
- Beech Bark Disease affects American beech, which prior to the introduction of this insect/fungus complex, was the longest lived hardwood in the forests of our region. A fungus, *Nectria coccinea*, enters the tree with the help of a scale insect that carries the fungal spores and inoculates the tree. *Nectria* upsets normal bark formation, which makes the tree susceptible to decay-producing fungi and thereby attracting carpenter ants. The weakened trees are susceptible to beech snap, caused by the inability of the trunk to support the weight of the crown, and therefore breaking. American beech sprouts aggressively from the roots and responds to disease and the resulting stress by vigorously

sprouting. Eventually a dense beech thicket emerges on some sites resulting in difficulty establishing a diverse mix of regeneration.

Approximately 5% of the beech are believed to be genetically resistant to this pathogen. Individuals exhibiting smooth bark manifest resistance and should be retained. The majority of the beech in New England and New York are infected; remedies are unavailable.

- Ash yellows disease has potentially affected a number of white ash trees particularly in stands #3 and #5 on the Boston Lot. Ash yellows is a disease that causes slow growth and decline of ash species, particularly white and green ash. Undiscovered until the 1980's, ash yellows is caused by wall-less microbes, called mycoplasma-like organisms, (MLOs), that are thought to be transmitted by leaf hoppers and related insects. Symptoms include permanent and rapid declines in tree growth, crown dieback and witches brooms at the trunk base. Diseased ash may still exhibit moderate growth unless other factors, like drought and competition, provide additional stress. Infected trees typically die within one to five years. Cures or protection methods are unknown.
- Pine canker (*Caliciopsis pinea*) was observed on white pine at the subject properties. Pine canker is prevalent in the dense pine stands found on Signal Hill and less common on the Boston Lot, where pine form a scattered, rather than a continuous canopy layer. This fungus reduces crown density, thereby reducing tree vigor and growth. Trees and stands infected with pine canker are also more susceptible to other pathogens and environmental stresses. This disease may affect long-term survival of infected trees. Symptoms include significant crown dieback and a related increase in crown transparency and profuse pitch flow between the whorls in the mid to upper stem, where bark is thin. Pine canker is not well understood; it was first identified in New Hampshire in 1997. Thinning infected stands to increase light, temperature and air flow and thereby reducing moisture levels may reduce the incidence of the fungus and mitigate its impact on tree health. This strategy yields mixed results.

Insects

Three non-native insects with the capacity to radically alter forest composition loom on the horizon: hemlock woolly adelgid, Asian longhorn beetle and emerald ash borer. The woolly adelgid has caused wide spread mortality of hemlock throughout the southern portion of this species' range (from Massachusetts South to the Appalachians in the Carolinas). This insect is present in Massachusetts, southern New Hampshire and in the Connecticut River valley of Vermont as far north as Rockingham. The likelihood of the hemlock woolly adelgid impacting this region is high. Officials at the NH Division of Forest and Lands believe that New Hampshire's hemlock will experience significant mortality within about 10 years.

The Asian longhorn beetle is responsible for killing thousands of maples, native and alien (Norway), in the Worcester, MA area. The State of NH, Division

of Forest and Lands, Forest Health Program is emphasizing both prevention and early detection of this insect. Asian longhorn beetle does not currently occur in NH. This insect attacks hardwoods, with a particular preference for maples.

The emerald ash borer (EAB) infects all species of ash: white, black and green. This insect is known only to impact ash and causes mortality. EAB occurs near Saratoga, NY, in the Canadian province of Quebec and there is an unofficial, and as yet unsubstantiated report, of an occurrence near the Danville, VT area. Most experts expect this insect to cause severe, and possibly complete, mortality to the ash components in the region. Several seed collection and saving efforts are in progress, including a Native American (Mohawk) initiative and a US Forest Service program. The intent is to re-populate ash species throughout its range after the EAB has killed the current population and the insect has hopefully died due to the lack of its host.

The prospect of these three insects and their collective impact on the region's forests is numbing. Control efforts are expensive and frequently ineffective, especially at landscape scales. The best protection against these insects is to encourage and maintain both species and age class diversity to the greatest possible extent.

Climate

Lastly, the impacts of climate change will result in temperature shifts, variations in disturbance regimes, and altered precipitation levels, all of which will influence our forests. Current predictions indicate that this region will likely become both warmer and wetter. Species composition and ranges are predicted to change and stand development patterns may not conform to those historically experienced. This will create added challenges for both foresters and landowners.

IV. MULTIPLE USE FEATURES

Cultural Features

Boston Lot and Signal Hill support various artifacts, both human-made and natural features that speak to past settlement and land use. At Signal Hill extensive networks of stone walls and barbed wire fence are found. Large open grown white and red oaks occur scattered throughout the Boston Lot, with remnants of stone wall or old fence along boundaries and around portions of the lake. The old reservoir itself represents both a cultural and water resource. These features are all testament to human influence and an agrarian past.

Stone walls delineate about half of the northern boundary as well as much of the western property boundary at Signal Hill. Barbed wire fence is found along these and other lines where walls are absent. The southern

property boundary starts at Alden Road as barbed wire, becomes defined by a blazed line to the jog in the southwest corner and then alternates between wall and wire. Several interior walls were observed within the property, formerly delineating various pastures. These generally run southeast to northwest. Several metal farm objects were observed near the southwest corner.

Signal Hill is aptly named for the positioning of a signal post on the South Summit in colonial times. This post was part of an extensive and intricate network that relayed warnings using semaphore arms during the day and fire at night. Small-scale commercial mining of kyanite and copper occurred at Signal Hill. A small open pit copper mine is located uphill from the two small ponds on abutting property and referenced in the hydrology section.

Defining and documenting the extent of the cultural resources on this tract is beyond the scope of this project. However, these vestiges of an agrarian past are a reminder of just how extensively the original forests were cleared to raise livestock and crops. The network of stone walls, barbed wire, open grown oaks, and open pit copper mine are all historically valuable features.

Recommendations

- Protect cultural features from unwarranted disturbance.
- Maintain and enhance the current condition of these features wherever possible and desirable.
- Define, document, map and delineate cultural features prior to performing forest management activities.

Wildlife Features

Direct wildlife observations and wildlife sign were noted and recorded during the inventory at Boston Lot and Signal Hill. The inventory itself presents a limited time in which to capture an accurate account of actual wildlife use on any given property. Therefore, structural components (described above), such as vertical and horizontal diversity, mast tree abundance, tree and plant species diversity (especially unique species), downed woody material, cavity trees and the abundance and size of snags were observed, quantified and qualified to provide an indicator the quality of wildlife habitat.

Game animals, non-game birds and mammals, amphibians and reptiles utilize various structures for a range of activities such as, breeding, nesting, roosting, foraging, perching, and territorial or other displays. Numerous species are known to utilize cavities to nest or den in. For example, pileated woodpecker, yellow-bellied sapsucker, flickers, great horned owl, barred owl, red-headed woodpecker, hairy woodpecker, black-capped chickadee, red-tailed hawk, winter wren, tufted titmouse, raccoons and porcupine. The size range is obviously wide and speaks to the need for trees and cavities over a range of

sizes as well. Snags and downed wood provide denning sites, thermal cover, protective cover, and food for black bear, weasels, skunks, voles, mice, raccoons, bobcat, otters and foxes.

Mast refers to the fruit and seed of trees that is utilized for food by wildlife. Mast take the form of either soft mast (black cherry, Juneberry, apple) or hard mast (the nuts of oaks, hickories, butternut and hophornbeam and the seeds of softwoods). Over 180 different birds and mammals use oak acorns as food: squirrels, blue jays, crows, red-headed woodpeckers, deer, turkey, raccoons and bear, to name a few (Burns and Honkala 1990). While uncommon, unique species like basswood are also an important wildlife component. Basswood is well known as a honey-tree; it is pollinated by a number of bees and insects. The seeds and twigs are eaten by mice, squirrels, chipmunks, upland game birds, songbirds and porcupines. The leaves have high levels of nitrogen, calcium, magnesium, and potassium at the time of leaf fall, which constitute nutrient inputs to the soil.

The Boston Lot supports greater vertical and horizontal diversity, higher species and age class diversity and larger volumes and quantities of structures such as down woody material, snags and cavity trees. Northern red oak, occurring individually and in groups composes a substantial portion of the species composition on this tract. Additionally, white oak and bitternut hickory are scattered throughout portions of the property, contributing to the available hard mast. These species have filled the mast void created by the chestnut blight, beech bark disease and butternut canker. Most importantly, Boston Lot, Indian Ridge/Sachem Village Open Space Conservation Easement and the Landmark Lands owned by Dartmouth College form a large, contiguous and undeveloped landscape, which provides interior forest habitat for birds and travel corridors for large mammals. Substantial areas of undisturbed landscapes occur less frequently as development pressures increasingly spawn residential and commercial uses in heretofore remote locations. This provides essential functions, in conjunction with adjacent and abutting properties, on the larger landscape. The diverse attributes of the Boston Lot, such as the size of contiguous forest, the large reservoir, the abundance of mast trees, and diverse array of small, distinct habitats such as rock outcrops, patches of white oak, vernal pools and streams, that punctuate the larger upland forest matrix, provide critical wildlife habitat in the Upper Valley region.

The forest inventory and NRI inventory teams observed evidence of bear, wild turkeys, deer, squirrels, woodpeckers and other wildlife usage on the property.

- Most bear sign observed during the NRI inventory—claw marks on tree boles, excavated logs, piles of scat, bite marks on saplings, regularly used trails, and even bear “nests”, were concentrated on the Landmark Lands and near Boston Lot Lake. An estimated five to seven bears live in this large unfragmented block of land, which is among the highest concentration in Lebanon (Alcott Smith, p.c. in Van de Poll 2010).

- Painted and snapping turtles, Lake chub, northern pearly eyes and largemouth and smallmouth bass were all observed at Boston Lot Lake (Van de Poll 2010).
- While Boston Lot is not high quality habitat for moose, sign was noted on the adjacent Landmark Lands.
- Based on the regularity and dispersed nature of the records, mink should be expected in all locales of the City (Van de Poll 2010).

While Signal Hill is not well suited for certain large-ranging mammals and aquatic species, the undeveloped mosaic of hemlock and white pine forest and open grasslands provide habitat for species like deer, turkey, and squirrels as well as unique species like river otter and monarch butterflies. Sign of river otter was recorded at an off-road track set on Signal Hill. Signal Hill is also a good locale for butterfly flights (Van de Poll 2010).

Recreational Features

Permitted recreational uses at Boston Lot and Signal Hill include hiking, skiing, horseback riding, biking and hunting. The Boston Lot has a well-established network of recreational trails that are heavily used by dog walkers, hikers, runners, bird watchers, and mountain bikers. During the five days of inventorying and examining the tract fishing and camping activity was also observed. The majority of the existing trails were originally harvesting trails constructed and/or installed during the 1987-88 harvesting operations. These trails are generally in good condition. Drainage issues plague small localized sections of the trail system and minor erosion over small areas was also noted. A combination of water and erosion control techniques, such as ditching, culvert and /or bridges installations, waterbarring and perhaps seeding exposed soils, can solve these problems.

Signal Hill supports a single trail recreational trail connecting the trailhead parking lot, located on the North end of Alden Road, with the South Summit; this trail continues southerly onto abutting property. Recreational use of Signal Hill appears to be far less than that experienced at the Boston Lot.

The network of recreational trails at both the Boston Lot and Signal Hill are vectors for non-native invasive species. Seed of invasive plants is spread by feet and tires, by mechanical means (mowing) and by birds and mammals that also use the trails as flight paths and travel lanes.

Timber

Timber was not identified as a management objective or subject of concern by the Conservation Commission. However, silvicultural treatments designed to accomplish goals and objectives, can produce timber products with substantial economic value.

A Forest Management Plan was prepared for the City of Lebanon by Continuous Forest Management, Inc. (CFM, Inc.), owned by Ehrhard Frost, in April 1987. That plan recommended an improvement cut, in some areas combined with thinning and in other areas in conjunction with various regeneration harvests, over about 260 acres of the 330 acre ownership at the time. These silvicultural treatments were conducted within the following currently designated stands: #1, #4, #6, #7, #8, # and #11. Treatments were not conducted on every acre and treatment intensity varied greatly based on the stand condition. The improvement cuts were remedial in nature, designed to improve timber quality in previously high-graded stands. Thinnings were applied to stands, or portions thereof, that supported high stocking levels of good quality timber. These treatments were designed to concentrate growth on the best quality stems. An overstory removal, with retention, was implemented in stands that supported low quality trees in the main crown canopy and a high quality understory. Group selection harvests were conducted in portions of stand #9 to regenerate species such as red oak.

The recommended treatments produced 333,764 BF and 372 cords composed of 233 cords of hardwood pulp and firewood, 67 cords of hemlock pulp, and 72 cords of pine pulp. Additionally, an unknown volume of whole tree chips, primarily hemlock and white pine, were produced. That unknown volume likely ranged from at least 300 cords to over 500 cords. The 1987-88 harvest removed about 25% of the total estimated board foot volume and probably 25-30% of the total pulpwood volume on the property.

The sale of forest products from that operation generated \$61,435 in gross stumpage receipts for the City. The City incurred various fees and expenses including: forester's fees for marking, supervising and administering the timber sale (about \$12,600), boundary location, blazing and painting fees (\$964), expenses for trail and landing design, supervision and administration of road improvements, trail and landing construction (\$359) along with the actual construction costs (\$8,630) and soil stabilization expenses (\$433). The net income received by the City of Lebanon was \$39,589.

The current forest conditions of the Boston Lot, as well as the extensive trail network, are a direct result of the 1987-88 harvest. That harvest was conducted to meet the management objectives articulated at that time by the City: improve future timber quality and provide increased recreational opportunities. The treatment accomplished both goals while also improving

species and structural diversity and protecting water resources, rare plants and exemplary natural communities.

V. EXAMINATION METHOD AND FOREST TYPE & NATURAL COMMUNITY CLASSIFICATION

Ehrhard Frost and Caitlin Cusack examined and inventoried the Boston Lot in September and October 2010 and the Signal Hill property in August and October 2010 using a GPS unit and GIS maps provided by the City of Lebanon. The Boston Lot was last inventoried in 1987 by Forest Management, Inc. (Ehrhard Frost) using a standard point sampling method. The 1987 inventory determined forest types, mapped prominent land features and gathered standard stand data including trees/acre, basal area/acre, sawlog and pulpwood volume/acre and species composition. The 2010 examination was qualitative in nature, emphasizing biodiversity, forest health, stand dynamics and structure and wildlife habitat; timber data was not collected.

Forest stands were initially delineated using aerial photographs and the Boston Lot stand map from the 1987 management plan. Coarse level data on overstory, midstory and understory composition, physical features such as topography and bedrock outcrops, and cultural features, such as stone walls and fences, were collected by walking meandering transects throughout the forest.

Detailed forest inventory data was collected at ten observation points at the Boston Lot and five observation points at the Signal Hill property. The following forest features were recorded at each observation point: forest type, size class, timber stocking level, crown cover, and vegetative composition (overstory, midstory and understory plants). Ecosystem components (e.g.: horizontal and vertical diversity, unique trees and mast trees) were noted and qualified. Other structural components such as cavity trees, snags and retained organic material (ROM) were measured. Snags and cavity trees greater than 10" DBH were sampled using a ten basal area factor (BAF) prism and tallied by species and 2" diameter classes. ROM (down woody material) greater than 16" in diameter at the largest point and at least 16' long were tallied by species, diameter and length within a 0.08 acre fixed plot (1/2 chain [33'] radius) embedded at point center. Occasionally, smaller pieces that did not meet these specifications were also tallied. A fixed 1/1,000th acre (3.72" radius) regeneration plot was also embedded at each observation point.

Aspect, surface features and terrain were also noted and recorded. Forest health factors including insect and disease presence or impact, logging damage, ice, snow or wind damage, and other signs of disturbance were noted and qualified. Water resources, wildlife sign and usage, human-made features such as roads, trails, stone walls and wire fences and other cultural features or evidence of human activity and land use were noted and/or mapped. Seven

hardwood and eleven softwood increment cores were obtained to estimate stand age and to evaluate disturbance history and forest stand dynamics.

Soil information for the Boston Lot and Signal Hill was obtained via soil map overlays provided by the Lebanon Planning Office and from the **Soil Survey of Grafton County Area, New Hampshire** (USDA NRCS 1987). Soil descriptions and site indices for tree species were obtained from that document.

Forest types were classified using the Society of American Foresters (SAF) forest types (SAF 1975, SAF 1980). The Society of American Foresters define a forest type as: "A descriptive term used to group stands of similar character as regards composition and development due to given ecological factors by which the may be differentiated from other groups of stands... Further, a cover type is a forest type now occupying the ground, no implication being conveyed as to whether it is temporary or permanent." The bulletins emphasize composition instead of development as the basis for identifying forest types and utilize the following principles to recognize them:

- The cover type occupies large areas in aggregate. The type does not necessarily cover a large area in a single stand, but composition is characteristic and typical throughout a considerable range.
- The cover type is distinctive and easily separated from other types that it closely resembles. Transition areas are always found in the field and result from natural occurrences, including those of man.

Forest cover types are named using species that describe the composition. Species appearing in the type name generally compose fifty percent or greater of the type. The SAF publications list and number forest types based on the habitats that they normally occupy: dry, fresh to moist and wet. Forest types on Boston Lot generally fall into the Northern Forest region but some Central Forest Region types also occur on the property. The inventory of the Boston Lot and Signal Hill property utilizes the SAF classification system because it emphasizes ecological factors and natural forest development rather than commercial timber species.

The forest types are arranged in the report first by their SAF sequencing. The sequence is next determined by size class when two or more of the same type occurs, (largest diameters first). Stand stocking or density (highest first) determines the listing order when the first two characteristics are the same. Finally, acreage (largest first) is used to determine sequence if all other determinants are the same.

A three-part alphanumeric stand code is used for mapping purposes. These codes utilize the name of the forest type in abbreviated form (alpha), a numeric code for size-class and an alpha code for stocking levels. The stand code WP/RO/RM4A translates to a white pine/red oak/red maple forest type composed of trees predominately in the standard (sawlog) size class, which is

fully stocked for timber production. SAF numbers are only used in the text for reference. Please refer to the Key to Vegetative Coding found in the Appendix for a complete listing of forest types, size classes, and stocking levels with their respective codes.

Note that stocking guides have been developed by forest researchers to compare actual numbers of trees to optimal numbers for timber production. These guides are usually developed for evenaged stands and are, therefore, not suitable as a measure of site occupancy in unevenaged or multi-aged stands. Unevenaged stands tend to more fully occupy a site due to the presence of multiple crown layers. In this report stocking levels are ranked based on a combination of stocking guidelines, site occupancy, crowding and competition judged by field observations, not solely on Forest Service stocking guides themselves.

Natural community types were also determined utilizing ***Natural Communities of New Hampshire*** (D. Sperduto & W. Nichols 2004) and an unpublished companion key by Peter Bowan.

VI. MANAGEMENT OBJECTIVES

The Lebanon Conservation Commission identified the following general management objectives for the Boston Lot and Signal Hill tracts.

High Priority

Maintain and encourage a functioning, vital, indigenous forest.

- Protect and maintain all forest components, structures and functions.
 - Soil, water and nutrient and energy cycles
 - Fragile habitats and conditions including wetlands, water courses, seeps and springs and shallow soils
 - Rare, threatened and endangered plants and exemplary natural communities
 - Snags and cavity trees
 - Retained organic material (or down woody material)
 - Legacy Trees
- Encourage forest diversity.
 - Native plants
 - Native animals
 - Tree size and age class
 - Large diameter and uniquely formed trees
 - Unusual species
 - Stand density
 - Horizontal and vertical diversity

Identify natural communities and vegetative types that would benefit from active management to increase diversity.

- Grasslands
- Shrub habitats
- Productive and accessible forestland

Control and prevent the proliferation of exotic invasive plants.

- Develop a plan to control invasive species on both parcels.

Medium Priority

Improve and maintain wildlife habitat.

- Protect and maintain all forest components, structures and functions.
 - Wetlands, water courses, seeps and springs
 - Snags and cavity trees
 - Retained organic material (or down woody material)
 - Legacy Trees
- Encourage forest diversity.
 - Native plants
 - Tree size and age class
 - Hard and soft mast trees and shrubs such as red oak, white oak, cherry, raspberry species
 - Horizontal and vertical diversity

Improve and maintain the forest for low impact public recreation and education.

- Maintain public access to town properties and provide modest parking.
- Provide low impact dispersed recreational opportunities, such as walking, skiing, snow shoeing, bird watching, nature observation, hunting and fishing, for the public.
- Consider other recreational uses, such as mountain bike trails, consistent with land constraints and easement conditions (where applicable).
- Encourage the educational use of the properties by schools, the community, professional organizations and educational groups for natural resource study.

Maintain and protect cultural and historical resources.

- Stone walls
- Cellar holes
- Wells
- Cemeteries
- Native American cultural sites

VII. ADAPTIVE FOREST MANAGEMENT AND ECOLOGICAL FORESTRY

This section of the forest plan is an attempt to define a new paradigm for forest management and the practice of silviculture. In developing the following silvicultural guidelines we draw heavily on scientific research and many years of forestry experience, and forest observations. "Guidelines for Biodiversity Compatible Forestry" from Wetland, Woodland, Wildland by Elizabeth Thompson and Eric Sorenson and research and publications by renowned and innovative foresters such as Jerry Franklin, Herb Hammond, Bill Leak and Chris Maser were also utilized to help shape this forest management approach.

The practice of forestry in this country is very young, only about 100 years old. Expressed in other ways:

- forestry in North America has been practiced for less time than the maximum attainable age of bigtooth or quaking aspen, both among our shortest-lived tree species!
- forestry on this continent has been practiced for less than one-eighth the maximum life span of Eastern hemlock, our longest-lived species in the Northeast!

Our silvicultural systems were handed down to us from Europe. These systems applied orderly agricultural models to the forest ecosystem. Forestry emphasized simplification and uniformity of the forest for the singular purpose of commodity production. Rotation ages and diameter objectives were rigidly applied. Regeneration methods were developed for the sole purpose of regenerating and growing commercially important tree species.

As society demands an increasingly intricate array of amenities from the forest, and as we realize that maintaining ecological function is essential to the production of these amenities, it follows that silvicultural systems must evolve to address both societal demands and our increased knowledge of natural functions. The basis of traditional forestry is actually rendered obsolete by the changing demands of our society and our increased knowledge of the complexity of all natural systems, including our forests.

A change of perspectives is the first essential element necessary to implement ecological forestry. The forest must become the focus, not the forest products. Forest structure, function, complexity and processes are necessary, and in fact, are responsible for creating the desired products. Further, we must recognize and appreciate the limits of our knowledge. We must embrace humility in our approach to the forest.

New nomenclature and terminology is also required to move beyond the traditional confines of even-aged and uneven-aged forest management. New definitions broaden perspectives, allow for a wider range of options for forest management and silvicultural systems. Expanded definitions and new terminology allow us, as foresters, to move into a new and dynamic role in concert with the forest ecosystem.

Forest management and applied silviculture also requires an adaptive management approach. Foresters must practice from a humble perspective acknowledging that our prescriptions are merely working hypotheses with uncertain outcomes. Management must be designed to enhance learning, knowledge and awareness, not to promote and maintain the status quo. Foresters must monitor and evaluate prescriptions, treatments and outcomes. Forestry must be flexible and adapt to changes in both knowledge and conditions. Management must be as dynamic as the very system it hopes to manage. Nothing in the forest is static. Only through observation and monitoring can foresters continually hone their silvicultural skills and avoid management pitfalls. This requires active, ongoing involvement, site-specific knowledge and a continual search for better understanding. Complacency results in the failure to retain the forest structure, integrity and function required to maintain sustainable forest ecosystems. Foresters must also assume responsibility for informing their clients when they make unrealistic demands on the forest and its capacity to produce goods and services.

Forests are complex and as such must be managed for wholeness and complexity instead of efficiency and simplicity (Kohm and Franklin 1997). "A biologically sustainable forest is a prerequisite for a biologically sustainable yield (harvest)" (Maser 1994). Sustainable ecological forestry must be based on the interaction between species and the processes that both create interdependence and define ecosystems (Kohm and Franklin 1997). Time must be redefined and approached on an ecological scale, not a human scale. The emphasis must be on structure, function and process, not on a desired commodity outcome. Make no mistake, society can extract commodities and amenities from the forest, but only in so far as structure, function and process are supported by the management system.

Ecological forestry is then necessarily based on a new perspective that requires a new terminology, both of which work together to create new approaches to management. The following basic ecological forestry principles and guidelines form the foundation for silvicultural prescriptions within this forest plan.

- Maintain soil structure and productivity. Minimize soil erosion, disturbance and compaction. Protect soil by harvesting only during appropriate weather and seasons. Frozen and/or snow covered ground affords maximum protection. Maintain nutrient cycles by retaining organic material on the forest floor and above ground as both live and

dead trees. Do not interrupt the down slope movement of soil, water and nutrients.

- Maintain the naturally occurring species composition of all native plants and animals. Utilize silviculture to restore the composition of radically altered stands to a naturally occurring species mix for the site.
- Harvest only from the abundance, retain and protect the rarities. Generally, utilize silviculture to create diversity of species, size and age classes and forest structures. Attempt to increase minority species that would naturally occur on sites within stands and throughout ownerships.
- Emulate natural disturbance regimes. Apply silvicultural techniques and schedules that are similar to natural disturbance patterns. Maintain higher stocking levels than traditionally recommended for optimum, short-rotation timber production to achieve slow-grown, fine-grained timber. Allow trees to achieve larger diameters than traditionally advocated. Utilize long cutting cycles, generally 15 to 25 years; occasionally a 10-year cycle may be appropriate, especially in young stands on good sites, and cycles of greater than 25 years may be necessary on poor sites. Remember, though it is natural for a tree to fall, it is not natural for that tree to move off-site. Do not harvest decayed trees. Allow them to return to the site. The lifetime of a tree may be far shorter than the time required for it to decompose. There is life in death and the decomposition process is a part of the essential energy flow within the forest; death provides vitality.
- Utilize silviculture to stimulate the development of species and structures that will naturally evolve over time on a site. Thin stands early to emulate the stem exclusion stage and promote development of a complex understory. Harvest to mimic natural disturbance. Use what is traditionally known as single tree and group selection. Single tree selection mimics individual tree fall. Group selection takes many forms from very small openings to mid-sized patches to large groups, all of which have counterparts in natural disturbance regimes. Allow natural disturbances, which will occur regardless of human management, to initiate stand replacement (clearcuts) on a large scale.
- Incorporate perpetual, variable retention of all stand structures and elements to ensure that the entire range of naturally occurring forest structures (i.e., retained organic material, snags and snag replacements, Legacy Trees, mycorrhizal fungi and other forest components) are present in the forest. Legacy Trees remain for their natural life cycle within managed stands; they represent the perpetual retention component of the multi-aged retention harvesting system. Strict criteria for the number of trees or basal area/acre are not necessary. However, recognition of the critical role these Legacy Trees play and the structures

and functions they support, is necessary for successful implementation. Generally, retained Legacy Trees should fall in a range of 10 to 20% of the basal area of a fully stocked stand. In large diameter Northern hardwoods assume full stocking is between 100 and 125 square feet of basal area/acre. Full stocking of softwood stands ranges from 180 to 260 square feet of basal area/acre. This translates to 10 to 25 square feet of retained basal area represented by roughly 5 to 13 trees/acre that are 18 inches DBH and greater in hardwood stands. In softwood stands retain between 18 and 52 square feet of basal area/acre or about 9 to 25 trees/acre, depending on the forest type. When an individual dies, another Legacy Tree will be designated. Retain Legacy Trees that represent the range of species and form found within stands. Legacy Trees should include a wide range of specimens including the best examples of form required for timber production to cavity trees and declining/decaying stems. These Legacy Trees provide a biological legacy for subsequent cohorts, provide essential elements of stand structure and ensure the continued function of the forest. Maintaining the dynamic natural processes of the forest is the only certain mechanism that will allow truly sustainable product extractions from that forest.

- Practice multi-aged management. This management strategy incorporates perpetual, variable structure retention harvesting principles that are adaptable to a wide range of species and forest types. This approach ensures that the entire range of naturally occurring forest structures remains within the forest. (See above.) Eliminate rotation age and maximum diameter objectives, both commodity constructs, from the “old school” management regime. Visualize regeneration as a continuous wave-like pattern rather than a definitive point in time triggered by age or diameter. When harvesting base the selection process on tree quality, vigor and site suitability. Retain those most likely to survive and maintain or improve in quality. Harvest those trees that appear least likely to live and improve in quality. However, always retain some trees that are not suitable for timber; they serve essential biological functions. Multi-age management requires working at various crown levels within stands. Follow harvests with Forest Stand Improvement (FSI) practices such as cull removal, weeding, thinning and release. Accomplish this by girdling large excess trees that do not contain sawlog volume or are not designated as Legacy Trees and drop excess smaller stems.
- Eliminate and prevent the spread of exotic invasive plants. Utilize a variety of control methods including mechanical and chemical techniques. Whenever possible, control invasive plants prior to performing silvicultural treatments, especially commercial ones such as thinnings, improvement cuts and harvests. Limit disturbance and maintain dense stands for long time periods to discourage invasives. Attempt to retain 300’ uncut buffers between infested areas and

uninfected areas. Invasive plants can, and do, modify and affect natural vegetation.

- Maintain a functioning forest first and foremost; all other desired outcomes will follow. Implement treatments that preserve future options and opportunities. Evaluate and modify treatments as necessary to achieve the desired goals and to accommodate an understanding of the site as more information is obtained.
- Identify, manage, and protect sensitive, fragile, unusual or rare plants, animals or communities. These are necessary and vital parts of the ecosystem.
- Relax utilization standards. Recognize that any removal of any portion of a tree is not natural. Only those portions of the stem and that portion of the forest that have true economic value justify harvesting. Accomplish stand improvement for commodities and amenities via FSI practices when harvest are not justified.
- Relax top logging requirements, except where human use demands this level of aesthetic manipulation. Top logging is costly and dangerous. Lopping tops frequently severs established regeneration. Lopped tops do not supply the range of wildlife and micro-site habitats typically found when trees fall or break.

VIII. GUIDING PRINCIPLES

The recommendations and prescriptions in this report are firmly guided by the understanding that all things are connected; that humans did not weave the web of life, that we are merely a strand of that web and that whatever we do to that web, we ultimately do to ourselves. Any given forest ownership is only one small strand of the larger web. Forests are living, changing, functioning, resilient, diverse and dynamic systems composed of a vast number of plants and animals, both large and microscopically small. All forest components contribute to forest function; no part is more important or less necessary than any other part. A forest is much more than trees, and certainly far more than only those trees considered by humans to possess commercial value at some arbitrary point in time. Forests live in a time frame beyond human scale.

Additionally, these recommendations are further based on a respect for the intrinsic worth of all things; a respect for all components of the forest, those known and unknown, those seen and unseen, those understood and those not understood. The prescriptions are made from a humble perspective, but with strong convictions, and with the understanding that we, the "professional" foresters, still have more questions than answers. We know very little relative

to the incredible intricacies of the forest, yet our recommendations and actions can have far-reaching implications. Forester, conservationist and author Aldo Leopold wrote, "Only a mountain has lived long enough to listen objectively to the howl of a wolf." We believe the same notion applies to the forest.

"The Practice of Forestry" assumes new meaning: we are eternally practicing, continuously observing and endlessly learning. After many years of "practicing" forestry, we have discovered that our intuition provides a reliable guide that is just as valid as our professional, scientific and technical knowledge. We must, as Leopold implied, think like a forest. We must feel like a forest, not a forester. This intuition, together with our knowledge and experience, weaves a tapestry of respect for the forest that hopefully manifests itself in a humble approach to responsible forest use and care.

Responsible forest use maintains options and choices. After a choice is made we can make another choice, and still another. The more options we create with our choices, the more choices we have. A relatively "light" touch in the forest is preferable: choices remain numerous; harvests reap the abundance yet protect and maintain the rare and unique. Forest integrity, diversity and function are respected and maintained. The cardinal rule of "tinkering" with our environment is to keep all the parts. Waste does not exist in natural systems; all naturally occurring components have a place and a purpose. Diversity, stability and resiliency are ecologically inherent and necessary characteristics of all natural systems. Again, Aldo Leopold recognized these principles over one-half century ago. Many forestry professionals and forest landowners are just beginning to recognize and incorporate these concepts so eloquently stated by Leopold into current forestry practices. It is time for all of us to recognize that the forest is far more than only trees.

It is from this perspective that we offer the following suggestions to the Lebanon Conservation Commission, the Lebanon City Council and the citizens of Lebanon for the stewardship and management of the Boston Lot and Signal Hill.

IX. TRACT DESCRIPTIONS

The Boston Lot

Location

The Boston Lot fronts on the East side of Route 10 just north of Wilder Dam on the Connecticut River. The property extends southeasterly from Rt. 10 to just below the summit of Burnt Mountain. The parcel encompasses the 45 acre Boston Lot Lake and the surrounding upland forests. Boston Lot is contiguous with the Indian Ridge/Sachem Village Open Space Conservation Easement to the North. Dartmouth College owns most of the land abutting the Boston Lot to the north, east and south. TransCanada Hydro Northeast, Inc. owns land adjacent to the Boston Lot along the western boundary. Several residential owners also abut on the west.

Boston Lot Acreage Chart

Stand Number	Stand Code	Vegetation Type	Area (acres)
1	WP/RO/RM4A	White pine/red oak/red maple	51
2	WP/RO/RM4A	White pine/red oak/red maple	46
3	WP/RO/RM4A	White pine/red oak/red maple	38
4	WP/RO/RM4A	White pine/red oak/red maple	17
5	WP/RO/RM4B	White pine/red oak/red maple	8
6	WP/RO/RM4A	White pine/red oak/red maple	9
7	WP/HM4A	White pine/hemlock	73
8	WP/HM4A	White pine/hemlock	22
9	HM/HD4A	Hemlock/hardwood	78
10	HM/HD4A	Hemlock/hardwood	15
11	RO4A	Red oak	3
12	NHW/RO4A	Northern hardwood/red oak	16
		Reservoir	45
		Power line ROW	15
		Open	2
		TOTAL	439

Commercial forestland composes 86% of the Boston Lot, or 377 acres. Powerline right-of-ways occupy 15 acres. Openings, comprised of the old landing and areas around the dam, encompass 2 acres of the tract. The 45 acre Boston Lot Lake represents 10% of the parcel's area.

Boundary and Survey Information

Two surveys depict the Boston Lot boundaries:

- The original Boston Lot parcel is depicted on a plan by Morgan E. Goodrich, T&M Surveys, Inc., Lebanon, NH, dated January 1980 and titled ***Property of City of Lebanon, 'Boston Lot Reservoir'***; this is recorded in the Grafton County Registry of Deeds as Plan 8767.
- The additional parcel that was added to the Boston Lot in 2009 is represented on a survey titled ***Conservation Easement for City of Lebanon***, Route 10—Grafton County-Lebanon, New Hampshire” by Pathways Consulting, LLC, dated September 11, 2009 and recorded as Plan #13624 at the Grafton County Registry of Deeds.

Old wire fence forms the south, west and a small portion of the northern boundary of the original Boston Lot. A small section of stonewall is also found forming a portion of the northern boundary in the western portion of the tract. An interior fence is found on the east side of the reservoir. The corner monuments consist of iron pins or pipes in the western portion of the property. Walls or fences are absent in the eastern 2/3rds of the tract; boundary lines consist solely of blazes. Stone piles and stakes or stones set in stone piles form the corner monuments in this section of the Boston Lot. The boundaries of the original tract are delineated by old blazes recently (within about 2 years) painted red. Blazes are frequently healed and covered largely by bark in many cases. The painted blazes are infrequent and too low in many cases. The blazes have been painted within the last few years.

The boundaries of the 108 acre addition are not marked on the ground, excepting the common line with the original tract. The common boundary between the original lot and the addition is still in evidence, but no longer requires maintenance. Corner monuments on this parcel consist primarily of iron pins (rebar) or pipes; stone bounds are found along the common boundary with Transcanada.

Clearly marked boundaries protect property owners from adverse possession claims and timber trespass, demonstrate use and occupancy and define the limits of ownership and management. Blazing, followed by painting is the best method for marking boundaries. The blaze creates a durable scar that can be detected for decades, even if not maintained. A high quality brush

type paint designed and formulated for boundary application provides good durability. Spray paints are less durable than brush paints; fluorescent spray paints are the least durable paint and should be avoided.

Recommendations

- Locate and blaze boundaries on the Boston Lot addition in 2011-2012. Paint blazes 3 to 6 months later.
- Maintain boundary lines by painting blazes at 5 to 7-year intervals and re-blazing and painting at 10 to 15-year intervals.
- During the next maintenance interval re-blaze the original Boston Lot (excepting the common line with the addition). Increase blazing frequency. Utilize a combination of standard line, side and 45° blazes along the boundaries to provide good visibility when walking the boundary or crossing the line from both within the property and from abutting tracts. Utilize accepted protocols for witnessing corners. Paint 3 to 6 months after blazing. Schedule about 5 years after the lines were last painted (approximately 2015-17).

Covenants and Restrictions

The original 330.7 acres of Boston Lot was protected in perpetuity by the City of Lebanon and the Society for the Protection of New Hampshire Forests (SPNHF) in 1997 for the following purposes:

- The preservation of open spaces, particularly productive forestland and the undeveloped water frontage and water body of Boston Lot Reservoir.
- The protection of the natural habitat and wintering area of white-tailed deer.

The easement prohibits the following:

- commercial and industrial activities (except forestry);
- forestry activities that degrade conservation values, the future production of forestry crops and impair soil health and water quality;
- cutting of growth within 150' of the shoreline of Boston Lot Reservoir, except as necessary to maintain or construct recreational trails;
- subdivision;
- mining or quarrying activities or the excavation or removal of rocks, minerals and other soil and geological resources;
- advertising structures;
- dumping of trash or other hazardous substances;
- and the manipulation of site topography, surface or subsurface hydrology unless it is necessary for forestry, conservation, habitat management, or noncommercial outdoor recreational uses and does not harm state or

federally recognized rare, threatened, or endangered species or scenic, recreational and wildlife habitat protection purposes.

The Conservation Easement also specifies that forest management activities shall be performed in accordance with a coordinated management plan for the sites and soils of the Property and current scientifically based practices recommended by state and federal conservation and management agencies.

On June 1, 2007 the City of Lebanon acquired an additional 108 acres from Dartmouth College west of the original 330 acre Boston Lot. In 2009 the 108 acres were protected by the City of Lebanon and the Society for the Protection of NH Forests for the purposes of:

- Protecting outdoor recreation by and the education of the general public.
- Protecting undeveloped land within the same watershed as the wetland areas impacted by the development of the Lebanon Airport apron area.
- Conserving and protecting open spaces and natural habitats of plants and animal species native to New Hampshire.
- Enlarging the existing Boston Lot protected parcel.

The use limitations are similar to the 1997 easement with more specific limitations related to forest management planning including:

- The plan must be prepared by a licensed professional forester and approved prior to conducting harvesting activities by SFNHF.
- Any timber harvesting prescribed shall be conducted in accordance with the plan, under the supervision of a licensed professional forester and shall:
 - o maintain or improve the overall quality of forest products;
 - o maintain soil productivity;
 - o protect water quality, wetlands and riparian zones;
 - o conserve scenic quality;
 - o protect unique or fragile natural areas;
 - o protect unique historic and cultural features; and
 - o conserve native plant and animal species.

In addition, no rights-of-way or easements shall be created or developed without the prior written approval of SPNHF.

Access

Timber access was not considered during the project; The Conservation Commission (CC) did not identify timber management or production as an ownership objective for either the Boston Lot or Signal Hill. However, as mentioned during the last meeting with the CC, silvicultural treatments, in some cases taking the form of timber harvests, are a tool to accomplish stated goals and objectives.

Access to the Boston Lot for recreational use or for forest management is provided by a well-maintained and gated gravel road. The road begins at the parking lot off of Route 10 across from the Wilder Dam and winds uphill about half a mile to the western edge of Boston Lot Lake and an open area that was created for a landing to serve the 1987-88 harvest. Recreational access may also be gained from the Indian Ridge Conservation Easement via the Sachem Village-Northside Trail and from Water Tower Road via the Water Tower trail. The possibility of utilizing the Water Tower Road for timber harvesting access must be further investigated. Access to the Boston Lot is good for timber harvesting; the road can support log trucks. Access within the property is adequate; forwarding or skidding distances are long to the eastern portion of the tract. A trail infrastructure and landings are lacking on the addition to the Boston Lot.

The current network of recreational trails was largely created as the result of the 1987-88 harvesting. A main trail, known as Westside, leads northerly from the old landing on the west side of the reservoir, branching out into the interior of the property to the north and east, where numerous trails are found. The 1987-88 harvest did not include the portion of stand #3 south of the lake and harvesting was limited to areas immediately adjacent to the west of the Westside trail. Evidence of an older harvesting trail was noted south of the lake in stand #3. The extensive trail network provides access to a large portion of the property for mountain biking, hiking, nature observation, dog walking, and running. The Indian Ridge area, including the Boston Lot, also has a tradition of Native American use.

Tract Description

The Boston Lot encompasses 439 acres. Upland forest comprises 377 acres (86%) of the property. The Boston Lot Lake, formerly a reservoir, is the crown jewel of the tract. Powerlines are located in the southwest and west portion of the property. Two small open areas are found on the parcel, both in proximity to the lake. One open area is southwest of the lake and is associated with the dam and spillway. The other open area near is found west of the lake below the Honeysuckle Loop trail; this was constructed and used as a landing area during the 1987-88 harvest.

Small wetlands are associated with streams, seeps and springs and are embedded within the upland forest matrix. Six vernal pools were mapped on the Boston Lot during the NRI inventory, four of which were observed during the forest inventory. Four vernal pools occur in stand nine and two in stand seven.

Five Significant Ecological Areas (SEA) were identified on or immediately adjacent to the Boston Lot during the NRI. These sites require special consideration and treatment due to their sensitive nature and unique resource characteristics,. Long-term conservation and/or protection options to avoid human impacts, such as those created by recreational trails and timber harvesting, are examples of potential strategies to ensure the continued integrity of these areas. The conservation easements provide varying levels of protection for some of these areas. These Significant Ecological Areas include:

- **Boston Lot Lake** with deepwater habitats for largemouth and smallmouth bass; remote open water for migrating loons, ducks, and other waterfowl; a soft muddy shoreline with reedy shallows for mosquito, midge, caddisfly, or damselfly larva.
- **Rich seepages surrounding Boston Lake** where at least five rare plants have been documented (and described above) in addition to three species of uncertain status in the state: wild chervil (*Cryptotaenia chinensis*), giant cohosh (*Caulophyllum giganteum*), and bitternut hickory (*Carya cordiformis*). The rare plant occurrences are found in the seepages near the reservoir in stands one and three.
- **Burnt Mountain** where fire adapted species like red pine and oak testify to the mountain's fiery history. This ESA is found just over the eastern border of the Boston Lot on abutting property.
- **The hemlock-hardwood forest on the west slope of Burnt Mountain and the west-facing slopes to the north** provides dense hemlock cover for overwintering deer and habitat for fisher, raccoon, bear, moose, mink and otter. The extensive ledgy basins contain shallow vernal pools. These two SEAs are partially contained within stand #9. (Van de Poll 2010)

Topography

The Boston Lot Lake, at 638' above mean sea level, is the central physical feature of the Boston Lot. This old reservoir lies in a bowl surrounded by hilltops and ridges. Colburn Hill is located to the north, just off of the property at an elevation of 935'. The southeast corner of the tract is found just below the peak of Burnt Mountain which sits at an elevation of 1,029'. Bald Hill, at about 1,030', lies southwesterly of the lake and the powerline on the abutting property. The peak of Honeysuckle Ridge is found at 816' of elevation to the

west of the lake. The Burnt Mountain hilltop extends northwesterly and Honeysuckle Ridge extends northeasterly to Colburn Hill, the shoulders of which continue northeasterly to the Lebanon/Hanover town line. The headwaters of Trout Brook are located on these northerly slopes. Mink Brook Nature Preserve, a conserved property owned by the Hanover Conservancy, lies just north of the town line. Collectively known as Indian Ridge, this constitutes a substantial area of undeveloped and unfragmented forest bounded by Interstate 89 to the South, Route 10 to the West, downtown Hanover and Dartmouth College Medical center to the North and Route 120 to the East.

The surrounding forest of the Boston Lot rises up from the reservoir approximately 380' to the southeastern quadrant of the tract, which, at an elevation of 1018', is the height of land. The elevational gain from the lake to the top of Honeysuckle Ridge is 178'. The land rises about 276' from the reservoir to the highest point on the northern boundary just south of the water tower on the abutting land to the north. All aspects are represented in the surrounding forest, which in combination with the bedrock geology and hydrology creates a diverse mosaic of forest types.

The 108 acre parcel annexed in 2007 extends from the summit of Honeysuckle Ridge, at an elevation of approximately 816', to about 426' to Route 10. Slopes range from gentle to moderately steep.

Soils

The Soil Survey of Grafton County New Hampshire (1987) indicates that eight soil series, on five slope classes, underlie the Boston Lot. The diverse and complicated soil patterns on the Boston Lot are largely due to the influence of the Connecticut River and glacial Lake Hitchcock. The following table provides soil information and characteristics for the tract.

Boston Lot Soil Description

Soil Type	% Slope	Map Symbol	Acre (acres)	% Total Area	Drainage Class	Site Index
Cardigan-Kearsage-Rock outcrop complex	8-15	361C	59.8	14	Well drained	Eastern white pine 73 N. red oak 65 Sugar maple 65
	15-25	361D	247.4	57		
	25-60	361E	21.6	5		
Cardigan-Kearsage complex	15-25	360D	7.7	2	Well drained	
Hitchcock silt loam	15-60	130E	27.0	6	Well drained	Eastern white pine 75 Sugar maple 65
Charlton fine sandy loam	15-25	63D	1.3	<1	Well drained	N. red oak 65 E. white pine 65 Sugar maple 55 Red maple 55
Rippowam fine sandy loam ²	--	5	3.4	<1	Poorly drained	Red maple 75 E. white pine 65
Quonset loamy sand	3-8	310B	3.7	<1	Excessively drained	E. white pine 61 N. red oak 47 Sugar maple 52
Stissing silt loam	3-8	341B	10.5	2	Poorly drained	E. white pine 65
Bernardston silt loam ¹	8-15	330C	9.1	2	Well drained	N. red oak 55 E. white pine 65 Sugar maple 65 E. hemlock 65
¹ Soils of statewide importance.						
² Soils of local importance.						

The Bernardston silt loam soils (330C) are found on the lower slopes of the Boston Lot addition. These soils occur on glaciated hills and were formed in glacial till underlain with compact, silty basal till. Bernardston soils are considered very deep and well drained. Despite the well-drained classification, a hardpan layer, found at 16-36 inches, impedes drainage seasonably and during periods of high rainfall. Erosion hazard and equipment limitation are both ranked slight on this soil found on the Boston Lot and windthrow hazard is considered moderate. The USDA Natural Resources Conservation Service (NRCS) considers this soil favorable for producing quality hardwoods.

Charlton fine sandy loam, very stony (63D) soils are considered very deep and well drained. This soil formed in loamy sediments and is found on glaciated uplands; it occupies a small area on moderately steep slopes of the Boston Lot between the powerline and the southern boundary. The soil survey ranks this soil as favorable for hardwoods. Windthrow hazard is ranked slight. Erosion hazard and equipment limitations are both ranked moderate on slopes occupied by this soil on the Boston Lot.

The Cardigan-Kearsarge-Rock outcrop complex underlies 76% of the Boston Lot. The majority of this soil unit is found on 15% to 25% slopes. The Cardigan-Kearsarge-Rock outcrop complex (361C, D & E) occur in an intricate pattern on the landscape and soils are not mapped separately. Cardigan soils are silty, moderately deep and well drained; depth to bedrock is 20 to 40 inches. Kearsarge soils are silty, shallow and somewhat excessively drained; bedrock is found at 10 to 20 inches. Rock outcrops are less than 100 feet apart. Cardigan soils compose about 40% of the soils unit, Kearsarge soils 30%, rock outcrops 15% and other soils 15%. This soil series is found on undulating or gentle to steep slopes, hilltops and hillsides. Erosion hazard and equipment limitations on both the Cardigan and Kearsarge soils are ranked slight on slopes up to 15% and moderate on slopes between 15% and 25% and severe on slopes greater than 25%. Windthrow hazard is moderate on Cardigan soils and severe on Kearsarge soils regardless of slope.

The Cardigan-Kearsarge complex (360D) underlies the southwestern corner of the Boston Lot. Cardigan soils comprise about 45% of this soils unit, Kearsarge soils approximately 30% and other soils the remaining 25%. These soils are located on rolling or strongly sloping hilltops and hillsides. The soil texture, drainage and depth and rankings for erosion and windthrow hazard for these soils are described above in the previous paragraph.

The Hitchcock soils formed from the deposits of glacial Lake Hitchcock. This glacial lake was created when ice and debris dammed the Connecticut River during the period of glacial retreat. This soil unit is found at the lower slopes of the Boston Lot Addition, roughly between Route 10 and the powerline. This series is found on steeper slopes of 15% to 60%. The Hitchcock soil series (130E) consists of very deep (>65 inches), well drained silt loam. The deeper portions of this soil series contain silty clay loam or silty clay. This soil is found on lacustrine formed terraces along the Connecticut River valley in Southern and central New Hampshire. Inclusions comprise 10% to 15% of this series and may consist of: 1) moderately well drained Dartmouth soils; and 2) poorly drained Binghamville soils found in depressions and along streams; 3) pockets or low mounds of well drained Agawam soils are throughout some areas of this soil unit; and 4) excessively drained Windsor soils at the escarpment border.

Quonset soils (310B) consist of deep, excessively drained gravelly fine sandy loams. These soils are formed in sandy and gravelly glacial outwash material on plains, terraces, kames and eskers. This soil underlies a very small area of the Boston Lot on 3% to 8% slopes. Quonset soils are found on the

landscape with Windsor, Warwick and Haven soils. The Quonset soils contain more gravel than the Windsor soils, more sand in the subsoil than the Warwick series and more sand and coarse fragments in both the surface and subsoil than the Haven soils. Erosion hazard, equipment limitation and windthrow hazard are all ranked slight on the Quonset soils underlying the Boston Lot.

Rippowam fine sandy loam soil (5) is found on floodplains and oxbows along the southern half of the Connecticut River and its' tributaries. This hydric soil is considered very deep, poor drained and is nearly level. Rippowam is found on a small portion of the Boston Lot.

Stissing silt loam, very stony (341B) formed in silty glacial till underlain with compact, loamy basal till. This soil is deep, gently sloping and poorly drained. This unit occurs in slightly concave areas and shallow drainages of drumlins and glaciated uplands; the areas are irregularly shaped. Stissing soils are found at the Boston Lot along the southern shore of the lake and other nearby areas. Depth to bedrock is greater than 65"; a hardpan layer is found at 18" to 36". The water table is found between 18" and the surface from October through May; this is considered a hydric soil. Fertility and moisture are poor for hardwood growth and fair to good for red spruce and balsam fir. Erosion hazard is ranked slight due to the lack of slope. Equipment limitations and windthrow hazard are severe on these soils. These are not productive forest soils.

Sites at Boston Lot range from fair to excellent for tree growth. Site indexes range from 61 to 75 for white pine, 47 to 65 for red oak, 55 to 75 for red maple and 52 to 65 for sugar maple. Red oak, red maple and white pine are all suited to the soil and underlying bedrock on the subject properties and are also able to adapt to the changing climate. Sweet birch, bitternut hickory and white oak are other species, currently at the northern extent of their historical range, that are suited to the sites at the Boston Lot.

Water and Wetlands

Originally a beaver marsh and headwater stream, then a mill pond, Boston Lot Lake was dammed in 1953 to create "a remarkable impoundment of nearly unparalleled size... and of even more remarkable quality" (Van de Poll 2010). Boston Lot Lake is considered a true lake with a significant portion of its area supporting depths greater than 6.6 feet (i.e. deepwater) and possessing waved-washed shorelines. The fringe wetlands are less than 6.6 feet deep and are mostly vegetated during the summer. Boston Lot Lake and the fringe wetlands exceed the mean score for all ranked wetlands in Lebanon according to attributes related to ecological integrity: water quality, landscape connectivity, native plant abundance and hydrologic integrity, etc. Boston Lot Lake is ranked third, just below Martin's Brook and Hubbard Brook, as a candidate prime wetland. These wetlands are significant due to size, unspoiled character, and fragile condition (Van de Poll 2010). Four brooks flow into the reservoir and one stream drains the lake from a spillway at the southwestern corner. The reservoir outlet stream follows a steep ravine paralleling the

access road before coursing onto TransCanada Hydro Northeast, Inc. property and subsequently emptying into the Connecticut River just north of the Wilder Dam.

Six vernal pools were mapped at the Boston Lot and are concentrated in stand #9. Vernal pools are critical breeding habitat for certain amphibian species such as wood frogs and spotted salamanders among others due.

Land Use History

The Boston Lot, or portions thereof, was subject to historic clearing for pasture. The eastern portion of the tract may not have been cleared due to the steep slopes and shallow soils. The current forest is second, or possibly third growth and in the mid to, in some sections, late stages of forest development. The forest has had a significant recovery period since agricultural abandonment and the subsequent re-growth of the forest. A diameter limit harvest was conducted on the original Boston Lot in the 1960s. Evidence of harvesting on the addition was noted. This forester supervised harvesting on about 260 acres of the original Boston Lot in 1987-88. The forest has had 23 years to respond to treatments since the harvesting was completed; human disturbance has been largely confined to maintaining recreational trails. Major natural disturbances since that time include the 1998 ice storm and the April 2007 wind event, neither of which created significant damage or change in the forest. As a result of past human land use and natural processes, the Boston Lot supports a diverse, dynamic and complex forest.

Greater diversity of species, size and age classes (saplings, seedlings and small pole-sized trees) was observed within the canopy gaps created by the 1987-88 harvesting than is found in untreated areas. Untreated stands dominated by hemlock are homogeneous, uniform and simple in structure. Species diversity is low due to the dense canopy and low light levels. Structural diversity, both vertical and horizontal is also low. Stand #9 in the eastern portion of the property and stand #10 in the northwesterly portion of the tract support dense hemlock stands. These stands provide winter cover for white-tailed deer. However, winter cover without an adequate food supply does not provide viable habitat. Additionally, the locally high deer populations are negatively impacting hardwood regeneration and thereby the ability to establish new and additional hardwood cohorts. The hemlock woolly adelgid and the changing climate will certainly alter this dynamic between deer wintering areas, deer populations and hardwood regeneration establishment and composition.

The forest cover consists of twelve distinct stands comprised of five forest types. White pine/red oak/red maple (WP/RO/RM), which comprises 169 acres, or about 45% of the forest area is the most common forest type occupying the Boston Lot. White pine/hemlock (WP/HM), hemlock/Northern hardwood (HM/NH), red oak (RO) and northern hardwood/red oak (NH/RO) forest types are also found at Boston Lot. (See the Forest Type Map.) White

pine is a prominent component in the majority of the forest types, covering about 70% of the forest area, or 264 acres. The white pine/red oak/red maple is considered stable on the majority of the sites on the property and these species also make productive use of the soils underlying the tract.

The overstory of Boston Lot is generally dominated by Eastern white pine, Northern red oak and red maple with varying tree species associates depending on the aspect and soils. Stand #5 supports a significant white ash component. The total area classified as Eastern white pine/Eastern hemlock (WP/HM) and Eastern hemlock/Northern hardwood (HM/NH) forest types are roughly equal: 95 acres and 93 acres respectively. Stand #8 differs compositionally from stand #7, the other WP/HM type: a significant hardwood component is present. Black birch, white ash, yellow birch, aspen and white oak are all found within this stand. Stands # 11 and #12 are unique on the Boston Lot. The former is 3 acre stand of Northern red oak (RO) containing a significant component of white oak. The later NH/RO stand supports a diverse mix of sugar maple, red oak, bitternut hickory and other hardwoods. Some stands exhibit localized indicators of enrichment. Species such as basswood, butternut, maidenhair fern, wild ginger, white snakeroot, red baneberry and other rich site indicator plants are present in low abundance levels.

Again, species and age class diversity increases substantially within the canopy gaps created during the 1987-88 silvicultural treatments. Species and structural diversity decline in portions of the property that have not been harvested within the last 30 years, such as in stand #10. Plant and structural diversity also plummets in hemlock-dominated stands. The herbaceous, shrub and regeneration layer is extremely sparse and absent in some cases. Stands dominated by white pine and red oak in the main canopy frequently possess a hemlock, and/or American beech midstory; striped maple is also prolific in those areas with slightly higher light levels. These stands will shift, over time, in composition from white pine and hardwoods to hemlock and/or beech unless management efforts are implemented. Hemlock has a homogenizing affect on the plant assemblages and radically decreases diversity. Hemlock is already a major component of forest types occupying 189 acres, or 43% of the forestland on the property. The implications of climate change and the impact of the hemlock woolly adelgid will negatively impact this species. Efforts to create greater, rather than diminished, species and age diversity provide increased resiliency to pathogens and climatic shifts.

The majority of the Boston Lot forest is relatively young. Increment core samples indicate that most of the forest is 80-100 years old. Scattered remnant white pine, white oak, red oak, and on a more limited basis, sugar maple, are certainly greater than 100 years old. Age data from the 1987 inventory largely corroborates these data. A portion of the sugar maple component in stand #12 are about 60 years old. The hemlock component generally ranges from 60 to 80 years old, though increment core data and observations indicate that at least a portion of this species exceeds 125 years in stands #7, #8 and #9. Estimating the age of this species is difficult due to

its shade tolerance and ability to respond to release after undergoing long periods of suppression. One hemlock in stand #7 was aged at 124 years old. Beech were not sampled and a portion of this component is probably in the 80-90 year range. Age sampling by increment boring is also constrained by the borer length. A 12" borer was utilized to sample cores, therefore the largest diameter that could be feasibly sampled was 20" to 22". Those remnant super-dominant trees that punctuate the main crown canopy with larger than average diameters could not be sampled. The aspen and paper birch, short-lived, early successional species are probably 50 to 60 years old.

FOREST TYPES: DESCRIPTIONS AND PRESCRIPTIONS

Stand # 1: WP/RO/RM4A (SAF #20) 51 Acres

Forest type: Eastern white pine/Northern red oak/Red maple

Natural community type: Hemlock-beech-oak-pine (S5)

Soil Type: Cardigan-Kearsage Rock outcrop complex 15-25% & 25-60% slopes (361D & E)

Size class: Standards

Stocking level: Overstocked

Main crown cover: Moderate to dense

Stand Structure: Two-aged

Stand Description

Stand #1 is found in the central portion of the property. This stand forms a variable width strip along the majority of the west side of the Lake, extending northerly around about half of the north side of the lake and flaring out further east to the northern extent of the tract. The westerly portion of stand #1 was formerly mapped (in 1986) as a part of a 38 acre white pine/hardwood stand, while the eastern section was included in a 138 acre Northern hardwood stand which also encompassed the following currently delineated stands or portions thereof: #6 (all), #7 (a portion), #8 (a portion) and #11 (all). The stand was considered overstocked at that time. Observation points were not located within this stand, though the stand was visited and examined by the inventory team. The majority of the stand slopes southerly; along the western shore slopes faces east. The terrain ranges from nearly flat to moderate slopes.

Coarse level stand data was collected along meandering transects though the stand. Observations points were not located within this stand.

Super dominant Eastern white pine periodically punctuate an otherwise uniform canopy of Northern red oak and associate hardwood species such as

sugar maple, black cherry, white oak, red maple, yellow birch, white ash, and American beech. Open grown oaks (such as a 41" DBH white oak) and white pines are scattered throughout the stand, indicating former open land. Associated species are not evenly distributed within the stand. A localized concentration of paper birch occurs at the southern end of the stand near the reservoir shore. Localized, low levels of rich site indicator plants were noted: basswood is present in the overstory and red baneberry was observed in the understory. A pocket of sugar maple, red maple and black ash is found in a wet area just west of the stand boundary with stand #8.

American beech, red oak and hophornbeam are found in the midstory. Understory species are more densely concentrated along the western shore of the reservoir and include bracken fern, Christmas fern, intermediate wood fern, cinnamon fern, hayscented fern, sensitive fern, helleborine, Jack-in-the-pulpit, small white aster. Bitternut hickory and white ash regeneration were also noted.

Disturbance

Portions of this stand were harvested in 1987-88 per the prescription in the 1987 plan. Prior to treatment the stand was overstocked. The stand is currently considered overstocked, a testament to vigorous forest growth following the 1987-88 treatment.

Deer browse is severe on the hardwoods. This constant stress is significantly impacting seedling survival and thus, the future species composition of the forest. Heavy browse will favor hemlock and invasive species such as common and glossy buckthorn, honeysuckle and barberry. White ash are in decline probably due to ash yellows. The majority of the American beech suffer from Beech Bark Disease (BBD). Pine canker may be present on a portion of the pine component.

Glossy buckthorn, Japanese barberry (fruiting) and honeysuckle (fruiting) were found along both recreational trails and old skid trails, as well as along the edge of the lake. Japanese barberry, bush honeysuckle and glossy buckthorn are found at low to moderately dense levels between the west edge of the old reservoir and the Westside Trail. Additional small populations or scattered individuals also occur along the other recreational trails that traverse the stand.

Minor wind events uprooted single stems or small groups as well as snapped stems creating small canopy gaps. The white pine along the western shore have been particularly impacted. These gaps have been colonized by tree, shrub and herbaceous species, explaining the higher concentration of understory species along this shore.

Management Recommendations

- **Control invasive plants.** Specific control options include:
 - o Hand pull small plants with volunteers or contracted labor.
 - o Contract a licensed herbicide applicator in collaboration with the managing forester to treat invasives with 1) a basal bark application of Garlon 4 Ultra® (triclopyr) mixed with mineral oil; 2) a foliar application; or 3) a cut stump treatment (CST), both utilizing a glyphosate product.

The chosen control method depends on the species, infestation severity (size and density), site sensitivity, native vegetation present (especially state listed rare, threatened or endangered species), labor required and the potential number of repetitive treatments necessary to gain control. The attitudes of Commission members and the public regarding herbicides use is another element in the decision- making process.

Garlon 4 Ultra® cannot be used within 50' of standing water. A wetland approved formulation of glyphosate is required for both CST and foliar applications within 50' of standing water. A special permit is also required for herbicide applications within this zone as well. Cutting or killing invasives may be in conflict with easement stipulations. Discuss proposed treatments with the easement holder prior to implementation. Evaluate treatments the following year and repeat as necessary. Monitoring invasive plant populations and vigor is a critical component of controlling these alien species.

- **Identify, retain (in any managed stand) and potentially release American beech trees that appear resistant to beech bark disease.** Trees with smooth bark (those trees that do not display cracking, but instead have rounded knobs where the fungus is walled off) may be resistant. Retain and release all such trees during any silvicultural treatments.
- **Consider creating openings around rock outcrops** along the Western edge of the lake to provide basking habitat for turtles and snakes. Cutting vegetation within 150' of the shoreline of Boston Lot Lake is prohibited by the easement. However, other easement clauses may permit or encourage wildlife habitat improvement. Again, discuss the treatment with the easement holder.
- **Consider manipulating understory vegetation** to promote greater species diversity. This is a non-commercial silvicultural treatment that entails cutting a portion of the understory.
- **Consider periodic group selection harvests with perpetual Legacy Tree retention** to promote age, size class and species diversity.

Implement this silvicultural treatment beyond the 150' lake buffer. Identify and retain Legacy Trees, cavity trees and unique trees, including future recruits for these categories. Identify, delineate on the ground and buffer wetlands, streams and other water resources. Identify R, T & E plants and follow the NH Heritage Bureau's protect recommendations. Maintain and where possible enhance conditions for R, T & E species.

Stand # 2: WP/RO/RM4A (SAF #20) 46 Acres

Forest type: Eastern white pine/Northern red oak/Red maple

Natural community type: Hemlock-beech-oak-pine (S5) and Appalachian Oak-Pine

Soil Type: Cardigan-Kearsage Rock outcrop complex ,15-25% slopes (361D), Bernardston silt loam, 8-15% slopes (330C), Hitchcock silt loam, 15-60% slope (130E), Rippowam fine sandy loam, nearly level (5) and Quonset loamy sand,3-8% slopes (310B).

Size class: Standards

Stocking level: Overstocked

Main crown cover: Moderate

Stand Structure: Two-aged

Stand Description

The majority of stand #2 occupies the Boston Lot addition; it lies in the western portion of the property with frontage on Route 10. This stand is roughly bisected by a 125' power line R-O-W running north to south. The aspect ranges from west to southwest. The stand is found on gentle to extremely steep terrain. A complex pattern of soils underlies this stand. Cardigan-Kearsage Rock outcrop complex is found under the steeper west facing slope adjacent to stands # 5 and #12. Bernardston silt loams underlie the flatter terrain along the power line. Hitchcock silt loams are found at the lower elevations along Route 10. Rippowam and Quonset soils underlie the portion of the stand abutting stand #3.

Data for this stand were collected from one observation point and along transects.

This two-aged stand is composed of a 60 year old white pine and Eastern hemlock cohort and an older 100-110 year old cohort of red oak. Though younger, the white pine tower above the canopy of red oak, red maple and associate species including white ash, yellow birch, American beech, paper birch, big-toothed aspen, white oak, bitternut hickory, and black cherry. Hemlock, red maple, American beech, and hophornbeam occur at low to

moderate levels in the midstory. The species observed in the shrub and herbaceous layers are listed in the following table.

Ferns & Fern Allies	Flowers	Graminoids	Shrubs	Invasive plants
Christmas fern Intermediate wood fern Marginal wood fern Cinnamon fern Hayscented fern Northern beech fern	Hog peanut	None observed	Witch hazel	Japanese barberry Glossy buckthorn Bush honeysuckle

Regeneration is predominately red maple (an estimated 4,000 stems/acre) with patches of bitternut hickory and white ash. Most seedlings are free to grow.

Ecosystem Components

Stand #2 exhibits moderate vertical and horizontal diversity. Honeysuckle, barberry, raspberry and other shrubs are found at moderately dense levels in and along the powerline and in close proximity to the lake. Hard mast is moderate to abundant. Unique trees include basswood, bitternut hickory and white oak, which contribute significantly to wildlife value.

One 37' piece of course woody material 11" in diameter and one 20" snag was measured on the observation point in stand #2.

Hunters in the area have observed black bear feeding on berries in the power line ROW.

Disturbance

As mentioned above, this stand supports two cohorts: 1) an older N. red oak population that initiated 100-110 years ago, possibly following agricultural abandonment. The 60 year old open grown E. white pine and E. hemlock initiated about 10 years after the 1938 hurricane. The roots of a portion of the paper birch are perched, indicating that the seed germinated either on a log or on a tipped up root wad, that decayed or deteriorated over time, leaving exposed roots above the ground. This is a common phenomena following wind disturbance, and is one mechanism for determining wind disturbance history. The majority of stand #2 was included in the Boston Lot addition, purchased in 2007; any record of management history is unavailable. Cut stumps and a girdled basswood indicate that previous owners managed their property at some level.

Deer browse is particularly severe on hardwood species. American beech trees are heavily infected with BBD. White ash show signs of decline, probably caused by ash yellows.

The greatest threat to the long-term health of the stand and the property is non-native invasive species such as glossy buckthorn, Japanese barberry, and bush honeysuckle. The invasives tend to be concentrated on the edge of and within the power line R-O-W and near the Honeysuckle Loop Trail.

Management Recommendations

- **Control invasive plants.** Japanese barberry, bush honeysuckle and glossy buckthorn all occur at low levels within the stand and honeysuckle and barberry form a dense shrub layer along the powerline and near portions of the lake. Control options are as stated earlier:
 - o Hand pull small plants with volunteers or contracted labor.
 - o Contract a licensed herbicide applicator in collaboration with the managing forester to treat invasives with: 1) a basal bark application of Garlon 4 Ultra® (triclopyr) mixed with mineral oil; 2) a foliar application; or 3) a cut stump treatment (CST), both utilizing a glyphosate product.

The control method continues to depend on numerous factors including the species composition, the size/maturity of plants, the density of the infestation, site sensitivity, the presence and abundance of native plants (especially rare, threatened or endangered), labor and materials costs, and attitudes of the Commission and the public regarding herbicides use. Constraints of herbicide application in proximity to water are outlined above in the invasive control discussion of stand #1. The treatment of invasives in stand #2 is constrained by water in a very limited area; the majority of the stand is upland forest. The vegetation within the powerline R-O-W is managed by the utility and is subject to periodic herbicide application. Hopefully, this treatment is sufficient to prevent flowering and fruiting of invasive plants. Again, always discuss proposed treatments with the easement holder prior to implementation.

Evaluate treatments the following year; repetitive are inevitable. Monitoring treatment success and changes in the invasive population is a critical component of successful control.

- **Identify, retain (in any managed stand) and potentially release American beech trees that appear resistant to beech bark disease.**
- **Consider manipulating understory vegetation** to promote greater species diversity. This is a non-commercial silvicultural treatment that entails thinning portions of the understory.
- **Consider periodic group selection harvests with perpetual retention of Legacy Trees** to promote age, size class and species

diversity. The stand is currently composed of a fairly diverse mix of species. The presence of beech and hemlock in the midstory indicates a likelihood that these species could dominate future stands absent management and manipulation.

Beech, one of our longest lived hardwoods prior to the introduction of BBD, has had its life expectancy reduced by roughly half. This species remains a valuable source of hard mast, complementing the oak and hickory components of the forest on the Boston Lot. However, a balance between maintaining a beech component on one end of the spectrum, and allowing beech to become the predominate species on some sites at the opposite end of the spectrum, seems appropriate. Beech naturally ranges from the Maritime Provinces of Canada, South to Georgia, Alabama and Mississippi, where it tends to occupy the cooler Northern aspects and is found at higher elevations (up to 6,000').

Similarly, Eastern hemlock ranges from Nova Scotia to Maine, through the other New England states, the Central states and extending into the Western-most portions of North and South Carolina and the very northern-most reaches of Georgia and Alabama. From Massachusetts south, the hemlock woolly adelgid has caused extensive mortality of this long-lived species. Hemlock is the critical softwood component for deer wintering areas throughout the region. In fact one of the stated purposes of the conservation easement is the protection of wintering areas for white-tailed deer. The value of a winter deer yard is dependent not just on the shelter afforded by a softwood canopy, but also requires adequate food availability within a proximity that allows deer to obtain a net caloric advantage relative to the energy expended to travel to access that food. In this region, depending on your perspective either the deer population is too high or the food availability is inadequate. The indisputable evidence is that hardwood regeneration is severely browsed, causing mortality, creating voids in age structure and thereby modifying species composition. In the case of hemlock, this dynamic simplifies and homogenizes the forest. Complexity and diversity of the forest ecosystems provides the greatest resiliency to pathogens and climate changes. The adelgid is in New Hampshire and experts believe that in about 10 years wide spread mortality will occur. Active management can create increased diversity through deliberate planning and action. Or, the hemlock woolly adelgid, an exotic invasive insect, can accomplish the task. Again, some balance between radical shifts seems appropriate and desirable.

Stand # 3: WP/RO/RM4A (SAF #20) 38 Acres

Forest type: Eastern white pine/Northern red oak/Red maple

Natural community type: Hemlock-beech-oak-pine (S5)

Soil Type: Cardigan-Kearsage Rock outcrop complex 15-25% & 25-60% slopes (361D & E); Cardigan-Kearsarge complex , 15-25% slopes (360D); Hitchcock silt loam soils, 15-60% slopes (130E); Stissing silt loam soils, 3-8% slopes (341B); and Charlton fine sandy loam, 15-25% slopes (63D).

Size class: Standard

Stocking level: Overstocked

Main crown cover: Moderate to dense

Stand Structure: Multi-aged

Stand Description

Stand #3 is located in the southwestern and south central portion of the Boston Lot. The southwest section of the stand is roughly bisected by a power line R-O-W, oriented northwest to southeast. The stand is found on gentle to moderately steep terrain. The aspect ranges from northeast to northwest. A variety of soil units underlies this stand. The Cardigan-Kearsage Rock outcrop complex and the Cardigan-Kearsarge complex underlie the majority of stand. A small area of Hitchcock silt loam soils underlies the southwest portion of the stand. Stissing silt loam soils are found along the southern edge of the reservoir. Charlton fine sandy loam soils are found under a small portion of the stand, south of the powerline and north of Olivia's Path. Large stones are occasionally visible at the surface. The main drainage from the lake runs westerly through the stand, just south of the border with stand#2. This is a perennial stream.

Detailed data were collected at three observation points and coarse level inventory data was collected along meandering transects within the stand.

Scattered super dominate white pine breakup a relatively uniform hardwood canopy. Hardwood dominance fluctuates between red maple, Northern red oak, yellow birch and white ash. White ash is concentrated on the gentle slope between the southern boundary and the power line R-O-W, while yellow birch is prevalent in the steeper section of the stand to the north of the R-O-W. Associate species in the main crown canopy include American beech, paper birch, big-toothed aspen, sugar maple and Eastern hemlock.

Red oak and white ash were established about 100 years ago. The white pine and hemlock components are 75-80 years old, originating slightly later.

Although the pine and hemlock were established at the same time, the hemlock is found at lower crown positions than the white pine. Hemlock, yellow birch, red oak, striped maple, American beech, and hophornbeam are found in the midstory and are probably 25 to 35 years old.

A number of common species were observed in the shrub and herbaceous layers; they are listed below. White snakeroot was observed along the drainage, indicating pockets of enrichment.

Ferns & Fern Allies	Flowers	Graminoids	Shrubs	Invasive plants
Christmas fern Intermediate wood fern Marginal wood fern Interrupted fern Cinnamon fern Hayscented fern Bristly club moss Tree club moss Maidenhair fern & ostrich fern (along drainage)	Starflower Canada mayflower Shinleaf Trailing arbutus Partridge berry Bedstraw sp. White snakeroot Hellaborine Jack in the pulpit	Woodland grass	Witch hazel Hobblebush	Japanese barberry Glossy buckthorn Bush honeysuckle

Regeneration is patchy. Most seedlings are partially free to grow to not free to grow. White ash composes the majority of the regeneration tallied. Hophornbeam was the only non-commercial species tallied.

Species	Regeneration (stems/acre)	Percent of total
Red maple	3,000	17
White ash	9,000	51
American beech	500	3
Bitternut hickory	1,000	6
Hophornbeam	2,500	14
Birch spp.	1,500	9
TOTAL	17,500	--

Ecosystem Components

Stand #3 supports a low level of both horizontal and vertical diversity. The herbaceous, shrub and midstory layers are not well developed due to low light levels beneath the main canopy. Canopy gaps occur rarely, with the exception of the power line R-O-W. Red oak acorns were abundant in fall 2010, providing ample hard mast for wildlife. The hard mast availability is ranked moderate in stand #3, principally due to the presence of red oak. Unique trees such as basswood and butternut are also found south of the

reservoir. The following table lists the ROM, cavity trees and snags measured at observation point within the stand.

Retained organic material			Cavity trees		Snags	
<i>Species</i>	<i>Diam. (inches)</i>	<i>Length (feet)</i>	<i>Species</i>	<i>DBH (inches)</i>	<i>Species</i>	<i>DBH (inches)</i>
Paper birch	19	33	Basswood	18	Hemlock	10
Paper birch	19	47			Red maple	12-16
Red maple	13	71			Basswood	18
Red maple	13	45				
Red maple	13	38				
White pine	24	27				

Wildlife signs observed in stand #3 include deer scat, deer scent markings on striped maples and pileated woodpecker holes in some of the white pines. Hunters in the area have observed black bear feeding on berries in the power line ROW. This stand favors canopy nesting songbirds; a shrub or midstory layer is lacking.

Disturbance

Stand #3 probably originated from open pasture. Stone wall or wire fence defines much of the southern property boundary, indicating past agrarian use. The majority of this stand was annexed to the original Boston Lot in 2007. That portion of the stand found on the original tract was classified as an adequately stocked Northern hardwood pole-size stand (NH3B) in the 1987 forest management plan prepared by CFM, Inc. Silvicultural treatments were not prescribed at that time. A number of well-decayed stumps indicate that logging occurred prior to 1987, probably part of the Goodwin cut in the 1960s.

Deer browse is heavy on the hardwoods, significantly impacting seedling survival. Continued severe browse will alter future species composition and forest age structure.

White pine canker was observed on the upper stems of some white pines; this fungus may affect the long-term survival of infected trees. The butternut exhibits symptoms of the butternut canker. Again, the majority of beech are infected with Beech Bark Disease. The ash are in decline. This species is destined to become a minor component, and perhaps totally fade from the stand, and the landscape within the next 10-20 years due to ash yellows and more importantly emerald ash borer. White ash mortality will create canopy gaps, thereby releasing any existing regeneration and also creating conditions conducive to establishing new regeneration.

Wind is another primary disturbance agent in stand #3. Single tree fall or stem snaps create small gaps that may be colonized by tree, shrub and understory species. Generally, these small canopy openings are too small to provide sufficient light to stimulate regeneration.

The close proximity of barberry, honeysuckle and glossy buckthorn in the powerline R-O-W presents a high risk of further invasion to stand #3. These species occur at low levels on a stand basis, though higher localized concentrations are present. Glossy buckthorn seedlings are also found along the lake. Japanese Barberry and honeysuckle commonly occur along the powerline R-O-W.

Management Recommendations

- **Control invasive plants.** See recommendations for stands #1 and #2 for treatment options.

The majority of the stand is upland forest. However, herbicide application in proximity to water requires a special permit as detailed above. The easement language may constrain treatment options. The utility manages the vegetation within the powerline R-O-W. This vegetation is treated periodically with herbicides, hopefully eliminating or reducing fruiting. Some utilities only control tall vegetation, and in this case invasives are minimally treated.

Evaluate results one year after treatment; repeat treatments are inevitable. Monitoring treatment success and changes in the invasive population is a critical component of successful control.

- **Identify, retain (in any managed stand) and potentially release American beech trees that appear resistant to beech bark disease.**
- **Consider periodic group selection harvests with perpetual retention of Legacy Trees** to promote age, size class and species diversity.
- **Thinning densely stocked portions of the stand** to promote tree vigor and potentially mitigate pine canker.

Stand # 4: WP/RO/RM4A (SAF #20) 17 Acres

Forest type: Eastern white pine/Northern red oak/Red maple

Natural community type: Hemlock-beech-oak-pine

Soil Type: Cardigan-Kearsage Rock outcrop complex, 8-15% & 15-25% slopes (361C &D)

Size class: Standard sawlogs

Stocking level: Overstocked

Main crown cover: Dense to moderate

Stand Structure: Two-aged

Stand Description

Stand #4 extends from the southeastern shore of the lake easterly along the southern boundary about half way to the southeast property corner. The majority of the stand is found on gentle to moderate terrain. Glacial erratics and rock outcrops are sparsely scattered throughout the stand.

Stand data was collected at one observation point and along meandering transects within the stand.

Northern red oak and Eastern white pine dominate the canopy. The white pines tower well above the main canopy of red oak and associate hardwood species. Associate canopy species include red maple, paper birch and white oak. Balsam fir is found where the property boundary intersects a drainage, just east of the lake shore. Eastern hemlock occupies the intermediate and suppressed canopy position, and along with American beech, dominates a patchy midstory. White pine and red maple saplings along with hazelnut are also found in this mid-canopy layer. Beech and hemlock is found at moderate levels in the understory, indicating a stand trajectory of these shade tolerant species in future main canopy. Hardwood regeneration is inadequate and most seedlings are not free to grow.

The white pine and red oak are 80-90 years old while the hemlock, established about 25 years later, is 55 to 65 years old.

Red maple was the only species tallied in the regeneration plot at a density of 2,000 stems/acre. American beech, white pine and red oak regeneration were observed outside of the regeneration plot.

The following table lists the species observed in the shrub and herbaceous layers.

Ferns & Fern Allies	Flowers	Graminoids	Shrubs	Invasive plants
Christmas fern Intermediate wood fern Hayscented fern Bracken fern Tree club moss	Starflower Canada mayflower Partridge berry Solomon seal Goldenrod Striped wintergreen Wild sarsaparilla	None observed	Witch hazel Mapleleaf viburnum Low bush blueberry	Glossy buckthorn

Ecosystem Components

Stand #4 supports a low to moderate vertical diversity; hemlock and beech provide patchy midstory structure. Horizontal diversity is low. Red oak and scattered white oak provide moderate to high hard mast levels within the stand.

Snags, cavity trees and downed material were not present at the observation point. Large and fine down woody material are both present at low levels throughout the stand.

Wildlife signs observed within the stand include deer scat and scent markings on the balsam fir. Blue jays and chipmunks were observed during the field visit.



Bear will scrape trees like this balsam fir to communicate messages such as the bounds of their territory.

Disturbance

Stand origin is unknown. This area was likely used as either cleared or wooded pasture about 100 years ago and reverted to forest following agricultural abandonment. The property boundary is delineated by a blazed line and barbed wire fence. Stand #4 was included as a portion of the 138 acre stand NH3-2A in the 1987 forest management plan. The stand was considered overstocked at that time. Portions of stand were treated in 1987-88. Logging damage on trees along the skid trails was observed. The presence of multiple

red oak stems in the main canopy that originated from stump sprouts indicates logging prior to 1987-88, or possibly fire damage. Seams or frost cracks were noted on the southeastern side of some red oaks. These typically originate at a branch or wound and expand, or open up during the winter freeze and close during the warmer months. Seams with lips indicates that the defect penetrates the stem; fungal conks indicate decay.

Hardwoods are severely browsed by deer. Again, this over browsing creates seedling mortality and will impact the future forest composition. American beech is largely infected with BBD. Single tree fall is a common disturbance. Pit and mound micro-topography of the forest floor indicates prior wind events.

A moderate population of glossy buckthorn is found along and near the old reservoir.

Management Recommendations

- **Control invasive plants.** See recommendations above for treatment options. The majority of the stand is upland forest, though invasives are found primarily in proximity to the lake. A special permit is required for herbicide application within 50' of water, as detailed above. Again, the easement may constrain treatment options; confer with the Easement holder.

Evaluate results one year after treatment; repetitive are inevitable. Monitoring treatment success and changes in the invasive population is a critical component of successful control.

- **Identify, retain and potentially release (in managed stands) American beech trees that appear resistant to beech bark disease.**
- **Consider planting blight-resistant chestnuts.** Chestnut was formerly a major component of this forest type.
- **Consider periodic group selection harvests with perpetual retention of Legacy Trees** to promote age, size class and species diversity.
- Maintain a 150' uncut protective buffer around the lake, as required by the easement.

Stand # 5: WP/RO/RM4A (SAF #20) 8 Acres

Forest type: Eastern white pine/Northern red oak/Red maple

Natural community type: Hemlock-beech-oak-pine (S5)

Soil Type: Cardigan-Kearsage Rock outcrop complex, 15-25% slopes (361D)

Size class: Standards

Stocking level: Overstocked

Main crown cover: Moderate to dense

Stand Structure: Even-aged

Stand Description

This stand is located in the north central portion of the tract, flanked on the east by stand #11 and on the west by stand #1. The warm southerly aspect creates a micro-climate conducive for red and white oak. The red oak and associated hardwood species such as white oak and aspen create a homogeneous canopy that is frequently punctuated by emergent white pine. Shade tolerant hemlock and beech comprise the majority of the midstory, along with lesser proportions of red maple and hophornbeam. Herbaceous layer is sparse to non-existent. This stand will shift to hemlock and beech over time without intervention.

Coarse level data were collected along a meandering transect within this stand.

Disturbance

Stand #5 was probably cleared at one time, and possibly also used as wooded pasture. This stand was included in the 138 acre NH 3-2A stand in the 1987 CFM, Inc. forest management plan. The stand was overstocked at that time, and remains so currently. At that time the stand was considered overstocked and was treated in the late 1980's. Portions of this stand were harvested in 1987-88. Single tree fall occurs commonly.

While not observed, BBD is probably present.

Invasive plants were not observed within stand #5.

Management Recommendations

- **Consider periodic group selection harvests with perpetual Legacy Trees retention** to promote age, size class and species diversity.
- **Consider manipulating understory vegetation** to promote greater species diversity.

Stand # 6: WP/RO/RM4B (SAF #20) 9 Acres

Forest type: Eastern white pine/Northern red oak/Red maple with white ash as a major association.

Natural community type: Hemlock-beech-oak-pine (S5) and Appalachian Oak-Pine

Soil Type: Cardigan-Kearsage Rock outcrop complex, 15-25% slopes (361D)

Size class: Standards

Stocking level: Adequately stocked

Main crown cover: Moderate

Stand Structure: Even-aged

Stand Description

This stand is located on Honeysuckle Ridge between the lake and the north/south oriented powerline. The majority of stand #6 occupies nearly flat to gentle terrain on this ridge top. This is a dry, warm site.

Data were collected at one observation point and along the meandering transect through the stand.

Stand #6 is similar to abutting stand #12. Both stands feature dominate Northern red oak and red maple. The white pine component is younger in this stand than its neighbor and also less abundant. Sugar maple mixes into stand #12, but is largely absent in stand #6. White ash occurs commonly within the stand. Associate species include bitternut hickory, butternut and black cherry. Striped maple and hophornbeam are found in the midstory. The red oak and white pine are both 70-90 years old, while the white ash is about 55-60 years old.

The following table lists the species observed in the shrub and herbaceous layers. Marginal wood fern was the most abundant understory

plant. The presence this fern along with white snakeroot, maidenhair fern, bitternut hickory and butternut indicate a somewhat enriched site.

Ferns & Fern Allies	Flowers	Graminoids	Shrubs	Invasive plants
Intermediate wood fern Marginal wood fern Hayscented fern Maidenhair fern Bracken fern	False nettle White snakeroot Small white aster	None observed	Witch hazel Raspberry species	Japanese barberry Glossy buckthorn Bush honeysuckle

White ash and bitternut hickory seedlings were tallied in the regeneration plot at 2,000 stems/acre for each species.

Ecosystem Components

Vertical diversity is low/+. Horizontal diversity ranked moderate/-; gaps created by mortality and minor wind damage contribute to patchiness.

Butternut, bitternut hickory and red oak all provide hard mast for wildlife. Butternut production may be reduced by disease related stress.

Downed wood is ranked moderate in occurrence in this small stand. Most of the down material consists of smaller stems (<12" diameter). However, one 11" diameter white pine piece 37' long and one 16" butternut piece 24' long were measured at the observation point. Cavity trees and snags did not occur within the observation point. Cavity trees were not noted with the stand. Snags are found at moderate levels, but are generally small diameter. The following table indicates the number of downed wood measured in stand #6.

Disturbance

The present stand #6 was delineated as part of WP/H3-2B, 38 acres and stand NH2-3C, 12 acres. The 1987 plan recommended managing this stand for aesthetics, recreation and water quality.

Barbed wire forms the original Boston Lot boundary, indicating former agrarian use.

White ash is declining, probably due to ash yellows. Butternut canker has caused decline and mortality of that species. The combined mortality of the white ash and butternut have created canopy gaps in which the honeysuckle is thriving. Seedling establishment is severely hampered by this invasive understory. The herbaceous layer is also negatively impacted.

Heavy deer browse was observed on the hardwoods.

Honeysuckle Ridge is appropriately named; the highest concentration of invasives within the forest itself is found in this stand. Glossy buckthorn and bush honeysuckle are found at high abundance levels.

Management Recommendations

- **Control non-native invasive plants.** A foliar application of glyphosate is probably the best control method in this situation. Cut any buckthorn over 12' tall the fall or winter prior to treatment. Allow sprouts to grow until September or October and apply the foliar spray to sprouts and honeysuckle.

Again, confer with the Easement holder regarding the proposed treatment and the easement language.

Evaluate the treatment the following year and repeat at two to three year intervals as necessary.

Stand # 7: WP/HM4A (SAF #22) 73 Acres

Forest type: Eastern white pine/Hemlock

Natural community type: Hemlock-beech-oak-pine (S5)

Soil Type: Cardigan-Kearsage Rock outcrop complex, 8-15% & 15-25% slopes (361C & D)

Size class: Standards

Stocking level: Overstocked

Main crown cover: Dense

Stand Structure: Two-aged

Stand Description

Stand #7 abuts the eastern shores of the reservoir, extending easterly up slope about 2/3rds of the way to the east property boundary. The majority of the stand occupies moderate to steep northwest to westerly slopes. The stand is found on gradual to excessively steep terrain. Glacial erratics are well distributed throughout and ledgy outcrops are concentrated in the southwestern corner extending northeast to the middle of the stand.

Data for this stand were derived from a coarse level inventory conducted during random meandering transects and one observation point.

Eastern hemlock, 125 to 130 years old, dominate the steeper terrain. White pine is more concentrated on the gentler slopes closer to the lake. The

red oak component is most prominent in the southern quadrant of the stand bordering stand #4. The red oak are about 80-90 years old. Red maple is the main associate canopy species. Hemlock and American beech form a dense midstory with occasional red and striped maple. Without significant disturbance (human or natural) hemlock will continue to dominate the upper slopes, and along with beech, will replace red oak and white pine when they die.

The following table lists the species observed in the shrub and herbaceous layers.

Ferns & Fern Allies	Flowers	Graminoids	Shrubs	Invasive plants
Christmas fern Intermediate wood fern Tree club moss	Canada mayflower Jack in the pulpit Hog peanut Striped wintergreen Wild sarsaparilla	None observed	Witch hazel Hobblebush	Glossy buckthorn

Regeneration is patchy and most seedlings are not free to grow. Hemlock seedlings were also observed in the stand.

Species	Regeneration (stems/acre)	Percent of total
Red maple	5,000	50
White pine	2,000	20
American beech	2,000	20
Red oak	1,000	10
TOTAL	10,000	--



Bear will climb American beech trees to feast on the protein rich beech nuts. It is important to protect bear trees such as this one, which also appears to be tolerant of Beech Bark Disease.

Ecosystem Components

The very dense hemlock overstory allows little light penetration and therefore the herbaceous, shrub and midstory layers are sparse. Vertical and horizontal diversity are ranked low; canopy gaps occur rarely. The red oaks in the southern quadrant provide high levels of hard mast in this portion of the stand. Overall hard mast availability within the stand is low/+. Cavity trees and snags did not occur within the observation point; their abundance tends to be low throughout the stand. One 13" piece of coarse woody material was measured at 32.5' long.

Wildlife signs observed in stand #7 include deer scat and bear claw marks on an American beech tree that appears resistant to BBD. Pileated woodpeckers were heard calling during the inventory.

Disturbance

Stand origin is unknown. Stand #7 was a component of stand NH3-2A, 138 acres in the 1987 CFM, Inc. forest management plan. The stand was overstocked at that time, and remains overstocked, despite the treatment conducted in portions of the stand in 1987-88. Cut stumps from that operation are still intact and in evidence.

Deer browse is particularly heavy on the hardwoods. Most American beech are infected with BBD. Wind disturbance is evidenced by snapped stems and pit and mound topography on the forest floor. Glossy buckthorn seedlings primarily occur in proximity to the lake at low to medium densities.

Management Recommendations

- **Control invasive plants.** See recommendations above for treatment options. A special permit is required for herbicide application within 50' of water, as detailed above. Again, the easement may constrain treatment options; confer with the Easement holder.

Evaluate results one year after treatment; repeat treatments are inevitable. Monitoring treatment success and changes in the invasive population is a critical component of successful control.

- **Identify, retain and potentially release (in managed stands) American beech trees that appear resistant to beech bark disease.**
- **Consider planting blight-resistant chestnuts in portions of the stand.** Chestnut was formerly a major component of this forest type.
- **Consider periodic group selection harvests with perpetual retention of Legacy Trees** to promote age, size class and species diversity. Hemlock and beech will likely dominate the future stand composition without intervention. BBD will continue to limit the beech component and hemlock woolly adelgid is likely to cause wide spread hemlock mortality within 10 to 20 years. Greater species and age diversity provides greater resiliency.
- Maintain a 150' uncut protective buffer around the lake, as required by the easement.

Stand # 8: WP/HM4A

(SAF #22)

22 Acres

Forest type: Eastern white pine/Hemlock (SAF #22)

Natural community type: Hemlock-beech-oak-pine (S5)

Soil Type: Cardigan-Kearsage Rock outcrop complex 15-25% & 25-60% slopes (361D & E)

Size class: Standards

Stocking level: Overstocked

Main crown cover: Dense

Stand Structure: Two-aged

Stand Description

Stand #8 wraps around the northeastern shore of the reservoir and extends northeasterly up a gentle slope toward stands #5 and #11. This stand is similar to stand #7: both are underlain with the same soils and both are dominated by hemlock on the upper slopes while the white pine component is concentrated closer to the lake shore. However, the southwest aspect results in a warmer site and the somewhat gentler slopes north of the shore create different growing conditions than those found in the adjacent stand to the south. These differences in site and micro-climate encourage a more diverse hardwood mix to associate with the hemlock and pine in stand #8. Yellow birch is co-dominant with red oak throughout the stand. Associate canopy species include red maple, paper birch, white ash, white oak, aspen and black birch. Hemlock, American beech, red maple and striped maple are present in the midstory; the midstory is not as dense as stand #7. Herbaceous species include Christmas fern, intermediate wood fern, Canada mayflower, wild sarsaparilla and hog peanut.

Ecosystem Components

The understory and midstory layers are sparse. Canopy gaps occur rarely. Horizontal and vertical diversity are both ranked low.

Disturbance

Stand origin is unknown. An old fence line is depicted on the survey running from the North property boundary, around the East side of the lake, to the vicinity of the Southeast corner of the lake. This stand, or portions of it, may have been wooded or open pasture at one time. The majority of stand #8 was included the 138 acre NH3-2A stand in the 1987 management plan. A smaller portion of the stand was typed as HM/H3-2A, 16 acres. Silvicultural treatments were made in 1987-88; cut stumps are still in evidence.

Deer are severely browsing hardwood regeneration. American beech is infected with BBD. White ash is frequently in decline.

Invasive glossy buckthorn seedlings occur close to the reservoir. This population can easily become a vector causing invasion of the adjacent forested areas.

Management Recommendations

- **Control invasive plants.** See recommendations above for treatment options. A special permit is required for herbicide application within 50' of water, as detailed above. Again, contact the Easement holder to discuss easement language that may constrain treatment options.

Evaluate results one year after treatment; repeat treatments are inevitable. Generally re-treat at two to three years intervals. Monitoring treatment success and changes in the invasive population is a critical component of successful control.

- **Identify, retain and potentially release (in managed stands) American beech trees that appear resistant to beech bark disease.**
- **Consider planting blight-resistant chestnuts in portions of the stand.** Chestnut was formerly a major component of this forest type.
- **Consider periodic group selection harvests with perpetual Legacy Tree retention** to promote age, size class and species diversity. Hemlock and beech will likely dominate the future stand composition without intervention. Increasing species and age diversity provides greater protection against pathogens and improve forest resiliency in the face of climate change.
- **Maintain a 150' uncut protective buffer** around the lake, as required by the easement.

Stand # 9: HM/NH4A**(SAF #23/25)****78 Acres****Forest type:** Hemlock/Northern Hardwood**Natural community type:** Hemlock-beech-oak-pine (S5)**Soil Type:** Cardigan-Kearsage Rock outcrop complex, 8-15%, 15-25% & 25-60% slopes (361C, D & E)**Size class:** Standards**Stocking level:** Overstocked**Main crown cover:** Dense**Stand Structure:** Even-aged***Stand Description***

Stand #9 is located in the eastern third of the property. The aspect of the majority of the stand ranges from north to northwest. The terrain is gentle to moderately steep. The height of land on the tract is located in the southeast corner of the stand. This stand occupies the highest elevations found on the property.

Data were collected at two observation points and along transects within the stand.

Seventy to 80 year old Northern red oak form a fairly uniform canopy with 90-115 year old Eastern hemlock. Associate species are scattered throughout the stand and include white ash, red maple, yellow birch, American beech, paper birch, white oak, black cherry and bitternut hickory. Super dominate white pine infrequently rise above the main canopy. The midstory is moderately stocked with hemlock and American beech; striped maple and red maple are present in lower abundance. The following table lists the species observed in the shrub and herbaceous layers.

Ferns & Fern Allies	Flowers	Graminoids	Shrubs	Invasive plants
Christmas fern Intermediate wood fern Hayscented fern Tree club moss	Starflower Canada mayflower Partridge berry Striped wintergreen Wild sarsaparilla Indian cucumber root Goldthread Small white aster Blue bead lily Solomon seal Bunchberry	Woodland grass	Witch hazel Low bush blueberry <i>Spirea</i>	Glossy buckthorn

Regeneration is not free to grow. Red maple is well stocked at 17,500 stems/acre and is fairly shade tolerant as a seedling. About 1,500 stems/acre of American beech are also present in the stand. Pockets of hemlock, red oak and yellow birch regeneration are present in canopy gaps.

Ecosystem Components

Horizontal diversity is low in Stand #9; significant canopy gaps are uncommon. One open vernal pool was observed in the northeastern quadrant of the stand; Van de Poll noted 6 vernal pools within this stand; four occur within the northeast portion of the stand and two are found in the southeast section. Vertical diversity is moderate. Mast tree occurrence ranges from low to moderate and includes small groups of white oak along with the predominate red oak. Cavity trees and snags did not occur within the observation point; abundance levels of both structures are low throughout the stand. One 13.8" diameter piece of American beech about 35.5' long was measured at the observation point.

Wildlife sign observed in stand #9 included deer scat and tracks near the Water Tower Trail and coyote and bear scat along the eastern boundary. Red squirrels were also observed.

Disturbance

Stand origin is unknown. Exposed bedrock, ledges and steep slopes certainly limit agricultural use; this stand may have evolved from wooded pasture. The majority of stand nine was delineated as the HM/H3A, 68 acre stand in the 1987 plan prepared by CFM, Inc. Portions of this stand were harvested in 1987-88.

Deer browse is particularly heavy on the red oaks. American beech is infected with BBD.

Single tree fall or stem snaps have created small gaps. Tree, shrub and herbaceous species have invaded the gaps created by wind and previous harvesting, providing a low level of age and species diversity. Glossy buckthorn seedlings were observed growing along the recreational trails.

Management Recommendations

- **Control non-native invasive plants.** Glossy buckthorn occurs at low levels and is generally confined to the recreation trails. Currently, the majority of these plants can be hand pulled. Evaluate treatments, monitor populations and re-treat as necessary.
- **Retain and protect American beech trees that appear to be resistant to beech bark disease.**
- **Consider periodic group selection harvests with perpetual Legacy Tree retention** to promote age, size class and species diversity. Hemlock and beech will likely dominate the future stand composition without intervention. Encouraging a diverse species and age structure provides increased resiliency to impacts of pathogens and climate change.

Stand # 10: HM/NH4A (SAF #23/25) 15 Acres

Forest type: Hemlock/Northern Hardwood

Natural community type: Hemlock-beech-oak-pine (S5) and Appalachian Oak-Pine

Soil Type: Cardigan-Kearsage Rock outcrop complex, 15-25% slopes (361D)

Size class: Standards

Stocking level: Overstocked

Main crown cover: Dense

Stand Structure: Even-aged

Stand Description

Stand #10 occupies steep northwest facing slopes to the west and downhill of Honeysuckle Ridge. This stand is part of the Boston Lake Addition.

Coarse level data were collected along meandering transects within the stand. Observation points were not located within this stand.

The stand is two-aged. Northern red oak, Eastern hemlock, and white ash dominant the main canopy. Associate species include Eastern white pine and bitternut hickory. Hemlock is the dominant midstory species along with

patches of striped maple. The understory is very sparse due to dense crown cover. The herbaceous layer is somewhat higher in a wet area near the northern property boundary where helleborine and interrupted fern were observed.

Ecosystem Components

Horizontal diversity is low in Stand #9; significant canopy gaps are uncommon. Mast tree occurrence is low. Cavity trees, down material and snags are ranked low throughout the stand.

Disturbance

American beech are infected with BBD. The white ash component is declining, most likely from ash yellows.

Invasive plants were not noted within the stand.

Hardwood regeneration is absent, hence deer browse was not observed.

Management Recommendations

- **Retain and protect American beech trees that appear to be resistant to beech bark disease.**
- **Consider periodic group selection harvests with perpetual Legacy Tree retention** to promote age, size class and species diversity. Hemlock currently dominates the stand, excluding regeneration and herbaceous plants, with its dense canopy. The hemlock woolly adelgid will radically alter future stand composition in 10 to 20 years when projected wide spread mortality occurs. These dry, warm west-facing slopes are well suited to red and white oak, hickories and chestnut.
- **Consider planting blight-resistant chestnuts in portions of the stand.**

Stand # 11: RO4A

(SAF #55)

3 Acres

Forest type: Northern red oak

Natural community type: Hemlock-beech-oak-pine (S5)

Soil Type: Cardigan-Kearsage Rock outcrop complex, 15-25% slopes (361D)

Size class: Standards

Stocking level: Overstocked

Main crown cover: Moderate to dense

Stand Structure: Even-aged

Stand Description

Stand #11 is located in the north central section of the Boston Lot just west of the Water Tower Trail. This stand faces south, as do adjacent and nearby stands #1, #5 and #8. The terrain is moderately steep. White oak and red oak comprise the majority of the overstory while white pine only occasionally punctuates the canopy. Bitternut hickory, a species uncommon to New Hampshire, occurs as a canopy associate with red maple. American beech and hemlock forms a midstory at low to moderate density; DBH is generally less than 4".

Coarse level data were while examining this stand. Observation points were not located within this small stand.

Disturbance

Stand origin is unknown. The stand very likely evolved from wooded pasture. The stand was included with the 138 acre NH 3-2A stand mapped in the 1987 plan. The stand was considered overstocked in 1987 and remains so currently. Invasive plants were not observed.

Management Recommendations

- **Consider removing beech and hemlock from the midstory to promote white and red oak and bitternut hickory.**
- **Retain and protect American beech trees that appear to be resistant to beech bark disease.**

- **Consider periodic group selection harvests with perpetual Legacy Tree retention** to promote age, size class and species diversity. Hemlock currently dominates the stand, excluding regeneration and herbaceous plants, with its dense canopy. The hemlock woolly adelgid will radically alter future stand composition in 10 to 20 years when projected wide spread mortality occurs. These dry, warm west-facing slopes are well suited to red and white oak, hickories and chestnut.
- **Consider planting blight-resistant chestnuts in portions of the stand.**

Stand # 12: NH/RO4A (SAF #25/55) 16 Acres

Forest type: Northern Hardwood/red oak/hardwood

Natural community type: Hemlock-beech-oak-pine (S5)

Soil Type: Cardigan-Kearsage Rock outcrop complex, 15-25% slopes (361D)

Size class: Standards

Stocking level: Overstocked

Main crown cover: Dense

Stand Structure: Two-aged

Stand Description

Stand #12 is flanked by the Honeysuckle Loop Trail up slope and the Westside Trail down slope. The terrain is gentle to moderate. Glacial erratics are occasionally present throughout the stand. The aspect of the stand is easterly.

Data were collected along meandering transects and on one observation point.

This stand is characterized by a uniform hardwood canopy comprised primarily of Northern red oak with lesser proportions of white ash, bitternut hickory, and red maple. The oak component is 90 to 100 year old. Other associates include paper birch, big-toothed aspen, sugar maple, white pine and white oak. A very impressive 62.5" DBH open grown red oak with a cavity is a legacy of the agrarian past. American beech, striped maple, bitternut hickory and sugar maple are present in the midstory.

Rich site plant indicators are found in low abundance levels and lack species diversity. The following table lists the species observed in the shrub and herbaceous layers.

Ferns & Fern Allies	Flowers	Graminoids	Shrubs	Invasive plants
Christmas fern Intermediate wood fern Interrupted fern Hayscented fern Maidenhair fern	False nettle White snakeroot Small white aster Goldenrod Virginia creeper	Woodland grass	Raspberry Alternate-leaf dogwood	Japanese barberry Bush honeysuckle

Regeneration is abundant, however, most seedlings are not free to grow. Bitternut hickory regeneration was also observed.

Species	Regeneration (stems/acre)	Percent of total
Red maple	3,000	8
White ash	31,000	89
Red oak	1,000	3
TOTAL	35,000	--

Ecosystem Components

Vertical and horizontal diversity are both low. The understory and midstory layers are sparse and canopy gaps occur rarely. Red oak, white oak and bitternut hickory provide abundant hard mast.

A large 36" white pine was measured at 75' long at the observation point.

Disturbance

Stand#12 and stand #5 formed a portion of what was stand NH 2-3C, 12 acres in the 1987 CFM, Inc. forest management plan. That plan recommended managing stand NH2-3C for water quality, recreation and aesthetics. A limited portion of stand #12 was harvested in 1987-88.

Deer browse was observed on the hardwoods. The white ash are declining but appear less stressed than those in stands #3, #6 and #10.

Japanese barberry and bush honeysuckle are encroaching from stand #6.

Management Recommendations

- **Control non-native invasive plants** when treating adjacent stand #6. A foliar application will provide the best control. Again, confer with the Easement holder; the easement may constrain treatment options. Evaluate the treatment the following year and re-treat as necessary.
- **Evaluate** this stand and the plant assemblages further. Additional rich site indicators may be present. The Natural Community may differ from the larger matrix community.
- **No other treatments are recommended at this time.**

Tract Summary

The Boston Lot forest supports a diversity of species, size classes and densities. The complexity of the forest is attributable to both the length of time since agricultural abandonment and the past cutting history. The forest generally ranges from 60 to 100 years old; a portion of the hemlock component exceeds 125 years old. The forest had a 23-year respite from forest management activity since the treatments conducted in 1987-88. Greater species and structural diversity was noted in harvested areas compared with untreated sections of the property. Significant natural disturbances, such as the regional 1998 ice storm and the local April 2007 wind event, had little impact on the forest.

Mast-producing species occur abundantly on the Boston Lot. Northern red oak, hophornbeam, bitternut hickory, butternut and beech produce hard mast; black cherry, Juneberry and apple produce soft mast. These are all valuable food sources for a variety of wildlife species. Red oak occurs abundantly throughout most of the property; white oak and bitternut hickory also occur at higher than usual levels for this region. Hophornbeam is common. This species provides food during a critical period because the persistent seeds are dispersed during the winter, when other food is less available. White oak and bitternut hickory will add to the hard mast menu in the future; these species are likely to increase their presence as the climate changes.

This property is one of several tracts that comprise a large, undeveloped and unfragmented tract of forestland. These large blocks provide essential wildlife habitat and refugia for biological diversity.

The Boston Lot Lake occupies the central portion of the tract and represents a human-made modification to the landscape. This old reservoir, though not strictly a natural feature, is identified as a Significant Ecological Area (SEA) by Van de Poll.

This tract is heavily utilized for a variety of recreational uses. Walking, running and mountain biking concentrate use on the trail system. The majority of the trails support the current levels of use. Portions of the trails are not adequately drained, and therefore suffer from rutting and muddy surfaces. Activities such as wildlife observation, hunting and fishing tend to disperse impacts on the landscape. Though the public recreational use of the Boston Lot is intensive, few recognize that this aesthetic back drop is not a natural occurrence, but rather a human induced environment.

Recommendation

- Identify trail sections with drainage issues and develop strategies for improving drainage and trail surfaces.

Invasive plants occur at low levels in limited areas of the tract. These species invade undisturbed areas over time and aggressively invade disturbed areas. Honeysuckle Ridge represents the greatest concentration of invasive plants (predominately honeysuckle!). Populations otherwise are largely confined to the trails, their peripheries and areas in proximity to the Boston Lot Lake. Successful treatment of these low level infestations is possible at relatively low costs; costs rise dramatically as populations grow and mature. The majority of the plants are too large to remove practically by pulling; this technique also increases soil disturbance and thereby creates a conducive seed bed for the existing seed bank. Judicious herbicide application provides the most cost-effective solution to controlling these invasive plants. Wetland permits are required prior to applying herbicides within 150' of the Boston Lake Lot and other wetlands. The easement prohibits "cutting of growth within 150' of the shoreline of Boston Lot Reservoir, except as necessary to maintain or construct recreational trails". Communication and coordination with the easement holder are essential prior to treating areas around the lake. Successful control requires two to three treatments at three to five year intervals. Volunteers can perform re-treatments consisting of hand pulling seedlings that germinate after the initial herbicide applications.

Recommendation

- Develop a strategy and budget for controlling invasive plants while populations are low and prospects for success are high.

Though the timber resource was not specifically evaluated, it is evident that this tract is stocked with high levels of commercially valuable timber. Observations also conclude that a judicious and thoughtful approach to harvesting increases diversity and complexity while protecting ecologically sensitive areas and producing revenue.

The Boston Lot supports a vibrant forest that is the product of time and land use. The forest will continue to evolve and respond to environmental conditions, both biotic and abiotic. This forest possesses a fair degree of resiliency by virtue of its complexity and diversity. Increasing structural complexity and species diversity, especially attempting to increase the abundance of species projected to benefit from a changing climate, can improve future forest resiliency.

Signal Hill

Location

Signal Hill fronts on Stevens Road, a city-designated Scenic Road, for 886' as well as 2,085' of Alden Road, a class VI, unmaintained road. Commercial forestland covers 188 acres, or 87% of the total property. The remaining 29 acres are open grassland or shrub habitat. Signal Hill is surrounded by residential development with the exception of Choice Storage LLC on Etna Rd, a commercial holding.

Signal Hill Acreage Chart

Stand Number	Stand Code	Vegetation Type	Area (acres)
1	WP4A	White pine	33
2	WP4-3A	White pine	112
3	HM/NH4A	Hemlock/N. hardwood	31
4	HM/NH4A	Hemlock/N. hardwood	12
		Upper field	10
		Lower field	16
		Summit meadow	3
		TOTAL	217

Boundary and Survey Information

Signal Hill was surveyed by K.A. LeClair Assoc., Inc. The plan is titled **William H. Morton Estate**, Allen Road and Stevens Road, Lebanon, NH, Project #16289, dated February 22, 1989. The majority of the boundary lines are formed by stonewalls and old wire fences. Approximately 2/3rds of the southern boundary is a blazed line, starting with barbed wire at Alden Road, turning into stonewall and yielding to blazes until the corner and jog in the boundary. All boundaries have been blazed and painted. Many blazes are healed. Blazes are lower and less frequent than optimal for viability, especially in the winter. The blazes have been painted recently (within 2 years+/-).

Recommendations

- Maintain boundary lines by painting blazes at 5 to 7-year intervals (2016-19) and re-blazing and painting at 10 to 15-year intervals (2021-27).
- During the next maintenance interval re-blaze the property boundaries. Increase blazing frequency. Utilize a combination of standard line, side and 45° blazes along the boundaries to provide good visibility when walking the boundary or crossing the line from both within the property and from abutting tracts. Utilize accepted protocols for witnessing

corners. Paint 3 to 6 months after blazing. Schedule about 5 years after the lines were last painted (approximately 2015-17).

Covenants and Restrictions

On September 13, 2007 the city granted a conservation easement to the Upper Valley Land Trust (UVLT) on the entire tract for the purpose of:

- Protecting the scenic quality of the Signal Hill ridgeline.
- Providing permanent and perpetual public access to undeveloped scenic land and trails for pedestrian-type recreational opportunities.
- Conserving and protecting biological diversity, important wildlife habitat and natural communities and the ecological processes that sustain these natural resource values.
- Specifically protecting the following attributes:
 - the summit of Signal Hill;
 - existing and potential recreational, cultural, and educational uses for the City, including current trails on the summit of Signal Hill;
 - over a half a mile of frontage on Stevens and Alden Roads;
 - unique geological features and significant wildlife habitat, including pasture and woodland, brooks, ravines, and high elevations.
- Ensuring that the forest resources are managed in such a manner that they are capable of producing long-term continuous flow of products and resources.
- Assuring the property will be retained forever in its undeveloped, scenic and open space condition and to prevent any use or fragmentation that will significantly impair or interfere with the unique and significant qualities of public benefit and conservation values.
- Preserving open spaces, particularly productive farm and forest land.

The easement prohibits the following activities:

- residential, commercial or industrial development;
- agricultural activities that degrade conservation values, the future production of agricultural crops and impair soil health and water quality;
- subdivision without UVLT approval;
- mining or quarrying activities or the excavation or removal of rocks, minerals and other soil and geological resources; advertising structures;
- dumping of trash or other hazardous substances;
- easements, roads, or utility lines without UVLT approval;
- and the manipulation of site hydrology or activities that impair water quality.

Small structures or facilities and unpaved recreational trails related to low-impact, non-motorized recreation or open spaces use, forestry and agriculture; maple sugaring operations and, with prior notice to UVLT, removal of a negligible number of trees for non-commercial purposes such as for fencing, firewood, maintenance of a limited view or wood crafts; and fences for securing crops or animals may be constructed with permission of UVLT. Low-impact recreational or educational activities or workshops conducted by a commercial or non-commercial enterprise are allowed with UVLT approval. Under the terms of the easement the City is required to maintain the fields in an open condition.

Specific requirements related to forestry activities include:

- A Forest Management Plan must be prepared or reviewed and endorsed by a professional forester and approved by UVLT prior to engaging in any forest management activity.
- Forestry activities that degrade the future production of forest products and impair soil health and water quality are prohibited.
- The plan must identify the City's long-term forest management objectives, describe forest stand conditions and silvicultural objectives, and contain a detailed forest type map and treatment schedule.
- Any timber harvesting prescribed shall provide for the maintenance or improvement of:
 - o The overall quality of timber;
 - o Soil productivity;
 - o Water quality;
 - o Public access, safety and quality of recreational trails; and
 - o Wildlife corridors and habitat through the property
- If heavy cutting, defined as "a harvest leaving a residual stocking level of acceptable growing stock below the C line as defined by the USDA stocking guides for the applicable timber type", is prescribed it must be compelling and consistent with the purposes of the easement, such as promoting the establishment or improvement of wildlife habitat or timber salvage.

Access

Timber access was not considered during the project; The Conservation Commission did not identify timber management or production as an ownership objective. However, as mentioned during the last meeting with the CC, silvicultural treatments, in some cases taking the form of timber harvests, are a tool to accomplish stated goals and objectives.

Signal Hill has extensive road frontage along Stevens and Alden Roads. One trail provides recreational access as well as access for mowing and maintenance equipment. This trail originates in the southeast portion of the lower field and runs westerly parallel to the southern edge of both the lower and upper fields before bearing southwesterly into the woods. The trail swings southerly, gains the Signal Hill ridge, primarily traversing this high ground to the South Meadow Summit, and continues southerly across the property line.

An infrastructure of harvesting trails and/or landings is absent on the Signal Hill tract. A thorough evaluation of access options is necessary prior to conducting commercial silvicultural activities at Signal Hill. A system of truck access and a trail network must be designed and constructed to provide adequate access for trucks and harvesting equipment. Harvesting trails would also provide additional recreational opportunities.

Tract Description

The Signal Hill Tract occupies a 1,300' high ridge in north central Lebanon. The parcel encompasses 217 acres comprised of 188 acres of upland forest and 29 acres of shrub and open land. This tract represents a substantial forested block surrounded by largely developed and fragmented land. Two forest types are found on the property: hemlock/Northern hardwood (HM/NH), totaling 44 acres and white pine (WP) encompassing 146 acres. Three "high quality wildlife habitat meadows" also occur on the property: the Lower Field, Upper Field and South Summit Meadow. The property is easily accessed for non-motorized recreational use at the trail head on Stevens Road near the junction of Alden Road.

Topography

Signal Hill encompasses a ridge that runs north to south for about 1.4 miles. The South Summit is found on the subject property; two other summits are located to the north on abutting parcels. The Signal Hill tract rises westerly from Stevens Road/Alden Road at an elevation of roughly 984' to about 1310' elevation at the South Summit Meadow. The elevation of the ridge varies about 110' in elevation, ranging from about 1,200 in the north to the summit at 1,310'. Slopes range from moderate to extremely steep from Alden and Stevens Road to the ridge top; small cliffs are found on the southeast shoulders of the ridge. Moderate to steep slopes descend westerly from Signal Hill to the property boundary.

Soils

The Soil Survey of Grafton County New Hampshire (1987) indicates five soil series, on four slope classes, underlie Signal Hill. The following table provides soil information and characteristics.

Signal Hill Soil Description

Soil Type	% Slope	Map Symbol	Acre (acres)	% Total Area	Drainage Class	Site Index
Cardigan-Kearsarge-Rock outcrop complex	3-8	361B	1.4	<1	Well drained	Eastern white pine 73 N. red oak 65 Sugar maple 65
	8-15	361C	18.5	8		
	15-25	361D	76	35		
	25-60	361E	54.3	25		
Cardigan-Kearsarge complex ²	8-15	360C	15.3	7		
	15-25	360D	38.2	17		
Pittstown loam ¹	8-15	334C	1.8	<1	Moderately well drained	N. red oak 72 Sugar maple 66 E. white pine 80
Pittstown loam, very stony ²	8-15	336C	3.9	2		
Bernardston silt loam, very stony	15-25	331D	10.6	5	Well drained	N. red oak 55 E. white pine 65 Sugar maple 65 E. hemlock 65
¹ Soils of statewide importance.						
² Soils of local importance.						

The Bernardston silt loam, very stony soils (331D) occupy a small portion of the southeast quadrant of Signal Hill. These soils occur on glaciated hills and were formed in glacial till underlain with compact, silty basal till. Bernardston soils are considered very deep and well drained. Despite the well-drained classification, a hardpan layer, found at 16-36 inches, impedes drainage seasonably and during periods of high rainfall. On the steeper slopes of Signal Hill equipment limitation, erosion hazard and windthrow hazard are all considered moderate. The USDA Natural Resources Conservation Service (NRCS) considers this soil favorable for producing quality hardwoods.

The Cardigan-Kearsarge-Rock outcrop complex (361B, C, D & E) occur in an intricate pattern on the landscape and soils are not mapped separately. The Cardigan-Kearsarge-Rock outcrop complex underlies 69% of Signal Hill. A majority of this soil series is found on steeper slopes (D & E – 15-25% and 25-60% slopes). Cardigan soils are silty, moderately deep and well drained; depth to bedrock is 20 to 40 inches. Kearsarge soils are silty, shallow and somewhat excessively drained; bedrock is found at 10 to 20 inches. Rock outcrops are less than 100 feet apart. Cardigan soils compose about 40% of the soils unit,

Kearsarge soils 30%, rock outcrops 15% and other soils 15%. This soil series is found on undulating or gentle to steep slopes, hilltops and hillsides. Erosion hazard and equipment limitations on both the Cardigan and Kearsarge soils are ranked slight on slopes up to 15%, moderate on slopes between 15% and 25% and severe on slopes greater than 25%. Windthrow hazard is moderate on Cardigan soils and severe on Kearsarge soils regardless of slope.

The Cardigan-Kearsarge complex (360C & D) underlies the South Summit of Signal Hill and the surrounding area on 8% to 15% slopes; it is also found along the lower slopes of the Lower Field and along a small portion of Alden Road. The Upper and Lower Fields are underlain with this soil unit on 15% to 25% slopes. Cardigan soils comprise about 45% of this soils unit, Kearsarge soils approximately 30% and other soils the remaining 25%. These soils are located on rolling or strongly sloping hilltops and hillsides. The soil texture, drainage and depth and rankings for erosion and windthrow hazard for these soils are described above in the previous paragraph.

Pittstown loam, (334C) and very stony loam (336C) soils occur on glaciated hills and are very deep and moderately well drained. Surface stones are found 5 to 30 feet apart and cover from less than 1% to 3% of the surface. Included soils within this mapping unit comprise about 15 % of the soil type and may include areas of poorly drained Stissing soils in narrow drainages and depressions, well drained Bernardston soils on low mounds and ridges and isolated areas of well drained Cardigan and excessively drained Kearsarge soils. Bedrock is found at a depth greater than 65 inches. The depth to dense basal till is 18 to 36 inches. During wet periods, commonly in early spring, the water table is perched above the hardpan layer. Erosion hazard is slight on slopes up to 15% and moderate on slopes greater than 15%. Windthrow hazard is moderate on all slopes. The site index is 80 for white pine, 72 for Northern red oak and 66 for sugar maple. This soil is considered favorable for hardwoods; intense hardwood competition will hinder white pine regeneration.

Sites on the Signal Hill Tract range from fair to excellent for tree growth. Site indexes range from 65 to 80 for white pine and 55 to 72 for red oak. The sugar maple site index is about 65 on all soil units. Red oak, sugar maple, red maple and white pine are all suited to the soil and underlying bedrock on the subject properties and are also able to adapt to the changing climate. Sweet birch, bitternut hickory and white oak are other species, currently at the northern extent of their historical range, that are suited to the sites on Signal Hill.

Land Use History

Signal Hill has a strong agrarian history; agricultural use certainly encompassed the entire tract. Agricultural was also abandoned more recently than at the Boston Lot. Consequently, the Signal Hill forest is younger and more homogeneous than the forest of the Boston Lot. The canopy is uniform and stands are mostly even-aged. Two forest types occupy the Signal Hill parcel: Hemlock/Northern hardwood (HM/NH) and White pine (WP), 43 acres

and 145 acres respectively. In portions of the white pine type the stand is moving toward the white pine/red oak/red maple forest type. Past agrarian use strongly influenced the current species composition of these stands.

The former agricultural use of Signal Hill is strongly expressed by the vegetation on the tract. The forests of lot are young; much of the property was open, or nearly so, 55 to 60 years ago. As a consequence of age and its related developmental stage, the stands possess a relatively simple structure. Canopy heights are uniform and one dimensional. Though scattered open grown trees are occasionally present, the diameters and heights of the majority of the trees are uniform. Composition, stocking and age class are homogeneous.

Recent wind events created several canopy gaps when trees in stand #2 were blown over or snapped. The largest area of wind disturbance is located easterly of the South Summit Meadow; about 2 acres was impacted. Disturbance, natural or human, creates openings in the forest canopy and thereby provides higher light levels to the forest floor. Some forms of disturbance also expose mineral soil. These factors encourage the development of tree regeneration, shrubs and herbaceous growth, which all contribute to greater species diversity and structural complexity. Unfortunately, at Signal Hill the recent disturbances have allowed invasive plants to further colonize the property. Species diversity decreases significantly in hemlock-dominated stands, except where gaps created by disturbance have permitted other species to establish.

Localized areas of enrichment were observed in stands #1, #2 and #3. Maidenhair fern, white baneberry (doll's eye), round-lobed hepatica, herb Robert, hog peanut, marginal woodfern and basswood were observed.

Invasive plants pose a considerable threat to the ecological integrity of Signal Hill. Glossy buckthorn is present in varying degrees of density and size in the white pine stands; most areas are moderately to heavily infected. Bush honeysuckle and Japanese barberry are present in the hedgerows and are invading forests borders of open areas. The Upper Field is largely occupied by shrubby growth, much of which is composed of invasive plants.

White pine canker is prevalent in the pine forests of stands #1 and #2. Live crown ratios are small due to the intense competition for light that occurs during the stem exclusion developmental stage. The fungus is further shrinking crowns; these crowns also display increased transparency. Evidence of ash decline was noted, probably attributable to ash yellows. Beech are heavily infected with beech bark disease. Severe herbivory on hardwood regeneration was noted and is a concern.

Wildlife species observed include red squirrel, gray squirrel, flying squirrel, snowshoe hare, fisher and white-tailed deer. Coyote, red and gray fox, and bobcat have all been observed in the area. The habitat on Signal Hill also supports various hawks and owls that prey upon the abundant mice and shrews

that live in the field and meadow edges. A barred owl was observed during a field visit in August 2010.

Management objectives specific to Signal Hill include:

- **Conserve the scenic and aesthetic attributes of Lebanon's rural character.** The Signal Hill Tract is a significant and high visibility ridge line.
- **Preserve the historical significance of the property.** Signal posts and fires relayed important information during colonial times.

FOREST TYPES: DESCRIPTIONS AND PRESCRIPTIONS

Stand # 1: WP4A (SAF 21) 33 Acres

Forest type: Eastern white pine

Natural community type: Hemlock-beech-oak-pine (S5)

Soil Type: Cardigan-Kearsage Rock outcrop complex 15-25% & 25-60% slopes (361D & E)

Size class: Standards

Stocking level: Overstocked

Main crown cover: Moderate to dense

Stand Structure: Two-aged

Stand Description

Stand #1 occupies a strip along the western boundary that extends from the northwest property corner southward to stand #3. The stand faces west to southwest. The terrain is moderately to extremely steep. Glacial erratics are scattered throughout the stand. Barbed wire fence and stone walls define the western property boundary.

Stand data were collected at one observation point and along meandering transects.

Eastern white pine dominates the overstory composition. Northern red oak and red maple are the principal associates along with lesser proportions of white ash, paper birch, big-toothed aspen, hemlock, sugar maple, black cherry, basswood and quaking aspen. The proportion of hardwood increases on the westerly slopes of the stand. Hemlock and hophornbeam compose the majority

of the midstory along with lower levels of striped maple. Christmas fern was the most common understory plant observed in the stand. A large patch of rich-site indicator plants, including basswood, maidenhair fern, white baneberry, white snakeroot and round-lobed hepatica, was observed along the western boundary where the barbed wire boundary transitions to a stone wall. Christmas fern and marginal wood fern also indicate somewhat enriched conditions. The following table lists the species observed in the shrub and understory layers.

Ferns & Fern Allies	Flowers	Graminoids	Shrubs	Invasive plants
Christmas fern Marginal wood fern Maidenhair fern	Canada mayflower Partridge berry Doll's eyes White snakeroot Round-lobed hepatica	None observed	Raspberry Dogwood	Glossy buckthorn Bush honeysuckle Japanese barberry

Regeneration is generally partially free to grow. In portions of the stand light levels provide a free to grow environment, while in some areas the canopy is too dense to allow seedling development. White oak seedlings were also observed in addition to the species listed below.

Species	Regeneration (stems/acre)	Percent of total
Red maple	11,000	64
White ash	9,200	12
Red oak	2,000	12
E. white pine	2,000	12
TOTAL	17,000	--

Ecosystem Components

Single tree fall and small patches of white pine blowdown provide a low to moderate level of horizontal diversity. Vertical diversity is low; the understory and midstory layers are sparse. The following table details the downed wood and snags measured on the observation point in stand #1. Cavity trees did not occur within the observation point.

Retained organic material			Snags	
Species	Diam. (inches)	Length (feet)	Species	DBH (inches)
White pine	18	72	White pine	24.5
White pine	14	46		

Game trails were observed throughout the stand.

Disturbance

Stand #1 originated from old fields that reverted to forest following agricultural abandonment. The majority of the stand was forested in 1955. A small silver of semi-open land is depicted on the 1955 aerial photo in proximity to the current boundary between stand #1 and #4.

Evidence of wind disturbance was noted within the stand. A 38 year old hemlock was located on a tip up mound and was surrounded by paper birch with perched roots, indicating a wind event in the early 1970s.

The majority of the hemlock component is roughly 75 years old, while a red oak core sample indicates that this component is about 54 years old. The oak was located next to a well decayed cut white pine stump which indicates establishment after logging in the mid 1950s. .

Deer browse was observed on hardwood seedlings.

White pine canker was observed on a portion of the white pine component. This fungus negatively impacts tree vigor and may affect the long-term survival of infected trees. American beech are infected with BBD. White ash are in decline, most likely due to ash yellows.

Glossy buckthorn, Japanese barberry, and bush honeysuckle are concentrated near the field edge and have invaded interior forest. These invasive plants threaten the enriched micro site along the western border.

Management Recommendations

- **Control non-native invasive plants.** Specific control options include:
 - o Hand pull small plants with volunteers or contracted labor.
 - o Contract a licensed herbicide applicator in collaboration with the managing forester to treat invasives with 1) a basal bark application of Garlon 4 Ultra® (triclopyr) mixed with mineral oil; 2) a foliar application; or 3) a cut stump treatment (CST), both utilizing a glyphosate product.

A foliar application of glyphosate is recommended for dense invasive populations of mature plants that are generally less than 12' to 15' tall. A basal bark treatment with Triclopyr mixed with mineral oil works well on single stems (buckthorn, Norway and amur maple) and when infestations are moderate or lower. As always, the best control method depends on the species, the infestation severity (size and density), site sensitivity, native vegetation present (especially state listed rare, threatened or endangered species), the cost of treatment and the potential number of repetitive treatments necessary to gain control. Attitudes regarding herbicide use is another element necessary

to consider in the decision- making process. The Easement language does not prohibit herbicide use.

A monitoring program that periodically evaluates treatments and impacts is an essential element of any control effort.

- **Retain and protect American beech trees that appear to be resistant to beech bark disease.**
- **Consider periodic group selection harvests with perpetual Legacy Tree retention** to promote age, size class and species diversity. Hemlock and beech could dominate the future stand composition without intervention, though the hemlock woolly adelgid may reduce this eventuality. Portions of the stand are shifting from white pine to hardwoods. A diversity of species and age classes provides increased resiliency to impacts of pathogens and climate change.

Stand # 2: WP4A (SAF 21) 112 Acres

Forest type: Eastern white pine

Natural community type: Hemlock-beech-oak-pine

Soil Type: Cardigan-Kearsage Rock outcrop complex, 3-8%, 8-15% & 15-25% slopes, (361B, C & D), Cardigan-Kearsage complex 8-15% slopes (360C), Bernardston silt loam, very stony 15-25% slopes (331D) and Pittstown loam, very stony, 8-15% slopes (336C)

Size class: Standards to poles **Stocking level:** Adequate to Overstocked

Main crown cover: Moderate to Dense **Stand Structure:** Even-aged

Stand Description

This is the largest stand on the Signal Hill Tract, occupying 52% of the property. The southern section of stand #2 encompasses the entire east to west breadth of the lot, running from Alden Road on the east, westerly over the ridge to the western property boundary. The stand spreads from the southern boundary northerly to the fields and stand #4. The aspect ranges widely from east to southeast facing slopes east of the ridge and west slopes on the western side of the ridge. The terrain ranges from gentle to extremely steep slopes punctuated with ledge. The majority of the stand occupies moderate slopes. Cardigan-Kearsage Rock outcrop complex and Cardigan-Kearsage complex soils underlie almost the entire stand. Bernardston and Pittstown soils are found under small areas at the lower slope position.

Stand data were collected at two observation points and along meandering transects.

Nearly pure white pine forms portions of the stand. Hardwoods, particularly red oak and red maple, interrupt the pine dominance in some sections. Hemlock also mixes in along the edge of stand #3 as well as in a small area of the Eastern section of the stand adjacent to Alden Road. In these sections, hemlock is typically found below the main crown canopy of white pine and its associates. This species frequently forms a dense midstory canopy. Stand age is 50 to 65 years old; the pine, oak and red maple all fall within this range. The red oak frequently displays the form of open grown or semi-open grown conditions; crowns are wide spreading and limb structure is coarse. Other associate canopy species include white ash, hemlock, big-toothed aspen, black cherry, sugar maple and fading or dead pin cherry. The midstory is composed of beech, sugar maple and basswood (especially near the ridge), black cherry (on the edge of the large field), hophornbeam, striped maple along with dense patches of hemlock as mentioned above. The following table lists the species observed in the shrub and herbaceous layers.

Ferns & Fern Allies	Flowers	Graminoids	Shrubs	Invasive plants
Christmas fern Inter. wood fern Marginal wood fern Hayscented fern Bracken fern Tree club moss Ground cedar Lady fern Bristly club moss	Starflower Canada mayflower Partridge berry Wild sarsaparilla Violet sp. Indian cucumber root Small white aster Cinquefoil Hellaborine Hog peanut Wild lettuce Yellow wood sorrel Baneberry Sweet-scented bedstraw Hawkweed Herb Robert	Sedge species Wild oats Pennsylvania sedge	Raspberry Elderberry Currents	Glossy buckthorn Common buckthorn Japanese barberry Bush honeysuckle

Regeneration occurs at high levels; most is not free to grow, unless canopy gaps are present.

Species	Regeneration (stems/acre)	Percent of total
Red maple	71,000	85
White ash	3,500	4
E. white pine	4,000	5
Red oak	500	1
Hophornbeam	2,500	3
Glossy buckthorn	2,500	3
TOTAL	84,000	--

Ecosystem Components

Stand #2 generally exhibits low vertical diversity; the canopy is relatively smooth. In portions of the stand that support a hemlock midstory the vertical diversity increases marginally. Horizontal diversity is also low; canopy gaps are uncommon. The stand contains three unique tree species: basswood, butternut and slippery elm. Old apple trees, which are non-native, are also found scattered throughout the stand.

Down material did not occur within the samples. Low levels of large woody material and moderate levels of fine woody material were observed on the forest floor. The stand is in the stem exclusion phase of development, and therefore snags are comprised of smaller diameters trees that have succumbed to natural mortality via competition. Wind disturbance is beginning to impact the stand, uprooting and snapping trees in small portions of the stand. The following table indicates the cavity trees and snags that were tallied on observation points within stand #2.

Cavity trees		Snags	
Species	DBH (inches)	Species	DBH (inches)
White pine	26-28	White pine	6
		White pine	8

Wildlife signs observed include deer scent markings on hophornbeam and turkey scratchings throughout the stand.

Disturbance

Stand #2 was largely forested in 1955. The South Summit Meadow along with other adjacent areas along the ridge were open or semi-open at that time.

A Nor'easter in April 2007 blew over patches and single trees. The largest canopy gap created by this wind event is found Easterly of the South Meadow; about 2 acres were impacted. Damage also occurred over smaller areas. Wind disturbance creates canopy gaps, increases horizontal diversity

and, over time, increases vertical diversity, age and species diversity. Wind events also expose mineral soil and create pit and mound micro-topography.

Glossy buckthorn is pervasive throughout most of the stand. Common buckthorn is found in the Western portion of the stand. Japanese barberry and honeysuckle are concentrated in proximity to open areas, roadsides and neighboring properties; these species also occur in the western section of the stand.

Deer browse is heavy on hardwoods.

Management Recommendations

- **Control non-native invasive plants.** A foliar application of glyphosate is probably the most cost effective treatment available. A seed bank is present and persistent. Long term control requires three, or more, repetitive treatments at 3 to 4 year intervals. Monitor treatment results and invasive populations.
- **Consider periodic group selection harvests with perpetual Legacy Tree retention** to promote age, size class and species diversity. Portions of the stand are shifting from white pine to hardwoods. The live crown ratio of the white pine component is frequently low due to the impact of pine canker fungus. Increased light levels will increase temperatures and decrease moisture levels, thereby potentially mitigating this fungus. Again, species and age class diversity increases stand resiliency to the effects of pathogens and climate change.

Stand # 3: HM/NH4A (SAF 23/25) 31 Acres

Forest type: Hemlock/Northern Hardwood

Natural community type: Hemlock-beech-oak-pine (S5)

Soil Type: Cardigan-Kearsage Rock outcrop complex 15-25% & 25-60% slopes (361D & E)

Size class: Standards

Stocking level: Overstocked

Main crown cover: Dense

Stand Structure: Even-aged

Stand Description

Stand #3 is located in the central portion of the property, forming a west to east tongue separating stands #1 and #2 in the west and protruding further easterly into stand #2. The majority of the stand occupies moderately steep to steep terrain. Several areas of exposed bedrock were noted. Rocks with quartz were observed on the surface and in stone walls.

Data were obtained at one observation point and along meandering transects. The observation point was located on the edge of a gap created by two tipped over hemlocks.

This stand is older than stand #4; the hemlock in the main crown canopy is about 130 years old. Eastern hemlock and Northern red oak dominate the canopy. Associate species include Eastern white pine, American beech, paper birch, white ash, yellow birch and sugar maple. Basswood was observed as a minor component. The midstory is composed primarily of hemlock and hophornbeam along with patches of striped maple. Christmas and intermediate wood ferns are the most abundant ferns. Hayscented, marginal wood, and bracken ferns were also present. White snakeroot, foam flower, hog peanut and a woodland grass species were found in a canopy gap along with basswood and flowering raspberry. Basswood and white snakeroot are indicative of enriched sites. Partridgeberry and Canada mayflower were more common under the dense hemlock stand interior. Rattlesnake plantain was observed under a hemlock near the ridge.



Rattlesnake plantain growing under a hemlock.

Seedlings at the observation point were free to grow due to the proximity of the canopy gap. However, dense hemlock cover inhibits regeneration throughout the majority of the stand. The regeneration found at the observation point is much higher than that observed throughout most of the stand.

Species	Regeneration (stems/acre)	Percent of total
Red maple	34,000	72
White pine	12,000	26
Yellow birch	1,000	2
TOTAL	47,000	--

Ecosystem Components

Vertical and horizontal diversity are low. The dense hemlock canopy suppresses establishment, growth and development of trees, shrubs or herbaceous plants. The stocking and composition are homogeneous. Canopy gaps occur infrequently. Hard mast species occur at low abundance levels on a stand basis; where red oak and beech mix with the hemlock abundance levels are locally higher.

The following table indicates the downed wood and snags that occurred within the observation point. Cavity trees did not occur within the observation point.

Retained organic material			Snags	
<i>Species</i>	<i>Diameter (inches)</i>	<i>Length (feet)</i>	<i>Species</i>	<i>DBH (inches)</i>
Hemlock	17	68	Hemlock	23.2
Hemlock	17	68		

Wildlife signs observed include deer scat.

Disturbance

Stand #3 originated from old fields. This stand was forested in the 1955 aerial photo. A stone wall runs in northeast to southwest direction and an old woods road runs north-south on the southeast facing slope. A network of mountain bike trails weave through the western slopes of the stand.

The majority of the American beech are infected with BBD. Most white ash trees are declining.

Single tree tip ups were observed in the stand. Glossy buckthorn seedlings were observed along the main recreational trail and along mountain bike trails.

Management Recommendations

- **Control non-native invasive plants.** Hand pull small plants along trails with volunteers. Evaluate the treatment the following year and repeat as necessary.
- **Consider removing striped maple and hemlock from the midstory** to promote greater diversity.
- **Retain and protect American beech trees that appear to be resistant to beech bark disease.** In managed stands release resistant beech and promote their propagation.

- **Consider periodic group selection harvests with perpetual Legacy Tree retention** to promote age, size class and species diversity. Hemlock currently dominates the stand. The dense cover homogenizes the stand, excluding regeneration and herbaceous plants. The hemlock woolly adelgid will radically alter future stand composition within the next 10 to 20 years. Localized enrichment within the stand indicates that some site could support extremely diverse plant assemblages.

Stand # 4: HM/NH4A (SAF 23/25) 12 Acres

Forest type: Hemlock/Northern Hardwood

Natural community type: Hemlock-beech-oak-pine (S5)

Soil Type: Cardigan-Kearsage Rock outcrop complex, 8-15%, 15-25% & 25-60% slopes (361C, D & E)

Size class: Standards

Stocking level: Overstocked

Main crown cover: Dense

Stand Structure: Even-aged

Stand Description

Stand #4 forms a strip along the northern property boundary. The aspect ranges from southeast to southwest. The majority of the stand occupies gentle to moderate terrain.

The stand is composed predominantly of Eastern hemlock. Northern red oak, red maple, American beech and paper birch are the primary associates. Hemlock, American beech and hophornbeam comprise the majority of the midstory at low levels. Hayscented fern is particularly abundant in gaps. The following table lists the species observed in the shrub and herbaceous layers.

Ferns & Fern Allies	Flowers	Graminoids	Shrubs	Invasive plants
Christmas fern Intermediate wood fern Hayscented fern Marginal wood fern	Canada mayflower	None observed	None observed	Glossy buckthorn Bush honeysuckle

Pockets of American beech and white ash regeneration are found in gaps. Regeneration occurs at low abundance levels throughout the stand (an estimated 1,000 stems of red maple seedlings), which is typical of dense hemlock stands.

Ecosystem Components

Vertical diversity is low. The dense hemlock canopy inhibits establishment and growth of the understory and midstory layers. The adjacent open field and white pine stand create a localized edge effect. Occasional canopy gaps created by single tree fall occur within the stand; horizontal diversity is ranked low/+. Red oak is found at low/+ levels within the stand and provides hard mast for wildlife feed. Van de Poll (2010) designated this stand as an “excellent site for wintering deer”.

The following table indicates the number of downed wood and cavity trees measured at the observation point. Snags did not occur within the observation point plot.

Retained organic material			Cavity trees	
Species	Diam. (inches)	Length (feet)	Species	DBH (inches)
Hemlock	17.4	34	Hemlock	17
Hemlock	18	47	Hemlock	25.5

Wildlife signs observed include deer scat and turkey scratchings.

Disturbance

In a 1955 aerial photo the stand was forested. A barbed wire fence and stone wall forms the northern property boundary. Stand origin is unknown, but is likely that this stand developed from old pasture. The hemlock and red oak components are both 90 to 100 years old. Minor wind damage, consisting of tip ups or snapped stems, was evident in the stand. Glossy buckthorn and bush honeysuckle are concentrated near the field edge.

Management Recommendations

- **Control non-native invasive plants.** Control options include:
 - o Hand pull small plants with volunteers.
 - o Contract with a licensed herbicide applicator to treat invasives with either a basal bark application of Garlon 4® (triclopyr) mixed with mineral oil or a foliar application of glyphosate.

Evaluate the infestation and determine the most appropriate and cost-effective treatment. Monitor the stand and schedule follow-up treatments two to three years after initial treatment.

- **Evaluate the stand further for deer wintering habitat.**

OPEN LAND: DESCRIPTIONS AND PRESCRIPTIONS

Upper Field

10 Acres

The Upper Field is reverting to shrubs and trees. A kidney shaped island of white pine regeneration is found in the north central portion of the field. Glossy buckthorn is prolific, especially around the borders with the forestland. A strip of saplings is found along the northern field edge. A hedgerow separates the Upper Field and Lower Field.

The recreational trail parallels the south edge of the field and is mowed annually to facilitate access.

A flock of wild turkeys were observed on a field visit feeding among the white pine regeneration.

Management Recommendations

- **Control invasive plants.**

Utilize a licensed herbicide applicator to treat invasives. The high densities found in this area are most effectively treated by foliar applications of glyphosate.

- **Consider allowing this area to revert to early successional shrub/sapling habitat.** Shrub growth provides habitat for chestnut-sided warblers, white-throated sparrows, catbirds, brown thrashers and other songbirds. Divide the Upper Field roughly into quarters or sixths. Clear $\frac{1}{2}$ to $\frac{1}{3}$ of the area every 3 to 5 years, depending on growth. Allow vegetation to grow a maximum of 16' to 20' tall prior to cutting. Deciduous trees and shrubs will readily sprout, providing dense cover. Soften the northern edge of the field and its interface with the saplings. Create variable width and length fingers of alternating vegetation and small clearings. This technique increases edge and improves security for wildlife by enhancing escape cover.

Lower Field

16 Acres

The Lower Field is mowed annually, perpetuating perennial wildflowers. The field was characterized by Van de Poll (2010) as a goldenrod-milkweed meadow. Blackberry and raspberry species, clovers, cinquefoils, blackeyed Susan, common milkweed, Canada goldenrod, and various grasses and sedges are present. The wildflower component comprises a greater proportion of the vegetation than the grasses and sedges. The Lower Field hosts a variety of

mammals, birds, and insects such as meadow voles, brown thrashers, and monarch butterflies. (Van de Poll 2010).

The recreational trail is mowed annually, beginning at the parking area kiosk and roughly paralleling the Southern field edge.

The minimum area necessary to support grassland birds is 20 acres. This field is slightly smaller than the minimum habitat requirement. Numerous fields in close proximity may provide better opportunities for grassland nesting birds, depending on the management regime.

The proportion of grasses in the Lower Field could be increased by multiple mowings between May and September. This practice will negatively impact habitat for grassland birds, if utilizing the area, during the period required to revitalize the field. Remove the hay or thatch from mowing to promote greater vigor and re-growth of the grass component. Applications of lime and fertilizer also improve grass production. Ideally, grasses should compose 50% to 75% of the vegetation to provide optimum habitat for grassland bird species. Fields that green up early are more attractive to birds.

Once grasses are established in greater proportion mow half of the area annually after August 1st. Divide the area in quarters and mow alternating blocks. Fire is another tool that could be utilized to maintain grassland habitat.

Currently, wildflowers dominate the field; grasses are no longer the dominant vegetation. Conduct local habitat research prior to undertaking an intensive management effort to re-establish a greater proportion of grasses in the Lower Field. Utilize aerial photographs to determine nearby open areas that are 20 acres or greater. Contact owners of the nearby fields meeting this acreage threshold regarding their mowing practices. Consider assessing nearby fields and performing a grassland bird inventory in fields that are not mowed for hay. If bobolinks, meadowlarks, whip-poor-wills and other grassland dependent species are absent from areas that currently provide quality habitat, these birds are not likely to populate less desirable sites.

South Summit Meadow

3 Acres

The recreation trail bisects the South Summit Meadow and both are mowed annually. Composition is similar to the Lower Field; the vegetation is dominated by goldenrod and milkweed. A high concentration of milkweed supporting monarch butterflies, goldfinch, indigo bunting and song sparrow were observed during a UVLT site visit (UVLT 2007).

Management Recommendations

- Brush-hog at least once a year after August 1st to maintain current open conditions.

- The 2003 management plan recommends establishing and maintaining five viewpoints in an arc extending approximately 200 degrees around the southern periphery of the South summit.
- That plan also recommends releasing apple trees near the South Summit.

Tract Summary

The forests of the Signal Hill tract are young, fairly homogeneous and fairly simple structurally; much of the tract was open 50 to 60 years ago. Recreational use of this tract is much lower than that experienced on the Boston Lot. Invasive plants dominate large portions of the understory, fields and field edges. Evidence of past harvesting is largely absent. Pine canker is negatively impacting the pine component, which dominates much of the forest area.

The 1998 ice storm had little impact on the tract. Wind events have created minor, and for the most part, small canopy gaps. These gaps have been aggressively exploited by invasives.

Mast-producing species occur uncommonly at Signal Hill. Northern red oak and hophornbeam are probably the most common hard mast species, but are minor stand components.

This property is surrounded by a developed and fragmented landscape.

Signal Hill is a historically significant ridge.

Invasive plants have heavily invaded the majority of the this tract. These species have spread from the fields into largely undisturbed forest settings. Glossy buckthorn is the most abundant invasive species. These invaders will negatively impact natural stand development. The declining vigor of much of the white pine due to pine canker will likely shorten this species life span throughout much of tract. The resultant mortality will likely create significant canopy gaps that invasive plants will further exploit.

Successful treatment of these high level infestations is possible, but costs are high. A significant control commitment that integrates monitoring and repetitive treatments over time is essential to success. High infestation levels must be initially control with herbicide applications; hand pulling seedlings is a viable follow-up option if labor is readily available.

Recommendation

- Develop a strategy and budget for controlling invasive plants.

Though the timber resource was not specifically evaluated, it is evident that this tract is stocked with high levels of commercially valuable timber. The majority of this volume and value is comprised of white pine, much of which is threatened to varying degrees by pine canker. Harvesting would salvage value from the affected pine while potentially increasing structural and species diversity. However, harvesting would also further encourage existing invasive populations. At least two, and possibly three, invasive control treatments must be applied pre-harvest, should that activity be pursued. These treatments will require a 10 to 15 year time span to fully implement. Therefore, any potential harvest is also 10 to 15+ years in the future. The advent of invasive plants has increased the need for planning and the time horizon necessary to accomplish goals and objectives.

The open land of the tract is in poor condition from a grassland perspective. Shrubs (including a high proportion of invasives) are invading the upper field. The lower field is composed primarily of goldenrods and other “weed” species. The lower field is below the generally accepted minimum area required to support grassland nesting birds.

The forests of Signal Hill are typical of the region and generally unremarkable in nature. Though the property fronts along substantial road distances, access to the forest for management or recreation is poor. The high infestation of invasives presents numerous management challenges. These invasive plants present a high risk to the natural development of the future forest and will further homogenize an already uniform forest while also degrading wildlife habitat.

X. CONCLUSION & SUMMARY

Forests are diverse and continually changing. They are influenced by underlying bedrock, soils, drainage, slope, position on the slope, climate, weather and human use. The forests of the Boston Lot and the Signal Hill Tract are both typical of the region, though they each display vastly different characteristics. The current conditions found on both tracts are directly attributable to the farming and logging practices of yesterday. Undoubtedly, human influence, natural succession and disturbance, along with the unknown influences of climate change and invasive plants and insects, will continue to shape the character of these forests.

Regeneration is critical to perpetuate the forest. Currently, invasive plants and high levels of herbivory both negatively impact forest regeneration in the region, and to varying degrees, on these parcels. Site-suited regeneration is also an essential ingredient of vibrant multi-aged forests. These forests possess greater complexity than even-aged forests, developing structural integrity and diversity that provides resiliency in the face of climate change and exotic invasive plants and insects. A diverse mix of regeneration is also a necessary element of sustainable harvests designed to accomplish ownership objectives while producing the goods and services desired by society.

Both commercial harvests designed to obtain regeneration, commercial thinnings that control density and composition and precommercial weedings, thinnings and release are needed to achieve two overarching objectives articulated by Conservation Commission: 1) increasing biodiversity; and 2) improving forest resiliency in the face of climate change and the threats posed by exotic plants and insects. A proactive approach to these and other threats will likely result in achieving better outcomes than assuming a hands off approach. Unfortunately, the “natural” world is not as natural now, as it once was.

Though our present forest ecosystems are increasingly altered by invasive plants and insects, human use and climate change, these forests have actually been heavily influenced by human activity since European settlement. This settlement was responsible for the vast clearing of forests for agricultural use and subsistence homesteads, resulting in soil loss and compaction, siltation of our waterways and a radical shift in land cover and the future composition of the forest. Our present day forests are very much the product of past human activity. It is almost impossible to sort out the natural forest dynamics from those modified by human use or abuse over time.

Prior to European colonization of this continent, Native peoples also exerted an influence on the forest and the landscape, albeit less intensively and extensively than their European counterparts. Portions of the river valleys were cleared for seasonal village sites and agriculture production. Burning cleared

the understory and maintained an open forest which facilitated hunting game with spears, atlatl and bow and arrow. In some regions Native people modified the course of streams and rivers.

Portions of our landscape are currently managed at various levels, while others are either not managed or are exploited and abused. Natural areas are essential components of the landscape: they provide refugia for biodiversity, protect rare, threatened and endangered species, exemplary natural communities, wetlands, soil, water and other significant ecological elements and provide a baseline to evaluate natural stand dynamics and the impacts of climate, invasive plants and exotic insects on native forests. These reserves can manifest as both stand alone tracts or designated areas within a working forest matrix.

Silvicultural treatments increase age, species, vertical and horizontal diversity. Contrast the uniformity and simplistic stands of Signal Hill and the diverse and complex stands of the Boston Lot. Though the complexity found at Boston Lot is partially attributable to a forest that is older than that found on Signal Hill, past harvesting is a major factor in the diverse character of that tract. Past forestry activities produced desired outcomes and created increased complexity on a shorter temporal scale than would otherwise occur in natural unmanaged stands. Silvicultural treatments not only create complexity and diversity within the forest, but commercial treatments can produce revenue to fund the myriad management costs involved with land stewardship and conservation.

Periodic investments of time and/or money are also necessary to accomplish stated goals and objective. Budgeting a modest annual expenditure over the next 15 to 20 years that is derived from the land use change tax and/or future timber sale proceeds for management purposes is a practical method for meeting this need. In this manner progress is steady, yet priorities and treatment results can be continuously evaluated and modified as needed to best accomplish landowner goals.

Weeding and thinning young stands, or stand components, along with periodic selection harvests of commercial size trees will produce multi-aged stands that fully occupy the site and provide increased diversity. The percentage of white pine will diminish in the future, on both tracts, but this species can certainly maintain a presence for perhaps another century or more on both properties. White pine is well suited to the shallower soils found on the properties, though it is susceptible to wind throw on these sites. Even a small percentage of white pine can contribute significantly to the volume/acre and species diversity in future stands. The presence of pine canker, especially in the densely stocked stands on Signal Hill, will impact the featured white pine on that parcel; its impact on future stands is unknown. The hardwood component will undoubtedly increase with time over the majority of both the Boston Lot and the Signal Hill tract.

The composition of the future forest is partly dependent on the relationship of sunlight and shade, site characteristics, the unknown impact of invasive alien plants and insects, climate change and natural events. Higher stand densities and small crown openings will tend to favor tolerant hardwoods. Heavier cuts and larger openings will increase the proportion of intolerant hardwoods such as paper birch and aspen. Group selection favors a diverse mix of species including red oak, yellow birch, white ash and sweet birch on many of the sites on this tract. Red oak, white oak, bitternut hickory and black birch are all likely to compose a greater portion of the future forest in a warming climate scenario.

Higher light levels will also create conducive conditions for buckthorn, honeysuckle and barberry. Control strategies are necessary to preserve the ecological integrity of the forest at both sites, regardless of the implementation or absences of active forest management. These stands will continue to diversify and change, both as they develop naturally, and if they are manipulated by active management to achieve landowner objectives.

Exotic insects also pose significant threats to Boston Lot and the region at large. Hemlock woolly adelgid probably represents the greatest near term threat to our regions forests. This insect will significantly alter the composition of our regions forests and reduce the available softwood cover on the landscape.

The Boston Lot supports excellent wildlife habitat by virtue of both its area and its connection to other large undeveloped tracts and its diverse species composition, structural complexity and heterogeneous nature. The largely homogeneous stands of Signal Hill, though still providing important habitat, lack the richness, diversity and forest structure found on the Boston Lot. Wildlife habitat can be maintained and improved in many ways on both tracts. Improvements can be accomplished by both commercial and pre-commercial treatments. Any treatment designed to benefit specific species or conditions, logically creates disadvantages for other species. Treatments targeted at increasing diversity, complexity and structure will generally provide the greatest benefit for the greatest number of species.

Any activity on the properties must necessarily recognize the established indigenous residents, the intrinsic values possessed by the property and the landowners' objectives. These relatively small pieces of forestland, like the surrounding woodland in our region, are in many ways, still healing from the over-cutting and over-grazing of the past. Protecting and maintaining the soil, unique trees, native plants, animals and natural communities, and allowing at least a portion of each stand to follow its natural life cycle, even if actively managed, will assure a healthy and thriving forest which is capable of providing sustainable goods and services desired by the community and our society at large, while protecting the ecological components that are vital to that very forested ecosystem.

Both Signal Hill and the Boston Lot forests are capable of providing a source of timber and the resultant income, providing wildlife habitat, recreational enjoyment and an aesthetically pleasing landscape while also providing research and educational opportunities.

Utilize this plan thoughtfully and carefully; integrate the information contained within to make informed choices and decisions. Question the plan and seek additional information and guidance if any recommendation creates discomfort for any reason. This document is intended as a flexible guide and a source for information, not a cookie cutter how to manual. Respect the land, soil, water, plants and animals above all else when implementing suggested treatments. Do not hurry. Always act for the future, not simply for the present. Our decisions and actions will outlive us and the natural world will outlive our actions and decisions. Consider this plan a working document that is designed to aid decision making, to prioritize and to guide the work necessary to achieve both the landowner's goals and to maintain a functioning forest. Terrain, soils and stand conditions can vary widely within stands. Consider these variations, market conditions, landowner objectives and weather when implementing specific recommendations.

The Conservation Commission and the the City of Lebanon may be at a cross roads regarding the management of these and other City owned lands. Both a passive strategy (no management), as well as a proactive management approach entail potential benefits and determents, both received and actual. The commission must evaluate the information contained in this document, relate that to their stated goals and objectives, and ascertain a course of action moving forward. A right or wrong answer does not exist. Review the following recommendations, view them as suggestions, determine whether or not they might accomplish a desired goal, modify goals and objectives, if necessary, and then make a management decision.

Recommendations

- Locate, flag and blaze and paint the Boston Lot addition in 2012.
- During the next maintenance interval re-blaze both the Boston Lot and Signal Hill Tract utilizing more frequent and higher blazes. Schedule for approximately 2015-17.
- Begin to develop strategies for controlling invasive plants. Implement control efforts at the Boston Lot first. These will prove relatively effective and economical; successful control is achievable within approximately 5 to 10 years of implementation. Tackle the high infestations found at the Signal Hill tract after initial treatments at the Boston Lot are completed. Successful invasive control treatments at Signal Hill is possible, but to achieve success more treatments over a longer time period are required and higher

costs will be incurred. Successful control is achievable within 10 to 15 years of implementation.

- Consider a quantitative forest inventory of both the Boston Lot and Signal Hill (and possibly other parcels) to determine stand stocking levels, species composition by basal area, number of trees, volume and products. Both tracts support significant timber volume and value. Commercial silvicultural treatments can accomplish the Commission's goals, protect ecological integrity and conservation values, while also producing revenues. Inventory data can be integrated with the qualitative data collected in this report to provide more comprehensive detail.
- Consider evaluating all City owned Conservation Lands to develop a matrix of appropriate use and management for each tract and the total holdings. Incorporate reserves into any management strategy, both by individual tracts and within tracts.
- Consider all the issues revolving around the questions of active management or passive management. Consider integrating natural areas (forest preserves) within a matrix of working forest on both a tract and ownership basis. In some instances an entire tract may be devoted to a natural forest reserve (Farnum Hill) and in other cases portions of a parcel may be actively managed while other areas are reserved from active management. View timber harvesting not as an exploitive activity, but simply as a tool to accomplish ownership objectives.

The Lebanon Conservation Commission has an opportunity to employ thoughtful, deliberate forest management that is informed by the forest itself, on the lands that it stewards. Such a management approach provides educational opportunities to landowners, the community at large and other conservation commissions. Establishing a high standard of forest management performance that incorporates both an ecological and adaptive approach also creates a positive example of stewardship in the community that can potentially elevate the quality of forestry activities in the region.

The City of Lebanon is fortunate to own not only the Boston Lot and the Signal Hill Tract, but all of the numerous conservation properties falling under their tenure. The commitment by the City, the Conservation Commission and members of that body, past and present, to the conservation of the City's natural heritage is evident not only by the land area owned, but by the numerous Conservation Easements granted to protect the natural, intrinsic values of those properties. Such generosity and forethought are their own fitting legacy for future generations of Lebanon and the surrounding area.

A P P E N D I X

Works Consulted

- Allen, Shirley W. and Grant W. Sharpe, 1960. An Introduction to Forestry. 3rd ed. New York: McGraw-Hill.
- Bowman, Pete, 2007. Key to Natural Communities and Natural Community Systems of New Hampshire (draft version May 2007). New Hampshire Natural Heritage Bureau.
- Burns, R.M., and B.H. Honkala, tech. coordinators. 1990. Silvics of North America: 1. Conifers; 2. Hardwoods. Agriculture Handbook 654. Washington, DC. U.S. Department of Agriculture, Forest Service.
- Diagnosing Injury to Eastern Forest Trees: A Manual for Identifying Damage Caused by Air Pollution, Pathogens, Insects and Abiotic Stresses, 1987. University Park, PA: Penn State College of Agricultural Sciences.
- Foster, Steven and James A. Duke, 1990. The Peterson Field Guide Series, A Field Guide to Medicinal Plants, Eastern and Central North America. Boston: Houghton Mifflin.
- Fowells, H. A., USDA, Forest Service, 1965. Silvics of Forest Trees of the United States. Agriculture Handbook number 271. Washington, D.C.: Forest Service.
- Frank, Robert M. and John C. Bjorkbom, 1973. A Silvicultural Guide for Spruce-Fir in the Northeast. General Technical Report NE-6. Broomall, PA: USDA Forest Service, Northeastern Forest Experiment Station.
- Frank, Robert M. and Barton M. Blum, 1978. The Selection System of Silviculture in Spruce-Fir Stands - Procedures, Early Results, and Comparisons with Unmanaged Stands. Forest Service Research Paper NE-425. Broomall, PA: USDA Forest Service, Northeastern Forest Experiment Station.
- Harlow, William M and Ellwood S. Harrar, 1969. Textbook of Dendrology. 2nd ed. New York: McGraw-Hill.
- Hornbeck, James W. and William B. Leak, 1991. Ecology and Management of Northern Hardwood Forests in New England. General Technical Report NE-159. Radnor, PA: USDA Forest Service, Northeastern Forest Experimental Station.
- How to Identify and Manage Ash Yellows in Forest Stands and Home Landscapes. 1994. USDA Forest Service, Northeastern Area State and Private Forestry. NA-FR-03-94.
- Kohm, Kathryn A. and Jerry F. Franklin, 1997. Creating a Forestry for the 21st Century, The Science of Ecosystem Management. Cuvelo, CA: Island Press.

- Kricher, John C. and Gordon Morrison, 1988. The Peterson Field Guide Series, A Field Guide to Eastern Forests, North America. Boston: Houghton Mifflin.
- Lancaster, Kenneth F. and William B. Leak, 1978. A Silvicultural Guide for White Pine in the Northeast. General Technical Report NE-41. Broomall, PA: USDA Forest Service, Northeastern Forest Experimental Station.
- Leak, William B. and Neil Lamson. Revised White Pine Stocking Guide for Managed Stands. USDA Forest Service.
- Leak, William B., Dale S. Solomon and Paul S. DeBald, 1987. Silvicultural Guide for Northern Hardwood Types in the Northeast (revised). Research Paper NE-603. Broomall, PA: USDA Forest Service, Northeastern Forest Experimental Station.
- Lyons, J.B., W.A. Bothner, R.H. Moench & J.B. Thompson 1997 Bedrock geologic map of New Hampshire.
- Manager's Handbook for Aspen in the North Central States. General Technical Report NC-36. USDA Forest Service, North Central Forest Experiment Station.
- Managing Northern Hardwood Forests for Ecological Values and Timber Production: Recommendations for Landowners in the Taconic Mountains of Vermont. The Nature Conservancy of Vermont.
- Martin, Alexander c., Herbert S. Zim and Arnold I. Nelson, 1951. American Wildlife and Plants: A Guide to Wildlife Food Habits. New York: Dover Publications, Inc.
- Newcomb, I., 1977. Newcomb's Wildflower Guide. Boston: Little, Brown & Co.
- The New Hampshire Forest Sustainability Standards Work Team, 1997. Good Forestry in the Granite State. Concord, NH: Society for the Protection of NH Forests.
- New Hampshire Natural Heritage Bureau, 2008 . New Hampshire Natural Heritage Bureau Rare Plant List.
- Perky, Arlyn W. and Brenda W. Wilkins. Crop Tree Management in Eastern Hardwoods. Morgantown, WV: USDA Forest Service.
- Plant Tracking List: Including species listed as threatened or endangered under the NH Native Plant Protection Act of 1987 (Technical Copy), 2000. Concord, NH: New Hampshire Natural Heritage Inventory.
- Robbins, Chandler S., Bertel Bruun and Herbert S. Zim, 1966. A Guide to Field Identification Birds of North America. New York: Golden Press.
- Safford, I. O., 1983. Silvicultural Guide for Paper Birch in the Northeast (revised).

Research Paper NE-535. Broomall, PA: USDA Forest Service, Northeastern Forest Experiment Station.

Sander, Ivan 1., 1977. Manager's Handbook for Oaks in the North Central States. General Technical Report NC-37. St. Paul, MN: USDA Forest Service, North Central Forest Experiment Station.

Smith, David M., 1962. The Practice of Silviculture. 7th ed. New York: John Wiley & Sons.

Smith, David M., Bruce C. Larson, Matthew J. Kelty, P. Mark S. Ashton, 1997. The Practice of Silviculture, Applied Forest Ecology. 9th ed. New York: John Wiley & Sons Inc.

Society of American Foresters, 1954. reprinted 1975. Forest Cover Types of North America (Exclusive of Mexico). Bethesda, MD: Society of American Foresters.

Society of American Foresters, 1980. Forest Cover Types of the United States and Canada. Ed. F. H. Eyre. Washington D.C.: Society of American Foresters.

Soil Survey of Grafton County Area, New Hampshire, 1999. USDA, Natural Resources Conservation Service.

Sperduto, Daniel D. & William F. Nichols, 2004. Natural Communities of New Hampshire. New Hampshire Natural Heritage Bureau and The Nature Conservancy. Available at http://www.nhdf.org/library/pdf/Natural_Communities2ndweb.pdf. Accessed 14 January 2010.

Thompson, Elizabeth H. & Eric R. Sorenson, 2000. Wetland, Woodland, Wildland: A Guide to the Natural Communities of Vermont. Hanover, NH: University Press of New England.

Tubbs, Carl H., Richard M. DeGraaf, Mariko Yamasaki, and William M. Healy, 1987. Guide to Wildlife Tree Management in New England Northern Hardwoods. General Technical Report NE-118. Broomall, PA: USDA Forest Service, Northeastern Forest Experiment Station.

Van Diver, Bradford B. 1995 (5th printing). Roadside Geology of Vermont and New Hampshire. Missoula, MT: Mountain Press Publishing Company.

Wenger, Karl F., ed., 1984. Forestry Handbook. 2nd ed. New York: John Wiley & Sons.

Westveld, R. H., 1949. Applied Silviculture in the United States. 2nd ed. New York: John Wiley & Sons.

GLOSSARY

ACCEPTABLE GROWING STOCK (AGS): A crop tree managed to meet any given landowners' objective. Use Value Appraisal guidelines define AGS as commercial tree species containing one 12-foot log or two non-contiguous 8-foot logs, or that have the potential to produce these products in the future.

ACCEPTABLE MANAGEMENT PRACTICES (AMPs): Standards for protecting water quality on logging jobs developed by the Department of Forests, Parks and Recreation and outlined in the booklet titled *Acceptable Management Practices for Maintaining Water Quality on Logging Jobs in Vermont*.

ACRE: A standard unit of area measure. One acre equals: 43,560 square feet, 10 square chains or an area that is 209' X 209'.

ADVANCED REGENERATION: Natural regeneration that is established prior to, not as a result of a harvest.

ALL-AGED (UNEVEN-AGED): Age class category; applied to a stand of trees in which, theoretically, trees of all ages are found; a stand occupied by three or more age classes.

ANCIENT FOREST (OLD GROWTH FOREST): Forest in late successional stages; the older seral stages of natural forests.

ANNUAL RING: The growth layer of one year, as viewed on the cross-section of a stem, branch or root.

ASPECT: The direction of a slope.

BASAL AREA: The cross-sectional area of a tree computed from DBH measurements, expressed in square feet; the sum of the basal areas of all trees on an acre, expressed as basal area/acre, is an objective measure of density and is useful for making forest management decisions.

BIODIVERSITY: The variety of life and its processes including living organisms, genetic differences among them, the ecosystems in which they occur and the ecological and evolutionary processes that maintain their functions.

BIOMASS: The total above ground volume of a tree, stand or forest, usually expressed in tons/acre. This term is also used to describe a whole tree or chip harvest.

BOARD FOOT: A unit of measurement to determine volume of lumber; one board foot equals a board 12" x 12" x 1". Also a measure of standing or logs.

BROWSE: Buds, leaves, and twigs of tree seedlings and saplings, shrubs and herbaceous plants that are utilized for food by wildlife.

CANOPY: The combined forest cover formed by individual overstory tree crowns.

CHAIN: A unit of measure 66 feet or 4 rods in length; ten square chains equals one acre; 80 chains equals one mile.

CLEANING: A pre-commercial cutting made in a stand that is not past the sapling stage to release desirable trees from undesirable trees of the same age that overtop them or are expected to do so.

CLEAR-CUT: A method of harvesting that removes all the trees in an area for the purpose of regenerating a new stand; results in even-aged stands. Variations include patch cuts and strip cuts.

CLIMAX: The theoretical culminating stage in plant succession for a given site; vegetation is self-reproducing; the resulting community has reached stability under a particular set of environmental conditions through time.

CODOMINANT TREE: A crown classification; trees with crowns forming the general level of the forest canopy and receiving full sunlight from above but little from the sides. (See crown class.)

COHORT: An aggregation of trees that starts as a result of a single disturbance; a generation of trees.

CORD: A unit of roundwood volume equal to 128 cubic feet of wood, air and bark; a pile of four' long round or split wood piled four' high and eight' long; traditional measure of pulpwood and fuelwood, now commonly replaced by weight measurement. A cord generally contains 80 to 90 cubic feet of solid wood. One cord equals 500 board feet.

CROP TREE: A tree selected in a stand or plantation based on growth rate, crown position or stem quality which will be grown to maturity; growth of crop trees is the object of frequent thinnings or other improvement cuttings.

CROWN: The upper part of a tree including the branches and foliage.

CROWN CLASS: Classification of trees based on the relative position of their crowns.

CULL TREE: A tree of little or no economic value due to poor form, excessive limbs, rot or other defect. Culls frequently have wildlife, aesthetic or other values.

CUITING CYCLE: Frequency of logging operations on the same area, expressed as years.

CURRENT USE TAXATION: Assessed values for property tax purposes that are based on the current use of the land, not on fair market value. Such programs are found in many states: New Hampshire Current Land Use and Vermont Use Value Appraisal are examples.

DAYLIGHTING: Clearing vegetation along roads and trails to provide light and air drainage, to maintain herbaceous plants and to exclude woody plants from occupying the site; a maintenance and wildlife habitat enhancement practice.

DEN TREE: A tree possessing a cavity large enough to serve as a shelter for birds and mammals, or as a site to give birth and raise young. Den trees generally must be 15" DBH or" larger and have a cavity opening of 4" diameter or more.

DBH (Diameter Breast Height): Diameter measured outside the bark of a tree at 41/2 feet above the ground, expressed in inches.

DOMINANT TREE: A crown classification; trees with large crowns extending above the general level of the forest canopy and receiving full light from above and partial light from the sides.

ECOSYSTEM: A dynamic complex of plant, animal, fungal and microorganism communities and their associated non-living environment interacting as an ecological unit.

ECOSYSTEM APPROACH: A strategy or plan to manage ecosystems to provide for all associated native organisms in an ecosystem, as opposed to managing for individual species.

ECOTONE: The border between two habitat types that is composed of a mixture of species from neighboring habitats, creating a unique and often very rich habitat.

EDGE: The ecological changes that occur at the boundaries of ecosystems or habitats; the interface between different vegetation types. These changes may include species composition, size class, gradients of moisture, sunlight, soil and air temperature, soil type, wind speed...; edge effects can have both positive and negative impacts for wildlife.

ELDER TREE(S): An old and often (but not always) large diameter tree(s); occurring singly or in small groups; these are older and/or larger than the majority of the surrounding trees and often possess unique characteristics; often remnants from past harvests; when occupying larger areas or stands these may constitute old growth or ancient forests.

EROSION: Usually destructive movement of soil particles, often associated with logging operations and access roads.

EVEN-AGED: Age class category; a stand in which a small age differences exist between individual trees; the maximum difference in age permitted in an even-aged stand is usually 10 to 20 years, or 10% of rotation age.

EVEN-AGED MANAGEMENT: Any treatment system that establishes or maintains one age class, more than one even-aged stand can occupy a site. Even-age silvicultural systems include clearcut, seed-tree and shelterwood harvests.

FOREST STAND or FOREST TYPE or VEGETATIVE COVER TYPE: a group of trees occupying a specific area and similar characteristics of composition, species, age, arrangement, condition and ecological development which is distinguishable from other groups of stands. Forest types are typically defined by one or more of the dominant trees species in the type.

FOREST STAND IMPROVEMENT (FSI): Pre-commercial treatments designed to improve stand conditions without producing revenue, including cleaning, weeding, thinning, pruning, or cull removal. Also known as Timber Stand Improvement (TSI).

GIRDLING: A method used in FSI to eliminate unwanted trees; also used to create snags and future ROM. Blocking the flow of carbohydrates (food) from the leaves to the roots by cutting, usually with a chainsaw, a ring around the tree that penetrates past the inner bark, ultimately killing the tree; herbicides and hatchet frill can also be used to cut or kill the ring.

GROUP SELECTION: A method harvest method where groups of trees are removed to create openings that are designed to promote regeneration; results in an uneven-aged stand.

GROWING STOCK: A tree or trees that currently provides a desired product or service, usually quantified as sawlog production, or trees that are currently too small to contain a log, but that possess the necessary characteristics to produce a future sawlog; potential sawlog trees.

GROWTH RATE: Measurement of annual rings in the outer radial inch of a tree; indicates the rate of growth of a tree; expressed as rings/radial inch.

HABITAT: The environment in which an organism lives; also the organisms and physical environment in a particular place.

HARVEST: The removal of a crop or stand of financially or physically mature trees as a with the objective of establishing or releasing regeneration.

HARVESTING TRAIL: Small trails laid out in the woods over which logs are pulled (skidded) or carried (forwarded) from the stump to the landing.

HIGH-GRADING: A cut that extracts only the best quality trees or high value timber; made without regard to the future composition or quality of a stand or forest; degrades the forest ecosystem.

IMPROVEMENT CUT: An intermediate cutting made to regulate species composition and quality; called releasing in young stands.

INTERMEDIATE CUT: Various cuttings made during development of the stand from the reproduction stage to maturity; generally for the purposes of improving stand quality and composition for timber production.

INTERMEDIATE TREE: A crown classification; trees with small crowns crowded into the general level of the forest canopy, receiving some light from above but none from the sides.

INTOLERANT SPECIES: Trees unable to regenerate, grow and develop in the shade of other species; for example paper birch and quaking and big-tooth aspen.

LANDING: A place where logs are from the forest and accumulated for loading and transportation to market..

LEGACIES: Ancestors; residual organisms and structures handed down from a pre-disturbance ecosystem, including live trees, dead trees and wood, seeds, surviving roots, basal buds, mycorrhizal fungi, other soil microbes, invertebrates, mammals, and soil chemistry and structure. Legacies influence recovery, composition, structure and function of post-disturbance (including harvesting) ecosystems.

LIQUIDATION HARVEST: The removal of all, or the majority, of the merchantable products from the forest strictly for short term economic gain; creates a non-performing asset; frequently precedes the sale (liquidation) of the land.

MAST: Fruits or nuts produced by woody plants (including trees) which are utilized by wildlife for food; usually divided into hard mast (e.g.: acorns, beech nuts) or soft mast (e.g.: black cherry, apple).

MATURITY: 1. Financial maturity; occurs when a tree has reached financial value; frequently based on carrying costs and assumed or expected interest rates of return; reached long before biological maturity; 2. Biological maturity; the point where energy costs exceed the energy input from photosynthesis.

MBF: Abbreviation for thousand board feet; the standard unit of measure for logs.

MEAN STAND DIAMETER (MSD): The arithmetic mean diameter of the stand measured at DBH.

MERCHANTABLE TIMBER: Trees that are currently saleable.

MULTIPLE USE: Managing the same area of forestland for several uses simultaneously, i.e., recreation, wildlife, water, timber production....

MYCORRHIZAL FUNGI: A fungus living in a mutualistic association with plants; facilitates nutrient and water uptake.

NATIVE SPECIES: Plants, animals, fungi and microorganisms which naturally occur in an area or region.

NATURAL COMMUNITY: An interacting assemblage of plants and animals, their physical environment, and the natural processes that affect them; typically describing an expected or potential condition in the late successional stage of forests.

OPTIMUM GROWTH: The greatest growth achievable on a given site, usually in reference to timber volume.

OVERMATURE: That period in the life cycle of trees and stands when growth or value declines rapidly; frequently defined from a forest products or timber harvesting perspective; frequently a myth perpetuated to encourage timber harvesting.

OVERSTOCKED: A stand where the growing space is occupied leaving no or little room for future stand development or continued growth.

OVERSTORY: The upper crown canopy of the forest; the larger diameter and/or taller trees in the stand.

PIONEER SPECIES: Shade intolerant species that are the first trees to develop in an area after or the abandonment of a field or after a disturbance that covers a fairly large area. Pioneer species include aspen and paper birch.

POLES: A size class; trees that are 4" DBH to 10" DBH.

PRE-COMMERCIAL TREATMENTS: treatments in young or unmerchantable stands that do not, or can not, economically extract merchantable forest products; e.g.: FSI; cleaning, weeding, thinning and release.

PRODUCTION POTENTIAL: Mean Annual Increment (MAI); average growth of the stand over the rotation under optimum stocking conditions; expressed as volume/acre/year.

PRUNING: The practice of removing tree limbs so that a bole free of knots will develop over time; after pruning, the resulting wound heals and clear wood (knot free) is produced. Pruning is a component of FSI.

PULP TREES: Trees that can yield at least two 8-foot bolts with a minimum 4" top diameter inside the bark and which are unsuitable for sawtimber because of size, crook, rot or other defect; used for manufacturing paper products; these trees frequently represent a negative value on private non-industrial forests in this area.

REGENERATION: New growth obtained by natural seeding or sprouts.

RELEASE OPERATIONS: Free young stands of desirable trees, not past the sapling stage, from competition of undesirable trees that are or will suppress them; cleanings and liberation cutting.

REPRODUCTION: New growth artificially obtained by planting or direct seeding.

RETAINED ORGANIC MATERIAL (ROM): Woody material that lies on or near the forest floor; also known as down woody material (DWM) or down woody debris(DWD); provides essential ecosystem functions such as adding organic material to the soil, increasing moisture retention and creating habitat for animals and plants; the larger the diameter and the longer the piece, the greater the ecological value; This material is a stand legacy.

ROTATION: The period of years required to reproduce, grow and harvest a crop of timber; applies only to even-aged management.

SAPLING: A size class; trees less than 4" DBH and 4 1/2 to 10 feet tall.

SAWTIMBER: A product category: usually trees that are greater than 10" DBH for softwoods and 12" DBH for hardwoods and that are reasonably straight, free of defects and otherwise suitable for lumber or veneer production.

SEEDLING: A size class; trees up to 4 1/2 feet tall.

SHADE TOLERANCE: The ability of trees to reproduce and grow in the shade of other trees.

SILVICULTURE: The art and science of tending a forest; the application of the knowledge of silvics in the treatment of a forest; the theory and practice of controlling forest establishment, composition and growth. Silvicultural practices consist of various treatments applied to the forest to maintain and/or enhance their utility for any purpose or objective. Silvicultural practice is applied forest ecology.

SINGLE TREE SELECTION: A method of final harvest in which single trees are removed and the vacancies created promote new growth; results in uneven-aged stands.

SITE: An area considered in terms of its environment (including climate, slope, soil, temperature and moisture); particularly as a determiner of vegetation type and quality supported by an area.

SITE CLASS: A broad category of soil productivity; usually rated site I, TI, III, IV, from highest to lowest productivity.

SITE INDEX: A measure of the productivity of the site using the relationship of tree height to tree age; in the East 50 years is the basis: e.g.: a tree 60 feet tall and 50 years old indicates a site index of 60.

SITE POTENTIAL TREE HEIGHT: The average height of trees that have attained the maximum height possible on a given site.

SIZE CLASS: A classification of trees based on predominate tree size (diameter and/or height) within a stand or type.

SLASH: The tops, branches and defective parts of trees that are left on the ground after a logging job; these provide carbon which in the decomposition process produces calcium which is essential for cell formation.

SNAG: A standing dead or partially dead tree at least 6" DBH and 10' in height. Large diameter snags meet the needs of more wildlife species than do small diameter snags, and are more persistent.

SNAG REPLACEMENT: A tree selected to produce a future snag tree.

STAGNATION: A condition that occurs when too many trees are growing on a site; growth is minimal and vigor declines.

STAND: See "forest stand or forest type" above.

STANDARD: A size class; usually trees over 10" DBH for softwood and 12" DBH for hardwood and up to 24" DBH.

STOCKING LEVEL: A qualitative expression comparing existing number of trees and square feet of basal area in a stand to the amount desired for optimum growth of diameter and volume. Stocking guides are based on the relationship of the number of trees/acre, the square feet of basal area/acre and the mean stand diameter. Stocking levels are expressed as A, B or C lines. Stands near or above the A line are overstocked. Trees are crowded and growth is slow. Stands between the A and B line are fully stocked. Stands at the B line are at an optimum stocking level. Diameter growth is rapid and volume growth is high. Stands between the B and C lines should be fully stocked within 10 years. Diameter growth remains rapid, but volume growth diminishes. Stands below the C line are understocked. Stocking guides are developed for optimum timber production.

STUMPAGE: The value of standing timber dependent upon market conditions, quality of timber, accessibility and other factors.

STRUCTURAL DIVERSITY: The diversity in a community resulting from the occurrence of many horizontal or vertical physical elements, e.g., layers or tiers of the canopy; an increase in layering increases structural diversity.

SUCCESSION: A process of physical and chemical change which takes place on a site over time, resulting in a progression of forest types; The orderly and predictable replacement of one plant community by another over time in the absence of disturbance.

SUPPRESSED TREES: A crown classification; trees with small crowns that are entirely below the general level of the canopy, receiving no direct light from above or from the sides; also called overtopped.

THINNING: An intermediate silvicultural treatment that regulates stand density, composition and quality.

TOLERANT SPECIES: Trees that are able to reproduce and grow satisfactorily in their own shade or the shade of other trees. Tolerant species include sugar maple, beech, red spruce and hemlock.

UNACCEPTABLE GROWING STOCK (UGS): A tree not capable of producing a desired product or service, typically quantified by ability to produce sawlogs; also see growing stock.

UNDERSTORY: Trees growing below the main crown canopy, usually advanced natural regeneration.

UNEVEN-AGED: A stand that contains trees of many different ages and sizes; all aged.

UNEVEN-AGED MANAGEMENT: Any treatment system that establishes or maintains a stand of all age/size classes, treatments are multi-purpose, designed to establish natural regeneration, thin, and achieve other cultural objectives simultaneously.

VIGOR: The health and vitality of a tree; generally assessed by observing crown characteristics such as foliage density and color, live crown ratio, crown depth and width.

WATERBAR: A diversion created by mechanical means to redirect the flow of water (to prevent erosion) on roads and skid trails.

WINDTHROW: Damage to trees caused by winds, usually of a severe nature; results in tip ups and stem breakage.

**A TABLE OF MATURITIES AND/OR NORMAL EXPECTED AGES AND
MAXIMUM AGES FOR SELECTED TREES OF NORTHERN NEW ENGLAND**

Species		Expected or Scientific Name	Maximum Normal Age in years	Age
Common Name				
Eastern white pine	<i>Pinus strobus</i>	150-200		450+
Red pine	<i>Pinus resinosa</i>	150-200		300-400
Eastern larch	<i>Larix laricina</i>	100-200		335
Red spruce	<i>Picea rubens</i>	200		350-400
Black spruce	<i>Picea mariana</i>	100-150		250
Eastern hemlock	<i>Tsuga canadensis</i>			500-900
Balsam Fir	<i>Abies balsamea</i>	90-100		200+
Quaking Aspen	<i>Populus tremuloides</i>	60-70		150
Bitternut hickory	<i>Carya cordiformis</i>			175+
Yellow birch	<i>Betula alleghaniensis</i>	150		300
Sweet birch	<i>Betula lenta</i>	100		200-265
Paper birch	<i>Betula papyrifera</i>	60-75		140-200
American beech	<i>Fagus grandifolia</i>			300-400
White oak	<i>Quercus alba</i>			500-600
Northern red oak	<i>Quercus rubra</i>			200-300
American elm	<i>Ulmus americana</i>	150-200	300	
Black cherry	<i>Prunus serotina</i>	150-200		
Sugar maple	<i>Acer saccharum</i>			200-400
Red maple	<i>Acer rubrum</i>	70-80		150
American basswood	<i>Tilia americana</i>	90-140		100-140
Black ash	<i>Fraxinus nigra</i>			135-150
White ash	<i>Fraxinus americana</i>			300

Species Abbreviations **(in phylogenetic order)**

Conifers/Softwoods

WP	White Pine
RP	Red Pine
TM	Tamarack or Eastern Larch
RS	Red Spruce
BS	Black Spruce
WS	White Spruce
HM	Hemlock
BF	Balsam Fir

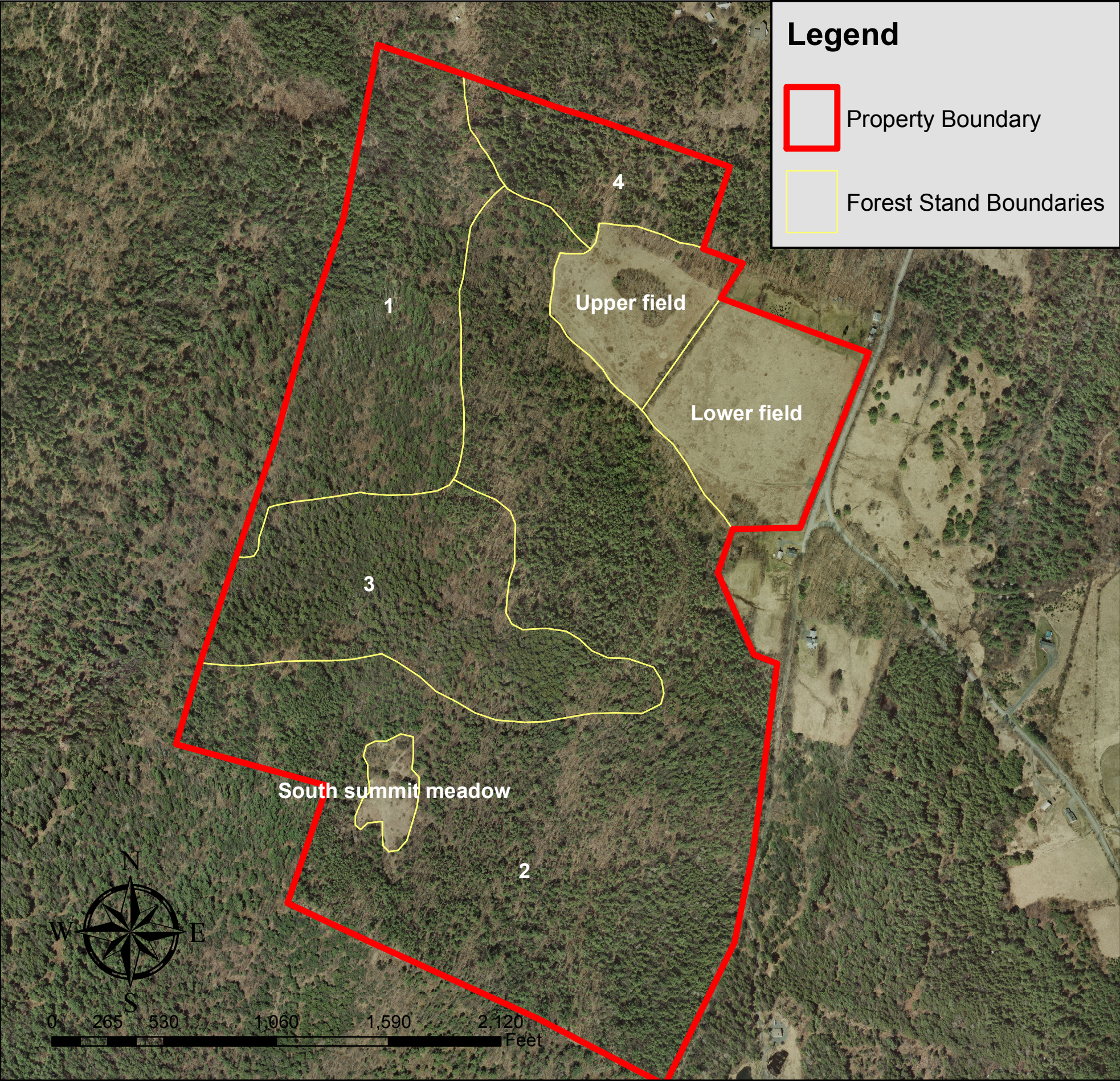
Deciduous/Hardwoods

QA	Quaking Aspen
BtA	Bigtooth Aspen
BP	Balsam Poplar
BN	Butternut
BH	Bitternut Hickory
YB	Yellow Birch
SB	Sweet Birch
PB	Paper Birch
GB	Gray Birch
HB	Hornbeam or Blue Beech; Musclewood
HH	Hophornbeam or Leverwood
BE	American Beech
WO	White Oak
RO	Northern Red Oak
BO	Black Oak
AE	American Elm
SE	Slippery Elm
BC	Black Cherry
PC	Pin Cherry or Fire Cherry
SM	Sugar Maple or Hard or Rock Maple
RM	Red Maple or Soft or Swamp Maple
BxE	Boxelder
SIM	Silver Maple
StM	Striped Maple
MtM	Mountain Maple
BW	Basswood
WA	White Ash
BA	Black Ash

KEY TO FOREST COVER TYPE CODING

VEGETATIVE TYPE	SAF #	CODE
BOREAL FOREST TYPES		
Balsam Fir	5	BF
Black Spruce	12	BS
Aspen	16	AS
Paper Birch	18	PB
NORTHERN FOREST TYPES		
Red Pine	15	RP
Gray Birch/Red Maple	19	GB/RM
White Pine/Northern Red Oak/Red Maple	20	WP/RO/RM
Eastern White Pine	21	WP
White Pine/ Hemlock	22	WP/HM
Eastern Hemlock	23	HM
Hemlock/ Yellow Birch	24	HM/YB
Sugar Maple/Beech/Yellow Birch	25	SM/BE/YB
Sugar Maple/Basswood	26	SM/BW
Sugar Maple	27	SM
Red Spruce/Yellow Birch	30	RS/YB
Red Spruce/Sugar Maple/Beech	31	RS/SM/BE
Red Spruce	32	RS
Red Spruce/ Balsam Fir	33	RS/BF
Paper Birch/Red Spruce/Balsam Fir	35	PB/RS/BF
Black Ash/American Elm/Red Maple	39	BA/AE/RM
Red Maple	108	RM
CENTRAL FOREST TYPES		
Northern Red Oak	55	RO
SIZE CLASS		
Seedlings: up to 4 1/2' tall		1
Saplings: trees from 3 to 10' tall, less than 4" DBH	2	
Poles: from 4 to 10" DBH		3
Standard: from 10 to 24" DBH		4
Elder: over 24" DBH and/or an, old tree		5
STOCKING LEVEL *		
Fully Stocked (from 1/2 way between the A & B line to the A line)	A	
Adequately Stocked (from the B line to 1/2 way to the A line)	B	
Understocked (at or below the C line)		C

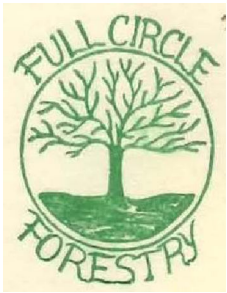
*Stocking levels based on optimum stocking for timber production as determined by USDA Forest Service Silvicultural Guides.



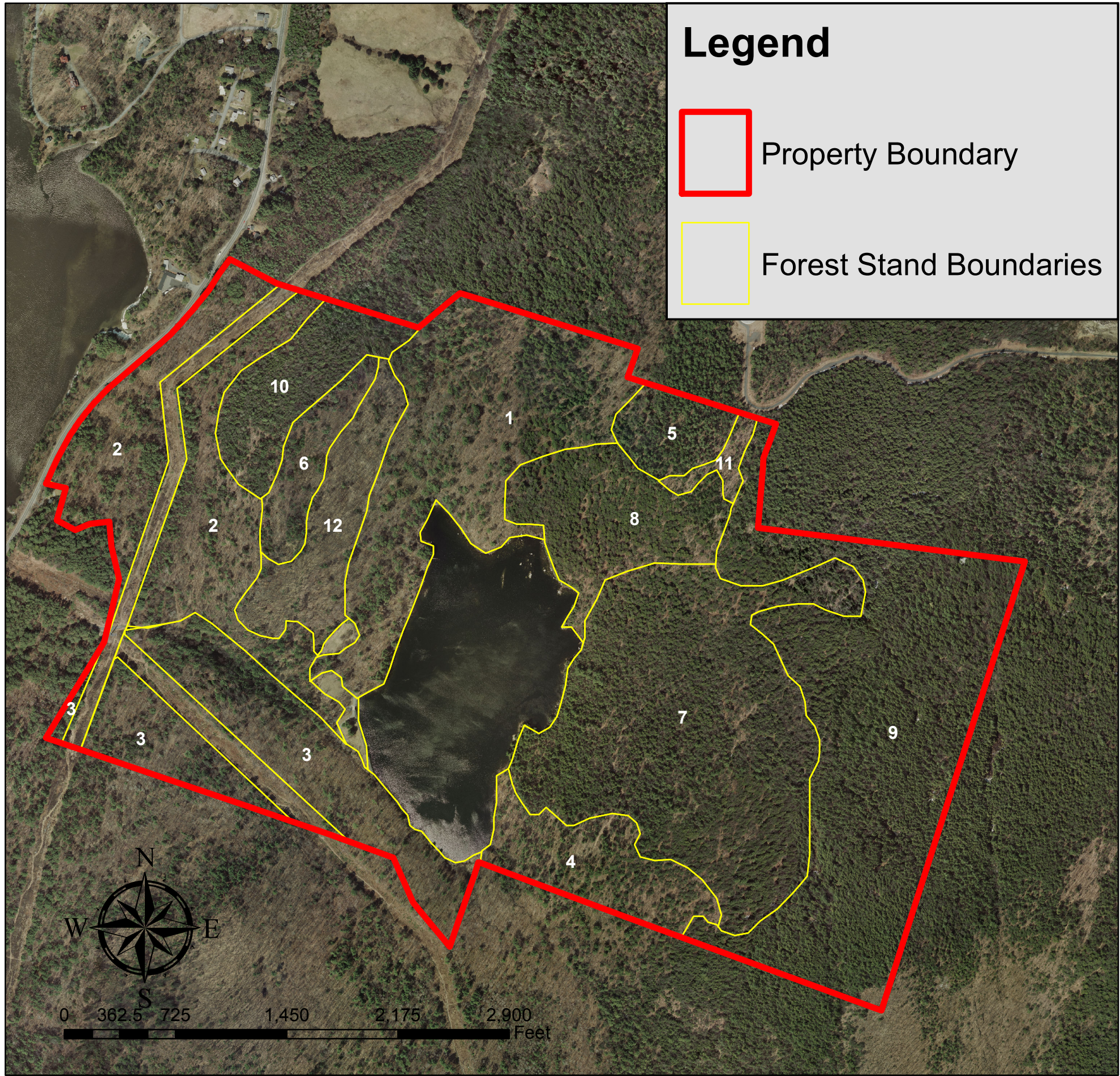
Forest Type Map of SIGNAL HILL City of Lebanon, New Hampshire

Scale 1:6,200
Map prepared by: C. Cusack, October, 2011
This map is not a survey.
All boundaries are provisional.

Area	Forest Type	Acres
1	WP4A	33
2	WP4-3A	112
3	HM/NH4A	31
4	HM/NH4A	12
Total forestland		188
Upper field		10
Lower field		16
South summit meadow		3
Total		217



Full Circle Forestry
Rt 113
Thetford Center, VT
(802) 785-4749



Forest Type Map of THE BOSTON LOT City of Lebanon, New Hampshire

Scale 1:8,500
Map prepared by: C. Cusack, October, 2011
This map is not a survey.
All boundaries are provisional.

Area	Forest Type	Acres
1	WPRO/RM4A	51
2	WPRO/RM4A	46
3	WPRO/RM4A	38
4	WPRO/RM4A	17
5	WPRO/RM4A	8
6	WPRO/RM4B	9
7	WP/HM4A	73
8	WP/HM4A	22
9	HM/NH4A	78
10	HM/NH4A	15
11	RO4A	3
12	NH/RO4A	16
Total forestland		377
Reservoir		45
Powerline ROW		15
Open		2
Total		439



Full Circle Forestry
Rt 113
Thetford Center, VT
(802) 785-4749

**Partial Botanical List for Boston Lot and Signal Hill
City of Lebanon, New Hampshire**

Common Name	Scientific Name
TREES	
American beech	<i>Fagus grandifolia</i>
Quaking aspen	<i>Populus tremuloides</i>
Balsam fir	<i>Abies balsamea</i>
Basswood	<i>Tilia americana</i>
Big-toothed aspen	<i>Populus grandidentata</i>
Bitternut hickory	<i>Carya cordiformis</i>
Black birch	<i>Betula lenta</i>
Black cherry	<i>Prunus serotina</i>
Butternut	<i>Juglans cinerea</i>
Eastern hemlock	<i>Tsuga canadensis</i>
Eastern white pine	<i>Pinus strobus</i>
Hophornbeam	<i>Ostrya virginiana</i>
Northern red oak	<i>Quercus rubra</i>
Pin cherry	<i>Prunus pensylvanica</i>
Red maple	<i>Acer rubrum</i>
Striped maple	<i>Acer pensylvanicum</i>
Sugar maple	<i>Acer saccharum</i>
White ash	<i>Fraxinus americana</i>
White birch	<i>Betula papyrifera</i>
White oak	<i>Quercus alba</i>
Yellow birch	<i>Betula alleghaniensis</i>
SHRUBS/VINES	
Alternate-leaf dogwood	<i>Cornus alternifolia</i>
Currents	<i>Ribes sp.</i>
Dogwood sp.	<i>Cornus sp.</i>
Elderberry	<i>Sambucus sp.</i>
Hobblebush	<i>Viburnum lantanoides</i>
Low bush blueberry	<i>Vaccinium augustifolium</i>
Mapleleaf viburnum	<i>Viburnum acerifolium</i>
Raspberry	<i>Rubus sp.</i>
Virginia creeper	<i>Parthenocissus quinquefolia</i>
Witch hazel	<i>Hamamelis virginiana</i>
NON-NATIVE INVASIVE SHRUBS	
Bush honeysuckle	<i>Lonicera spp.</i>
Common buckthorn	<i>Rhamnus cathartica</i>
Glossy buckthorn	<i>Frangula alnus</i>
Japanese barberry	<i>Berberis thunbergii</i>

**Partial Botanical List for Boston Lot and Signal Hill
City of Lebanon, New Hampshire**

Common Name	Scientific Name
FLOWERS	
Bedstraw sp.	<i>Galium sp.</i>
Blackeyed Susan	<i>Rudbeckia hirta</i>
Blue bead lily	<i>Clintonia borealis</i>
Bunchberry	<i>Cornus canadensis</i>
Canada goldenrod	<i>Solidago canadensis</i>
Canada mayflower	<i>Maianthemum canadense</i>
Cinquefoil	<i>Potentilla sp.</i>
Clover species	<i>Trifolium spp.</i>
Common milkweed	<i>Asclepias syriaca</i>
False nettle	<i>Boehmeria cylindrica</i>
Foamflower	<i>Tiarella cordifolia</i>
Goldenrod	<i>Solidago sp.</i>
Goldthread	<i>Coptis groenlandica</i>
Hawkweed	<i>Hieracium sp.</i>
Hellaborine	<i>Epipactis sp.</i>
Herb Robert	<i>Geranium robertianum</i>
Hog peanut	<i>Amphicarpa bracteata</i>
Indian cucumber root	<i>Medeola virginiana</i>
Jack in the pulpit	<i>Arisaema triphyllum</i>
Morning glory	<i>Ipomoea sp.</i>
Partridge berry	<i>Mitchella repens</i>
Rattlesnake plantain	<i>Goodyera pubescens</i>
Red baneberry	<i>Actea rubra</i>
Round-lobed hepatica	<i>Hepatica americana</i>
Shinleaf	<i>Pyrola elliptica</i>
Small white aster	<i>Aster vimineus</i>
Solomon seal	<i>Polygonatum pubescens</i>
Starflower	<i>Trientalis borealis</i>
Striped wintergreen	<i>Chimaphila maculata</i>
Sweet-scented bedstraw	<i>Galium triflorum</i>
Trailing arbutus	<i>Epigaea repens</i>
Violet	<i>Viola sp.</i>
White doll's eyes	<i>Actaea pachypoda</i>
White snakeroot	<i>Ageratina altissima</i>
Wild ginger	<i>Asarum canadense</i>
Wild lettuce	<i>Lactuca canadensis</i>
Wild oats	<i>Uvularia sessilifolia</i>
Wild sarsaparilla	<i>Aralia nudicaulis</i>
Yellow wood sorrel	<i>Oxalis europaea</i>

**Partial Botanical List for Boston Lot and Signal Hill
City of Lebanon, New Hampshire**

Common Name	Scientific Name
FERNS/FERN ALLIES	
Bracken fern	<i>Pteridium aquilinum</i>
Bristly club moss	<i>Lycopodium annotinum</i>
Christmas fern	<i>Polystichum acrostichoides</i>
Cinnamon fern	<i>Osmunda cinnamomea</i>
Ground cedar	<i>Lycopodium tristachyum</i>
Hayscented fern	<i>Dennstaedtia punctilobula</i>
Intermediate wood fern	<i>Dryopteris intermedia</i>
Interrupted fern	<i>Osmunda claytoniana</i>
Lady fern	<i>Athyrium Filix-femina</i>
<i>Maidenhair fern</i>	<i>Adiantum pedatum</i>
Marginal wood fern	<i>Dryopteris marginalis</i>
Northern beech fern	<i>Thelypteris phegopteris</i>
Ostrich fern	<i>Matteuccia struthiopteris</i>
Sensitive fern	<i>Onoclea sensibilis</i>
Tree club moss	<i>Lycopodium obscurum</i>
GRAMINOIDS	
Woodland grass spp.	
Sedge sp.	<i>Carex sp.</i>
Pennsylvania sedge	<i>Carex pensylvanica</i>

Notes:

Rich site species are indicated by bold italics.

**Partial Botanical List for Boston Lot and Signal Hill
City of Lebanon, New Hampshire**

Signal Hill	Boston Lot
X	X
X	X
	X
X	X
X	X
	X
	X
X	X
	X
X	X
X	X
X	X
X	X
X	
X	X
X	X
X	X
X	X
X	X
	X
X	X
	X
X	
X	
X	
	X
	X
	X
X	X
	X
	X
X	X
X	
X	X
X	X

**Partial Botanical List for Boston Lot and Signal Hill
City of Lebanon, New Hampshire**

Signal Hill	Boston Lot
	X
	X
	X
X	X
X	
	X
X	
	X
	X
X	
X	X
X	
X	X
X	X
	X
X	
X	X
X	
X	X
X	
	X
X	X
	X
X	X
	X
X	
	X
X	
X	
X	X
	X
X	
X	
X	X
X	

Partial Botanical List for Boston Lot and Signal Hill
City of Lebanon, New Hampshire

Signal Hill	Boston Lot
X	X
X	X
X	X
	X
X	
X	X
X	X
	X
X	
X	X
X	X
	X
	X
	X
X	X
X	X
X	
X	

August 4, 2021

Mr. James Donison, PE
Director
Public Works Department
193 Dartmouth College Hwy.
Lebanon, NH 03766

SUBJECT: New Groundwater Well Source Test Well Exploration Summary
Lebanon, NH

Dear Mr. Donison:

The City of Lebanon, New Hampshire (Lebanon) is exploring the potential for a new groundwater source to meet future demand and provide redundancy to the existing water treatment plant. Lebanon is currently looking for a source on the order of 2.5 MGD (~1,700 gallons per minute (gpm)). A source of this magnitude in New England typically needs to be located in near a surface water body to provide consistent sustainable yield and drought resistance.

New source test well exploration was conducted at the Wastewater Treatment Plant Property (Site) adjacent to the Connecticut River (**Figure 1, Attachment A**). This Site was identified based on a favorable new groundwater source study completed by Wright-Pierce (WP) in 2001. WP identified three areas on the Wastewater Treatment Plant Site (North, South, West) with the potential for capacity development within which the test well exploration was focused (**Figure 2**). Based on test well exploration data, location TW 1-21 has the highest potential to support a production well and it is recommended to proceed by constructing a large diameter well at location TW 1-21 and performing an extended pumping test. This would allow for the collection of critical data in the assessment of the sustainable yield, well design and long-term water quality. The following is a summary of the work and findings:

Site Geology

The Site is located adjacent to the Connecticut River and on the west side of Main Street. It is delineated on the New Hampshire Geological Survey Map entitled "Surficial Geologic Map of the Hanover Quadrangle – Grafton County, New Hampshire" (Map No. Geo-091-024000-SMAP), as alluvium and overburden that consists of sand, silt, gravel, and muck in flood plains along the Connecticut River. A hydrogeologic cross section A-A' was developed for the Site using soil observations from test wells (**Figure 2A, Attachment A**). The location of the hydrogeologic cross section A-A' is shown on **Figure 2**.

A surficial soil map of the area using the Natural Resources Conservation Service (NRCS) soil mapper is shown on **Figure 3**. Surficial soils for the west area of the Site are mapped as Suncook loamy fine sand and classified as high to very high capacity to transmit water.

Saturated thickness in the West Lebanon aquifer is estimated to exceed 80 feet in some areas and estimated transmissivity is less than 4,000 feet squared per day based on U.S. Geological Survey (USGS) Water Resources Investigations Report 94-4181 "Geohydrology and Water Quality of Stratified-Drift Aquifers in the Middle Connecticut River Basin, West-Central New Hampshire". A boring completed near the confluence of the Connecticut River and Mascoma River showed a stratigraphic log of 33 feet of medium sand and gravel overlain by 29 feet of fine to medium sand. The USGS report indicates that the esker aquifer is adjacent to the eastern bank of the Connecticut River and is estimated to be about 80 feet thick. Estimated contours for aquifer saturated thickness are shown on **Figure 3**.

Bedrock geology consists of undifferentiated Ordovician Ammonoosuc Volcanics ranging from dark green-black fine to medium grained hornblende gneisses to black and white metavolcanics with hornblende-rich and feldspathic layers. Bedrock geology and water well inventory is shown on **Figure 4**. Probable depth to bedrock is shown for test wells and water wells.

Test Well Drilling

Small diameter test wells were completed at the Wastewater Treatment Plant Site with four-inch diameter casing using an ATV drive and wash drill rig from May 17 to June 10, 2021. Test bores were drilled by East Coast Explorations at six locations TW 1-21 through TW 6-21 shown on **Figure 2**. Well logs for these locations are included in **Attachment B** and well construction details are summarized in **Table I**.

Table I Test Well Construction Details

Parameter	Boring Depth (feet)	Screened Interval (depth feet bgs)	Test Well Pumping Rate (gpm)
TW 1-21	94	84-94	84
TW 2-21	80	74-79	83
TW 3-21	84.5	80-85	7
TW 4-21	99	50-55	2
TW 5-21	85.5	50-55	2
TW 6-21	49	24-49	2

TW 1-21 and TW 2-21 were installed on the peninsula adjacent to the Connecticut River and Mascoma River at the West Area (**Figure 2**). TW 1-21 is located on the western area of the peninsula approximately 100 feet north of the Mascoma River. This location showed a significant amount of fine to coarse sand and gravel and some water-bearing soils overlain by fine grained soil (sand, silt). Productive soils were observed from 67 feet to 94 feet bgs (below ground surface) with the most productive zone observed between 74 feet to 94 feet bgs. The bottom of boring is 94 feet bgs at bedrock. Groundwater level was measured at approximately 11 feet bgs.

A well was constructed with 5 feet of 60-slot PVC screen from 84 feet to 89 feet bgs and 5 feet of 80 slot stainless steel screen from 89 feet to 94 feet bgs and developed with a diaphragm pump. The well was rated at 84 gpm using a centrifugal pump.

A short-term step pump test was completed at this location to assess specific capacity and water quality. A centrifugal pump was used to perform a pumping test on the well. Water levels were measured in the same test well using the four-inch diameter outer casing. Water levels during the step pumping test are shown on **Graph 1, Attachment C**. After pumping at 84 gpm for 38 minutes, 3.17 feet of drawdown was observed in the observation well resulting in a specific capacity of 26.5 gallons per minute per foot of drawdown (gpm/ft). The pumping rate was reduced to 68 gpm and after pumping at this rate for 15 minutes, 2.24 feet of drawdown was observed in TW 1-21 resulting in a specific capacity of 30.3 gallons gpm/ft. The pumping rate was reduced to 40 gpm and drawdown of 0.76 feet was measured resulting in a specific capacity of 52.6 gpm/ft after 25 minutes of pumping.

Graph 2, Attachment C shows specific capacity for each step of the short-term pump test and can be used to estimate theoretical well efficiency. Specific capacity for TW 1-21 increased as pumping rate decreased due to well efficiency at lower pumping rates. Comparing the specific capacity at each step of the pumping test allows for a gross estimation of well performance at higher pumping rates. However, it should be noted that these specific capacities are based on short term pumping data.

TW 2-21 was installed approximately 100 feet northeast of TW 1-21. Brown silt was observed to a depth of 8 feet bgs. Fine to coarse sand and gravel was observed at this location with the most productive intervals of coarse gravel observed from 59 feet to 64 feet and from 74 feet to 80 feet bgs. Probable bedrock was encountered at 80 feet bgs. The well was constructed with 5-feet of 60-slot PVC screen from 74 feet to 79 feet bgs and developed with a diaphragm pump. The well was rated at 83 gpm using a centrifugal pump.



Short Term Pumping Test on TW 1-21

A short-term step pump test was completed at this location to assess specific capacity and water quality. A step pumping test was performed by pumping and measuring water levels in TW 2-21 and data is shown on **Graph 3, Attachment C**. Specific capacity ranged from 4.1 gpm/ft at a rate of 1 gpm to 23.0 gpm/ft at a pumping rate of 12 gpm. Based on the short-term step pumping test data, this location resulted in a lower specific capacity than the TW 1-21 location.

Locations TW 3-21 and TW 4-21 were drilled on the South Area located south of Market Street and the Wastewater Treatment Plant (**Figure 2**). Test well TW 3-21 is located approximately 90 feet north of the Mascoma River. Rocky gravel was encountered to a depth of 8 feet bgs. Fine to coarse sand was observed during drilling to a depth of 79 feet bgs. Soils from 79 feet to 84.5 feet bgs consisted of fine to coarse sand and gravel. Refusal was encountered at 84.5 feet bgs. The well was constructed with 5-feet of 30-slot PVC screen from 80 feet to 85 feet bgs and developed with a diaphragm pump. The well was rated at 7 gpm using a centrifugal pump.

A test well was installed at TW 4-21 located approximately 100 feet southeast of TW 3-21. Dense rocks and gravel were encountered to a depth of 8 feet bgs. Gray fine to coarse sand was observed to a depth of 95.5 feet bgs. Tight gravel was observed from 95.5 to 99 feet bgs but was not observed to be water bearing. Refusal was not encountered at this location. Based on these observations, no significant water bearing soils were encountered and a monitoring well was constructed at this location. Five feet of 10-slot PVC screen was installed from 50 feet to 55 feet bgs and developed with a whale pump.

TW 5-20 was constructed at the North Area located northeast of Market Street and the Wastewater Treatment Plant and south of the Connecticut River. A layer of gravel was observed to 9 feet bgs and dark brown fine sand from 9 feet to 55 feet bgs. Gray fine sand was observed from 55 to 74 feet bgs. Sand and gravel was observed from 74 feet to 85.5 feet with a productive interval from 81 feet to 84 feet bgs. Probable bedrock was encountered at 85.5 feet bgs. Based on the thin layer of productive soils, a monitoring well was constructed at this location. A well was constructed with five feet of 10-slot PVC screen from 50 to 55 feet bgs and developed with a whale pump.

A monitoring well was constructed at TW 6-21 to obtain additional data on subsurface conditions and to serve as a monitoring location between test well TW 1-21 and the wastewater treatment plant. Sand and gravel was observed to a depth of 6 feet bgs and brown fine sand from 6 feet to 13 feet bgs. Sandy gravel was observed from 24 feet to 49 feet bgs. Refusal was encountered at 49 feet bgs. A monitoring well was installed with 25 feet of 10-slot PVC screen from 24 feet to 49 feet bgs and developed with a whale pump.

Water Quality

Recharge to a well source at the TW 1-21 location would be derived almost entirely from infiltration from the Mascoma and Connecticut Rivers with a very small percentage of the recharge being from groundwater. It is difficult to say what percentage of water would ultimately be derived from surface water, however given the geology at the site and constant head boundaries relative to the well groundwater would likely be on the order of a few percent of the total yield. Therefore, we would anticipate little adverse impacts to a well source at TW 1-21 from water derived from the TW 6-21 location. Furthermore, the dissolved metals and de-icing chemicals concentrations would likely under-go significant changes as well. However, future testing under stressed aquifer conditions would be needed to confirm this.

Water samples from TW 1-21, TW 2-21, and TW 6-21 were analyzed for dissolved metals, nitrates, nitrites, hardness, VOCs, and perfluorinated compounds. Testing for perfluorinated compounds (PFAS) included PFOA, PFOS, PFNA, PFHxS, PFHpA, and PFBS. Parameters were analyzed by Eastern Analytical, Inc. of Concord, New Hampshire. Water quality laboratory results are summarized in **Table II** and laboratory reports are included in **Attachment D**.

Table II Water Quality Analysis

Parameter	MCL	TW 1-21 (5/19/2021)	TW 2-21 (6/16/2021)	TW 6-21 (6/16/2021)
Hardness	NA	300	NT	NT
Total Alkalinity	NA	210	210	180
pH	NA	7.59	7.61	7.43
Iron	0.3	0.45	0.52	0.33
Manganese	0.05	0.42	0.27	3.2
Calcium	NA	100	98	150
Sodium	50	100	110	110
Chloride	250	220	230	360
Uranium	30	7.1 ug/L	5.8 ug/L	2.3 ug/L
Arsenic	0.010	0.0038	0.0056	0.0012
Nitrate	10	< 0.5	< 0.5	< 0.5
Nitrite	1	< 0.5	< 0.5	< 0.5
Sulfate	25	40	41	51
Sulfide	NA	< 0.05	NT	NT
Dissolved Solids	500*	660	630	860
TOC	NA	< 0.5	< 0.5	0.58
VOCs	NA	ND	ND	ND
PFAS	18	ND	ND	PFHxS: 32.9 ng/L

Bold indicates that value exceeds standard MCL = Maximum Contaminant Level

All standards are in milligrams per liter unless otherwise noted.

Ug/l = micrograms per liter ng/L = nanogram per liter

* = Based on Secondary Drinking Water Regulations

ND = Non-Detected NA = Not Applicable NT = Not Tested

Elevated levels of iron, manganese and dissolved solids were detected in water quality samples from the test wells. It is anticipated that water quality will change in response to a pumping well operating at a higher pumping rate and over a longer period of time as induced infiltration of surface water occurs from the Mascoma and Connecticut Rivers. It is likely that the elevated parameters will decline when 'older' water in the aquifer is replaced by oxygenated surface water with low dissolved iron and manganese. Additional water quality sampling is recommended during stressed aquifer conditions.

Sodium and chloride were detected at all tested locations at or near the drinking water standard. Typically, these chemicals are derived from de-icing activities. The nearby interstate could be a potential source or could be from onsite activities. The source of sodium and chloride should be assessed further as a part of developing a well source at this location.

PFAS was detected in the water quality sample obtained from TW 6-21 in excess of the NHDES drinking water standard. This location was constructed adjacent to the wastewater treatment plant and with 25 feet of well screen to serve as a monitoring location for water quality concerns associated with the facility. The area has been used to store pipe, culverts, etc. in the past. Water quality sampling of test wells followed the protocol used for a test well exploration program, but it is possible that the detection is a result of cross contamination during water quality sampling. It should be noted that samples collected from TW 2-21 on the same day were non-detect. It is recommended to resample for PFAS during the next phase of testing to confirm this result. Additional evaluation of the source and distribution of PFAS would be prudent.

Groundwater Under the Influence of Surface Water

To meet the 400-foot setback from the wastewater treatment plant, TW 1-21 and TW 2-21 were constructed on the peninsula between the Connecticut River and Mascoma River and within 200 feet of surface water (**Figure 2**). Since the proposed location for a groundwater well at TW 1-21 is within 200 feet of surface water, the source will require testing to determine whether it is under the influence from surface water. Sampling for parameters for groundwater under the influence of surface water will be required. This would include macro-particulate analysis (MPA) and spore-forming bacteria testing. We have completed several projects recently that required sampling for these parameters on well projects in NH.

A flood hazard map for the Site is shown on **Figure 5** and a FEMA Firmette is included as **Figure 5A**. TW 1-21 and TW 2-21 are located in the AE Flood zone, an area that presents a one percent annual chance of flooding according to FEMA Flood Maps. The final wellhead elevation is required to be a minimum of three feet higher than the 100-year flood elevation per Env-Dw 302.26(b).

Well Recharge and Sustainable Yield

Analysis of available recharge is a key part in assessing the preliminary sustainability of potential well sites. The development of a new groundwater well source at TW 1-21 would derive recharge from both the Connecticut River and Mascoma River. The Streamstats application generated by USGS was used to delineate the Connecticut River and Mascoma River watersheds at the sites.

The Mascoma River basin is shown in **Figure 6** and the Connecticut River basin is shown on **Figure 7**. Reports generated for this analysis are included in **Attachment E**.

The Connecticut River basin has a drainage area of 4,092 square miles and has a mean daily flow of 7,198 cfs. Streamflow data was obtained from the USGS Streamgage 01144500, located approximately 5,000 ft (1 mile) upriver from the Site. The 7-day 10-year low flow (7Q10) for the Connecticut River basin is approximately 1,890 cfs. Streamflow data for the Mascoma River basin was obtained from USGS Streamgage 01150500 located approximately 6 miles upriver from the Site. Mean daily flow of the Mascoma River at the streamgage is 216.8 cfs. The 7Q10 for this basin is approximately 13.6 cfs (6,100 gpm). Assuming a well source derives half of it's water from the Mascoma River, impacts to flow would be approximately 14% of the 7Q10 (850 gpm). Streamflow parameters for the Connecticut River and Mascoma River are summarized in **Table III**.

Table III Connecticut River And Mascoma River Streamflow

Basin Parameter	Cubic Feet per Second (cfs)	Gallons per Minute (gpm)	Million Gallons per Day (MGD)
Connecticut River Basin Mean Daily Flow	7,198	3,231,074	4,652
Connecticut River Basin 7Q10	1,890	848,232	1,221
Mascoma River Basin Mean Daily Flow	216.8	97,313	140
Mascoma River Basin 7Q10	13.6	6,103	8.8

Both the Connecticut River and Mascoma River are Designated Rivers and will require instream flows to be met per Title L, Chapter 483:9-c. The Connecticut River has significant upgradient drainage and the development of additional source capacity at the Site within the proposed range is not expected to be impacted by minimum streamflow requirements. The Mascoma River instream flow requirements are similarly not likely to be an issue given that the site is located the confluence of the two rivers and the proposed source is a backup for the existing withdrawal from the Mascoma River source and would not be considered additional withdrawal if operated as such. Under this configuration the impacts to streamflow in the Mascoma River would be considerably less than that of the existing surface water source given that the recharge to the well source would be from a combination of both rivers. This would be refined after long-term high-rate pumping test(s) were conducted at the site.

Potential Contamination Sources

An updated inventory of Potential Contamination Sources (PCs) was identified through New Hampshire Department of Environmental Services (NHDES) OneStop Database. **Figure 8, Attachment A** shows PCs including underground storage tanks, auto salvage yards, asbestos sites, hazardous waste generators, remediation sites and solid waste facilities (landfills). The following is a summary of potential contamination sources:

- Four remediation sites are mapped within 0.5 miles of the proposed well site. These sites are closed LUST sites (leaking underground storage tanks) and not considered a significant threat to water quality.
- Several USTs are located at the Lebanon Wastewater Treatment Plant. Some of these tanks have been replaced over recent years and there is a closed LUST site at this site. Additional research should be completed regarding construction, installation date and other available information for these USTs. Other USTs are located south and southeast of the well site that serve retail business in the area. These USTs are south of the Mascoma River (positive head boundary) and are not a significant threat to water quality for a well source.
- Several hazardous waste generators are mapped within the 0.5 mile radius and have limited potential for adverse impacts to groundwater.
- Potential for leaking sewer mains and other infrastructure at the site. Generally, this is not considered a significant based on the proposed source location and the resulting primary source of recharge. It is anticipated that the zone of influence of the source would be very limited due to the presence of constant head boundaries.
- De-icing chemicals (sodium and chloride) from onsite activities and roadways.

Given the geology at the site and the assumption that the majority of water to wells at the site would be recharge from the Connecticut and Mascoma Rivers, it is anticipated that the source will likely be largely insulated from most contaminant threats. This will be evaluated based on future testing at the site.

A true groundwater source requires 400-foot setback from potential contamination sources such as buildings, sewer mains, leach fields, etc. The existing infrastructure at the Site was discussed with NHDES regarding existing sewer mains and the wastewater treatment plant. NHDES indicated that a groundwater source would need to be greater than 400 feet from the existing sewer mains and wastewater treatment structures. The location of TW 1-21 at the West exploration area could serve as a groundwater source on the peninsula between the Connecticut and Mascoma Rivers and meets the 400-foot setback from the wastewater treatment plant.

Based on conversations with NHDES, the upstream wastewater outfall would not likely be an issue for a source at this location given the size of the Connecticut River and anticipated river bottom infiltration rates. Contamination sources associated with the wastewater treatment facility include underground storage tanks, sewer lines, and hazardous waste located at the facility. A monitoring well at TW 6-21 was constructed adjacent to the wastewater treatment facility to monitor potential contamination sources associated with this location. The primary source of recharge to the well is anticipated to be from induced infiltration from the Connecticut and Mascoma Rivers which is further anticipated to limit the impact area of the proposed well to the east.

Additional water quality sampling of TW 6-21 and TW 2-21 located east of the proposed large diameter well and between this location and the wastewater treatment facility is recommended to evaluate potential contamination associated with the Site.

Findings and Recommendations

Based on findings from test well exploration, TW 1-21 appears to be the best location for a groundwater supply source. Soils at TW 1-21 were the most productive and this location has the most favorable conditions for the development of a new groundwater well source. The safe yield of a well constructed at this location is difficult to determine without pumping test data from a large diameter well to identify constant head boundaries relative to well yield. Based on test well data, a well constructed at TW 1-21 and screened from 74 feet to 94 feet below ground surface with a static water level of 11 feet below ground surface has 83 feet of saturated thickness. This leaves approximately 63 feet of available drawdown in the well above the screen. Using estimated specific capacity of 52 gpm/ft, a production well at TW 1-21 with 20-feet of screen could theoretically produce 1,600 gpm (2.3 MGD) using only half of the available drawdown. This estimate does not include the positive effects on aquifer levels at higher pumping rates due to positive boundary conditions, therefore can be considered to be conservative. Data suggests that a single well at TW 1-21 could meet the project goal (1,700 gpm).

The site does have potential for the development additional capacity above the 1,700 gpm. Given that the constant head boundaries of the Mascoma and Connecticut Rivers could potentially provide higher yields and potentially have limited environmental impacts, permitting a new well source with respect to future growth is worth exploring. The permittable/sustainable yield and environmental impacts for a high yield well source are difficult to determine with the data collected to date. However, a long-term pump test would allow for estimations of yield and well (field) design.

Flood maps for the site (**Figure 5A**) indicate that the well site is within the mapped floodway. These areas are designated for limited development under federal law. Given that the proposed changes are wells that are no that would have similar or lesser impacts to streamflow than the existing natural vegetation, this may be a non-issue. However, U.S. Army Corps of Engineers would need to be engaged. We have successfully completed this type of permitting for other projects and are currently permitting a new RCW in Haverhill, Massachusetts under these rules. This issue would need to be evaluated during the course of the project.

Based on the limited dataset, the site does have potential for the development of a radial collector well source (RCW) source, which could serve as a regional supply. The costs for this type of source are significantly greater than that of a groundwater source constructed with conventional wells due to exploration, testing, well construction and treatment as a surface water source. However, preliminary data suggests that an RCW is potentially feasible given unconfined aquifer conditions, the limited well boring data and depth.

Water quality sampling at this location resulted in elevated parameters including iron and manganese. Soils were observed to be gray indicating anoxic conditions which typically result in high dissolved metals in groundwater. The aquifer at this location is likely stagnant due to the location between two constant head boundaries. The introduction of oxygen rich recharge from surface water will likely result in significant changes in water quality under long-term pumping conditions.

Elevated de-icing chemicals and PFAS identified at the site should be evaluated. It will be critical to understand the source of these chemicals as a part of the permitting process for the site. This work would require additional monitoring wells and water quality testing. However, a monitoring well network and additional subsurface data will be required for obtaining a Large Groundwater Withdrawal Permit (LGWP). It should be noted that the water quality from a well pumped at the desired permit rate will ultimately be the driver for the project.

Ownership of a 400-foot protective radius around the well location would be required by NHDES to develop a well source. The 400-foot protective radius at TW 1-21 shown on **Figure 2** overlaps onto the Connecticut River, Mascoma River and parcel 114-3 to the south. Parcel 114-3 to the south is owned by the City of Lebanon and Lebanon Conservation Commission. NHDES might require change of land use for public access to the boat launch at this location to prevent vehicle access within the sanitary protective radius. NHDES will be engaged during the next project phase regarding any restrictions that would be required by the City to protect the area surrounding the well. Generally, the boat launch is not used for large boats given the poor condition of the access to the water. This location could potentially be moved upstream to a location on the Mascoma River upstream or to the adjacent Town owned property to the south (**Figure 2**).

The well is located within the flood plain. A survey would be needed to establish elevations and the final well casing would be extended to a minimum of 3 feet above the 100-year flood elevation per NHDES requirements.

Additional testing is recommended for the site. Generally, a large diameter test well would be the next step to determine water quality under stressed aquifer conditions as water quality is anticipated to change due to recharge from infiltrated surface water. Determining whether the source will be a true groundwater source or under the influence of surface water is a significant driver for costs of treating water from the site and will need to be evaluated. Based on available subsurface data at the site, soil thickness and grain-size observed does indicate good potential for filtration and use of a well as a groundwater source.

Cost estimates for a large diameter test well (12-inch) were provided previously. However, given the findings of this work, we would like to explore options for the next steps. The aquifer is somewhat deeper than originally quoted based on available data and the price of steel has increased indicating that revisiting the subcontractor cost for the large diameter well should be revisited. Additional water quality samples and monitoring locations may be needed as well to assess water quality and drawdown during large-diameter well testing.

8/4/2021

Mr. James Donison, PE

Page 11 of 11

Generally, this would consist of long-term pump testing with a large-diameter well to assess water quality under pumping conditions. We envision a meeting to discuss the findings of this work and the potential next steps to be the most logical approach. Following this meeting, we need to have a discussion with NHDES prior to conducting additional work to obtain buy in based on the findings of this work.

Sincerely,

WRIGHT-PIERCE

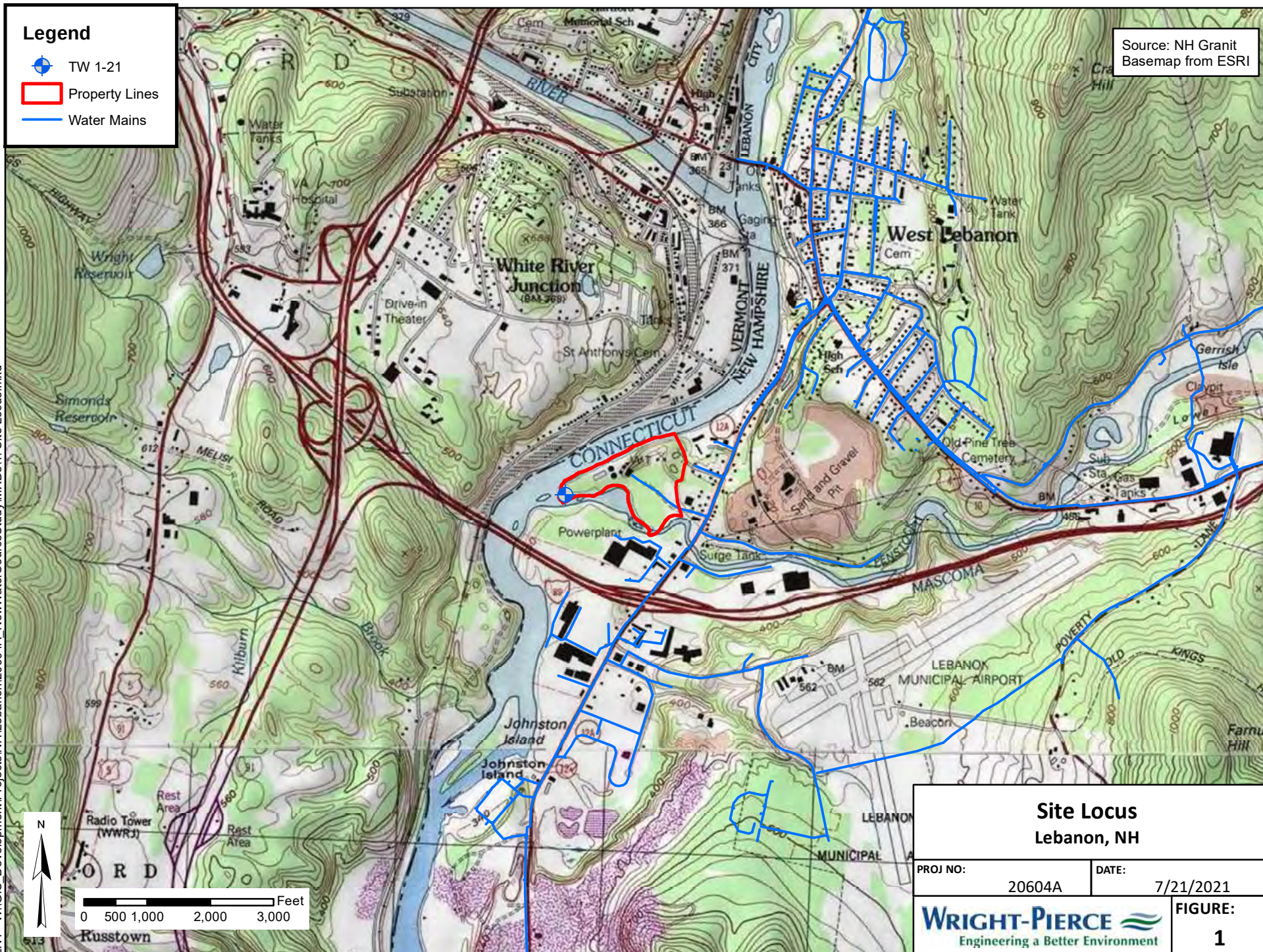


Greg J. Smith, CG, PG Senior Hydrogeologist

greg.smith@wright-pierce.com



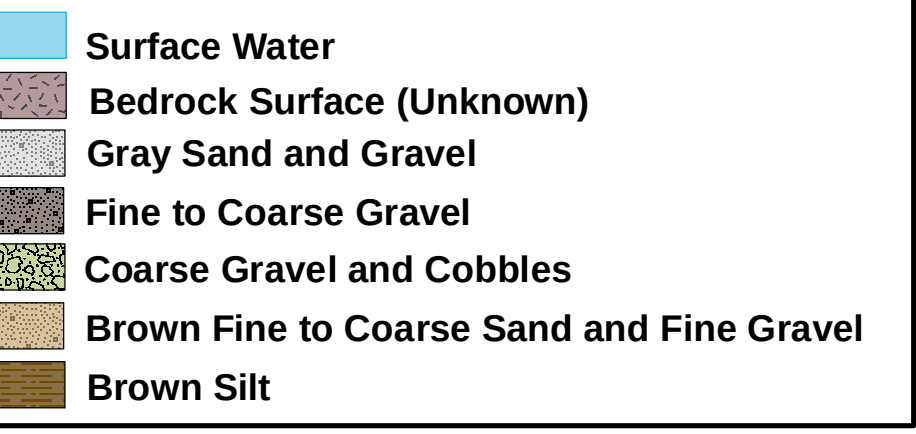
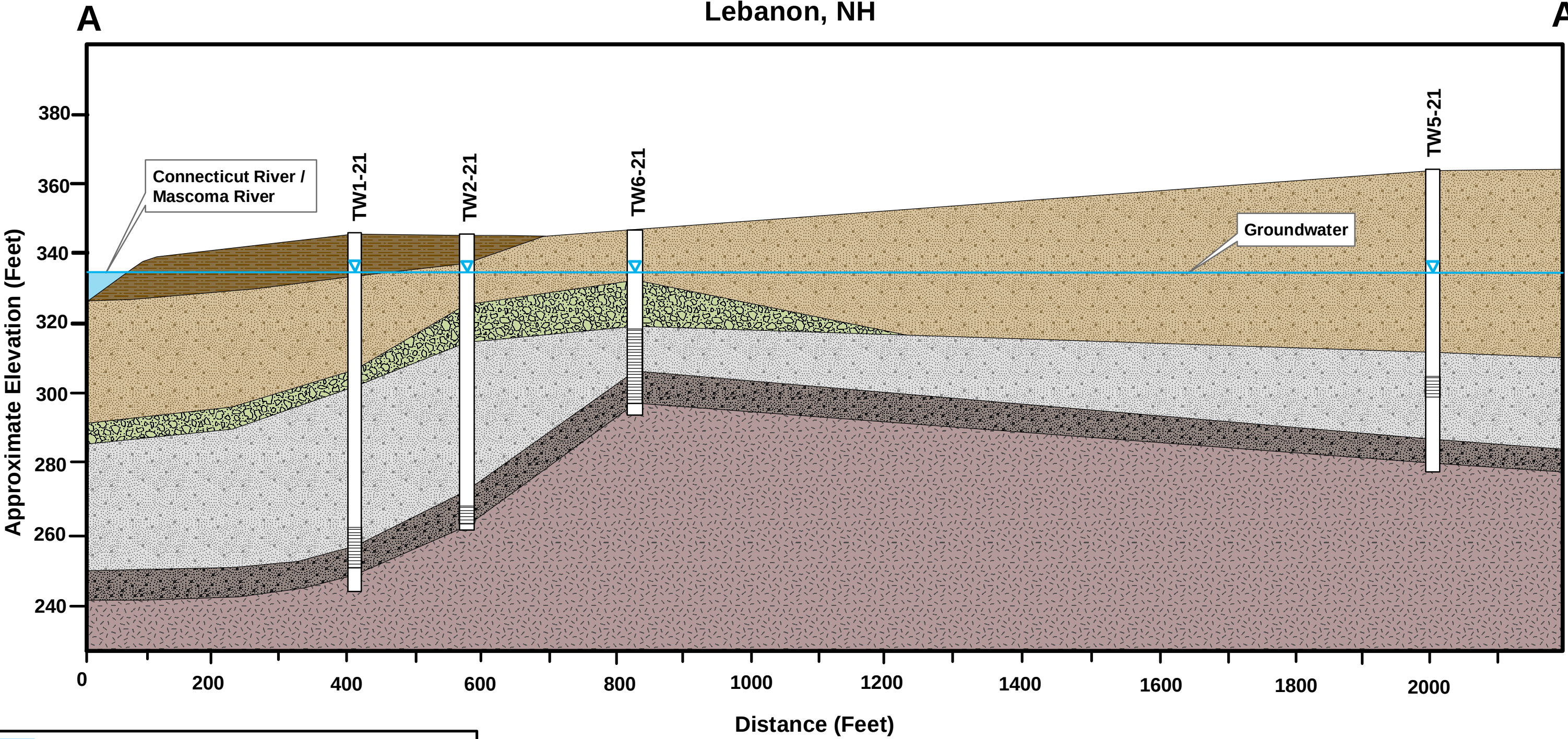
Attachment A Figures



LNT: W:\GIS_Development\Projects\NH\Lebanon\20604A_NewWaterSourceStudy\MXD\2. Site Plan 11x17.mxd



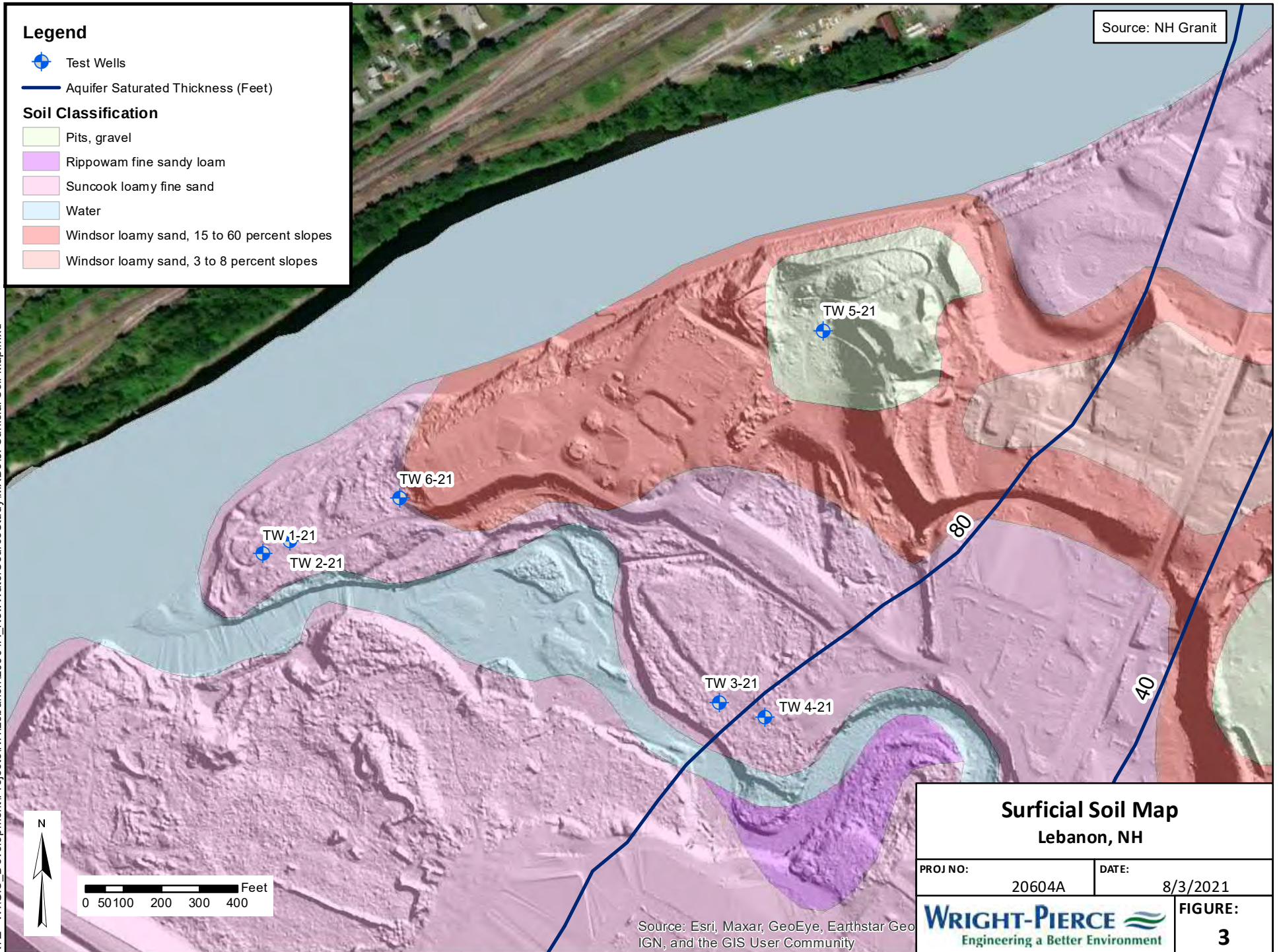
Hydrogeologic Cross-Section A-A`
Test Well Sites at Lebanon Water Treatment Facility
Lebanon, NH



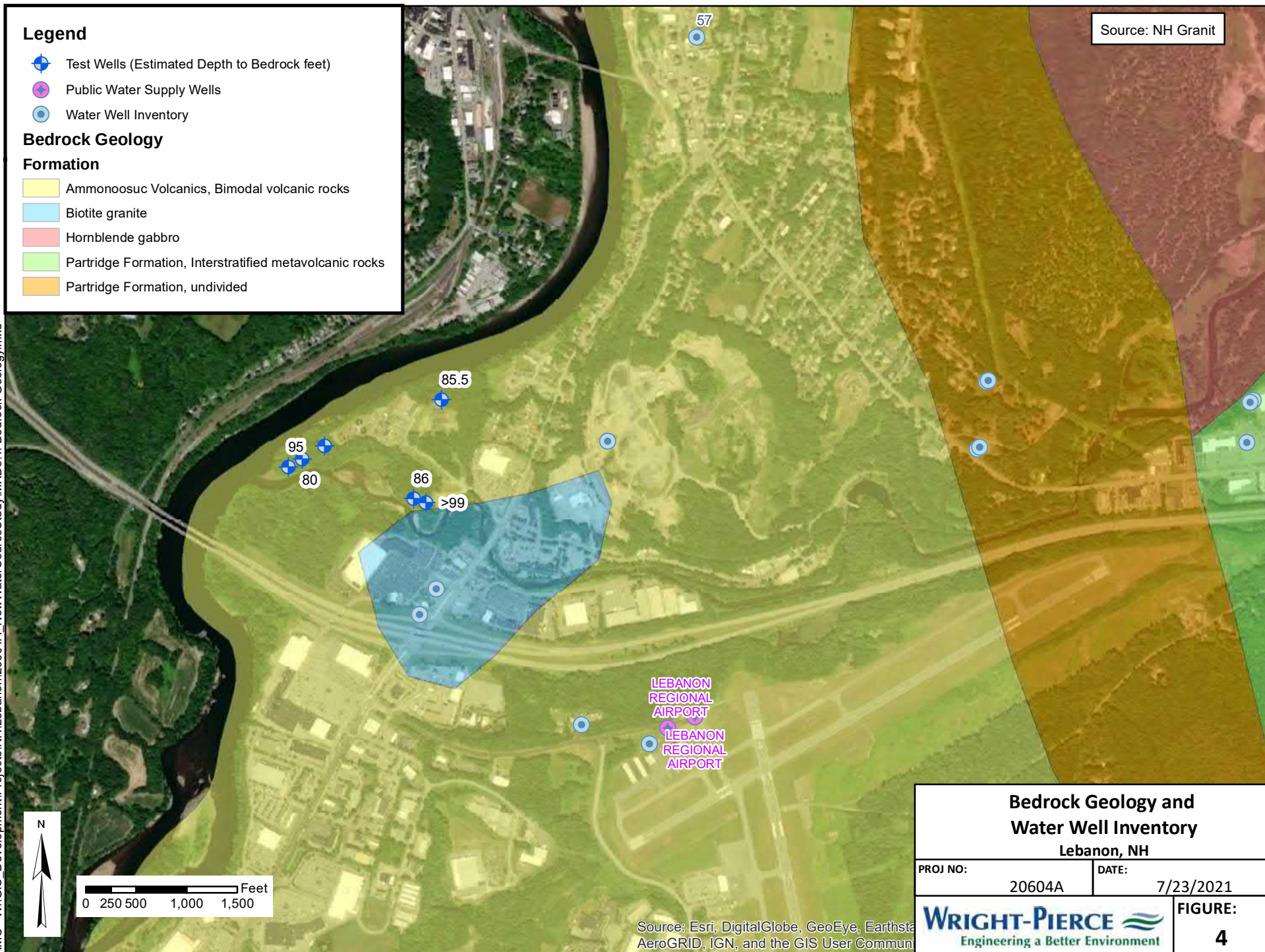
Hydrogeologic Cross-Section A-A`
Test Well Sites at
Lebanon Water Treatment Facility
Lebanon, NH

PROJ NO: 20604A	DATE: 7/2/2021	FIGURE: 2A
-----------------	----------------	------------

WRIGHT-PIERCE
Engineering a Better Environment



K:\GIS Development\Projects\NH\Lebanon\20604A NewWaterSourceStudy\MXDs\4. Bedrock Geology.mxd



LNT W:\GIS_Development\Projects\NH\Lebanon\20604A_NewWaterSourceStudy\MXDs\5. Flood Hazard Map.mxd

Legend

 Test Wells

 Property Line

Flood Hazard Zone

 0.2 PCT ANNUAL CHANCE FLOOD HAZARD

 AE

 X

Source: NH GRANIT



Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, U

Flood Hazard Map
Lebanon, NH

PROJ NO: 20604A

DATE: 8/3/2021

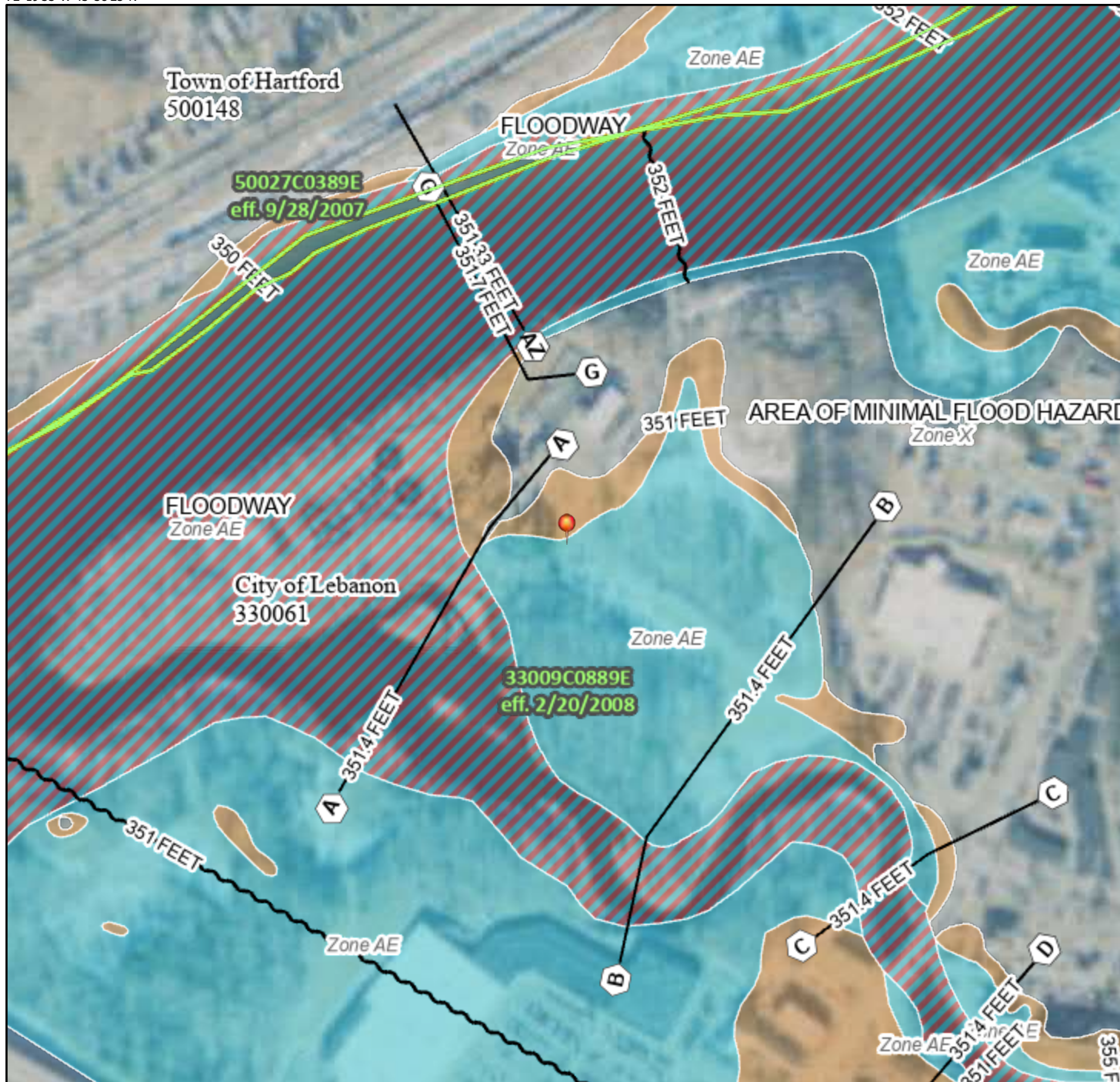
 **WRIGHT-PIERCE**
Engineering a Better Environment

FIGURE:
5

National Flood Hazard Layer FIRMette Figure 5A



72°19'33"W 43°38'25"N



0 250 500 1,000 1,500 2,000 Feet 1:6,000

Basemap: USGS National Map: Orthoimagery: Data refreshed October, 2020

Legend

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR FIRM PANEL LAYOUT

SPECIAL FLOOD HAZARD AREAS		Without Base Flood Elevation (BFE) Zone A, V, A99
		With BFE or Depth Zone AE, AO, AH, VE, AR
		Regulatory Floodway
OTHER AREAS OF FLOOD HAZARD		0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile Zone X
		Future Conditions 1% Annual Chance Flood Hazard Zone X
		Area with Reduced Flood Risk due to Levee. See Notes. Zone X
		Area with Flood Risk due to Levee Zone D
OTHER AREAS		NO SCREEN Area of Minimal Flood Hazard Zone X
		Effective LOMRs
GENERAL STRUCTURES		Area of Undetermined Flood Hazard Zone D
		Channel, Culvert, or Storm Sewer
		Levee, Dike, or Floodwall
OTHER FEATURES		20.2 Cross Sections with 1% Annual Chance Water Surface Elevation
		17.5
		Coastal Transect
		Base Flood Elevation Line (BFE)
		Limit of Study
		Jurisdiction Boundary
MAP PANELS		Coastal Transect Baseline
		Profile Baseline
		Hydrographic Feature
		Digital Data Available
		No Digital Data Available
		Unmapped



The pin displayed on the map is an approximate point selected by the user and does not represent an authoritative property location.

This map complies with FEMA's standards for the use of digital flood maps if it is not void as described below. The basemap shown complies with FEMA's basemap accuracy standards

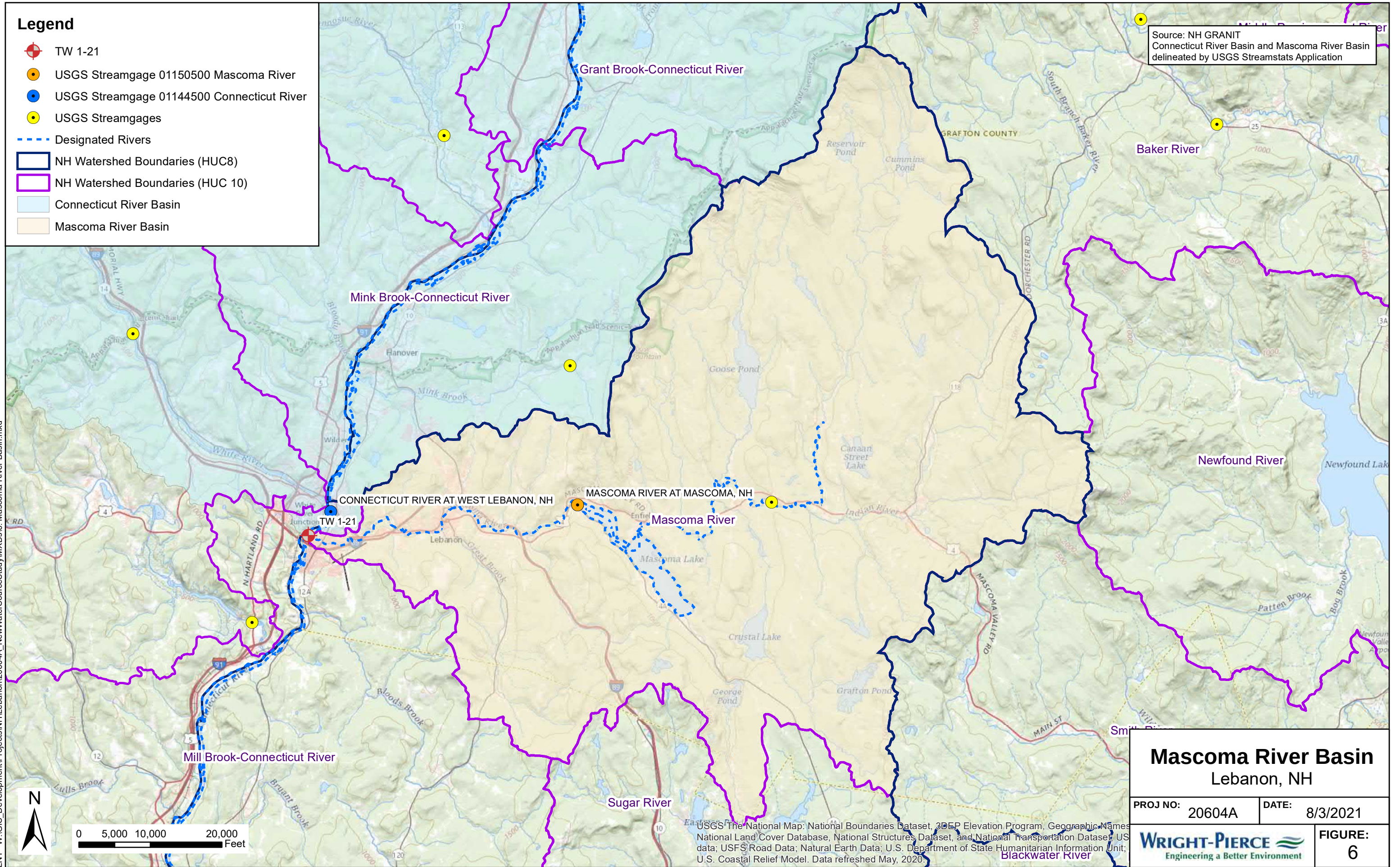
The flood hazard information is derived directly from the authoritative NFHL web services provided by FEMA. This map was exported on 7/21/2021 at 3:24 PM and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time.

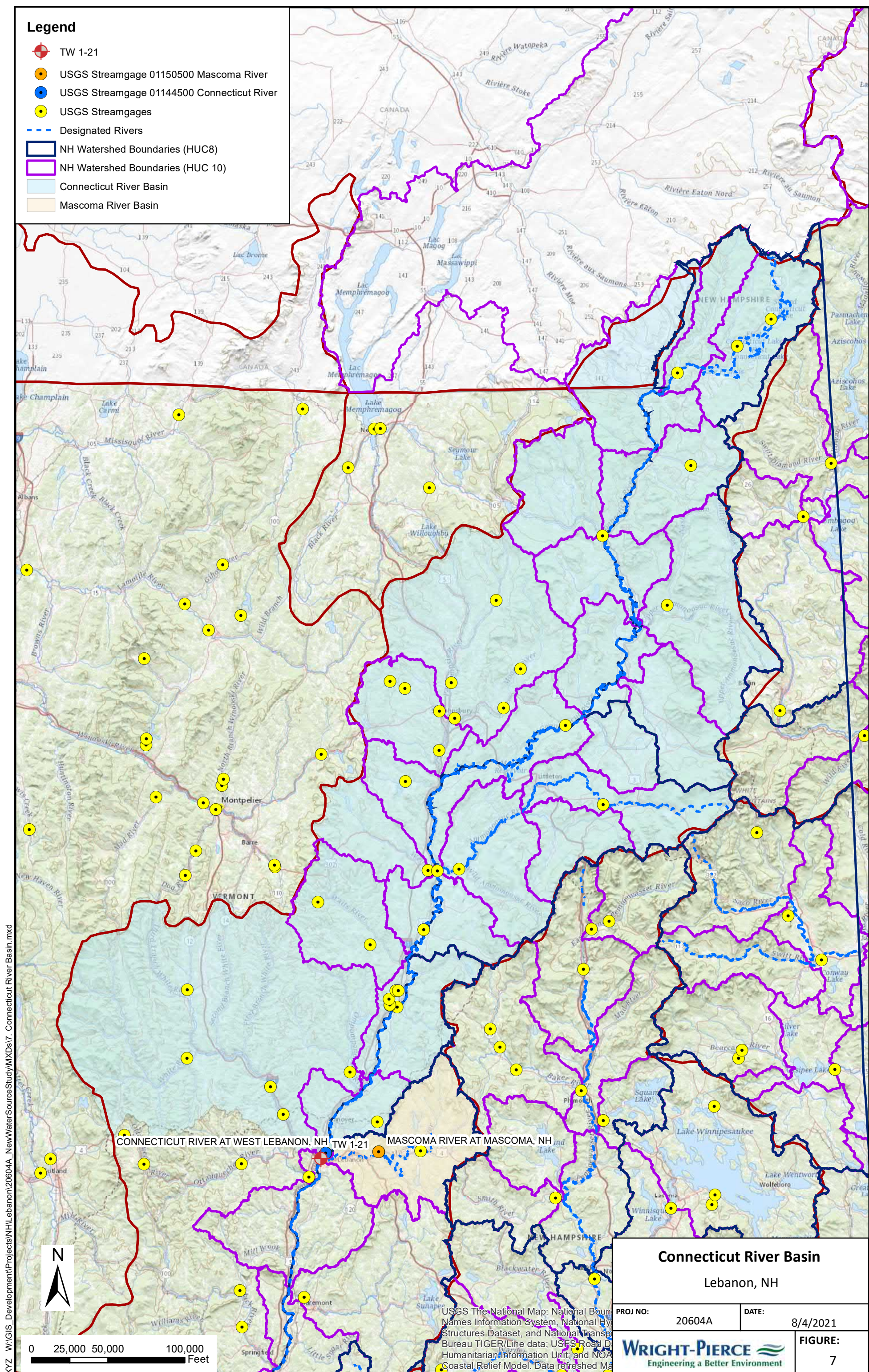
This map image is void if the one or more of the following map elements do not appear: basemap imagery, flood zone labels, legend, scale bar, map creation date, community identifiers, FIRM panel number, and FIRM effective date. Map images for unmapped and unmodernized areas cannot be used for regulatory purposes.

LNT W:\GIS_Development\Projects\NH\Lebanon\20604A_NewWaterSourceStudy\MXDs\16_Mascoma River Basin.mxd

Legend

-  TW 1-21
-  USGS Streamgage 01150500 Mascoma River
-  USGS Streamgage 01144500 Connecticut River
-  USGS Streamgages
-  Designated Rivers
-  NH Watershed Boundaries (HUC8)
-  NH Watershed Boundaries (HUC 10)
-  Connecticut River Basin
-  Mascoma River Basin

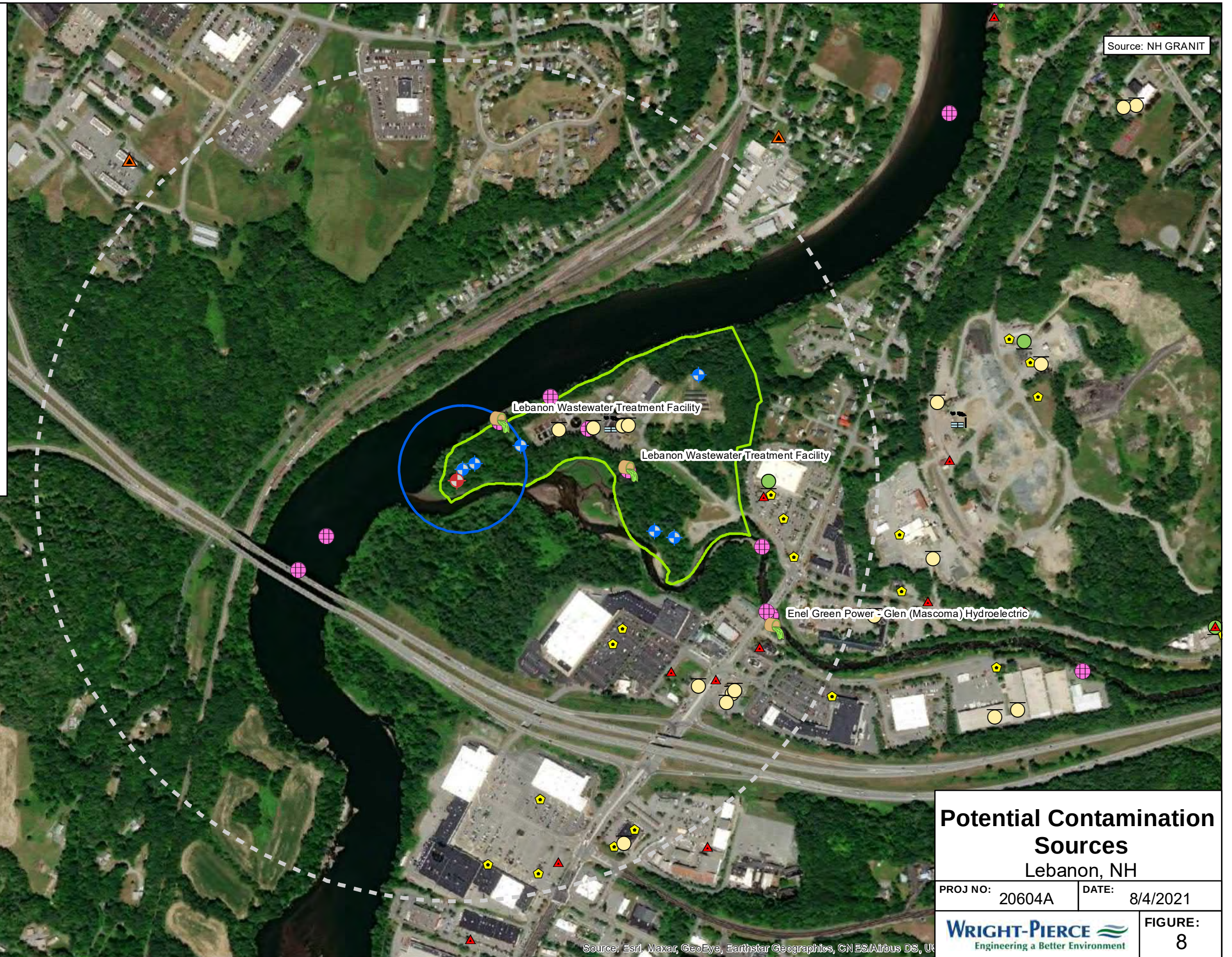




LNT: W:\GIS_Development\Projects\NH\Lebanon\20604A_NewWaterSourceStudy\MXDs\8_Potential Contamination Sources.mxd

Legend

-  Proposed Large Diameter Test Well
-  Test Wells
-  NPDES Outfalls
-  Hazardous Waste Site
-  Underground Storage Tank Sites
-  Solid Waste Facilities
-  Remediation Sites
-  Local Potential Contamination Sources
-  Hazardous Waste Generators
-  Environmental Monitoring Sites Nonsecure
-  Automobile Salvage Yards
-  AB Asbestos Disposal Sites
-  Air Facility Systems
-  Aboveground Storage Tank Sites
-  400 Foot Radius
-  Property Lines
-  0.5-Mile Radius
-  Lebanon



Potential Contamination Sources

Lebanon, NH

PROJ NO: 20604A

DATE: 8/4/2021

WRIGHT-PIERCE
Engineering a Better Environment

FIGURE:
8

Attachment B
Well Logs

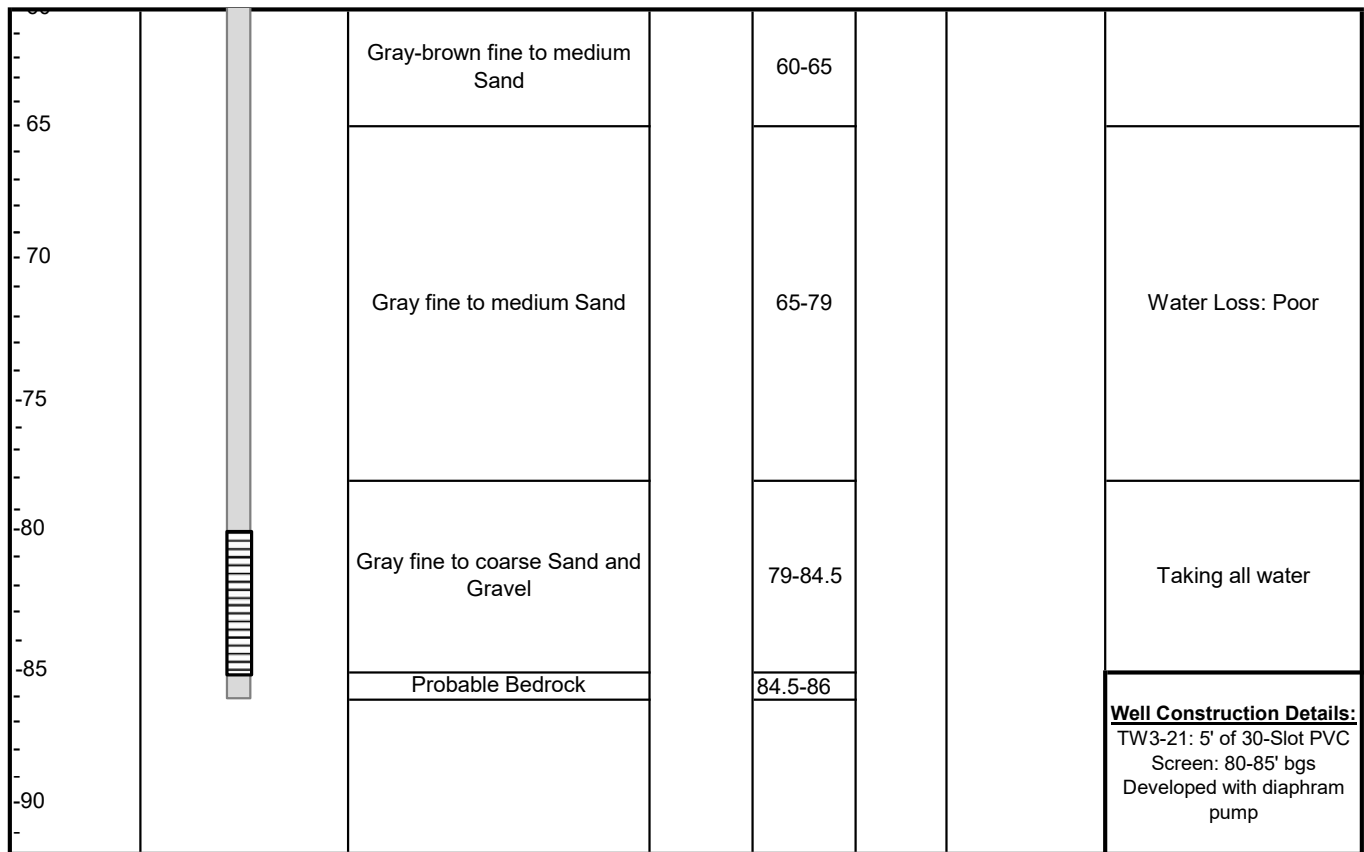
 WRIGHT-PIERCE Engineering a Better Environment					250 Commercial Street, Suite 4014 Manchester, NH 03101 Telephone: 603-430-3728 Fax: 603-430-4083 Website: www.wright-pierce.com			TW 1-21		
PROJECT: Lebanon New Water Source Study					JOB NO. 20604A			Fishing area at fork in road; West Area (southwest peninsula)		
CLIENT: City of Lebanon					DATE STARTED: 5/17/21					
CONTRACTOR: East Coast Explorations					DATE FINISHED: 5/18/21					
	CAS.	SAMP.	CORE	TUBE	ELEVATION: Approx. NA					
TYPE	Steel		-	-	ELEVATION (PVC): NA					
DIAMETER			-	-	GROUNDWATER (ft bgs): 11					
WEIGHT		-	-	-	DRILLER: Chris Palmer					
FALL		-	-	-	INSPECTOR: Greg Smith, Lauern Thistle					
DEPTH (ft)		WELL CONSTRUCTION		FORMATION CLASSIFICATION		SAMPLE			Notes	
						NO.	INTER. (ft)	REC. (ft)		BLOWS/6"
0								N/A	N/A	No water loss
5				Brown Silt with trace pyrite			0-12.5			
10				Fine to medium Gravel			12.5-14			
15				Light brown fine to course Sand and fine Gravel			14-19			Water Loss: Poor
20				Dark brown medium to coarse Sand with trace fine Sand			19-29			Water Loss: Poor
25										
30				Dark brown fine to coarse Sand			29-42			Water Loss: Poor
35										
40				Brown coarse Gravel			42-45			Water Loss: Fair
45				Fine to medium Sand, slight color change to gray brown			45-55			Water Loss: Poor
50										
55				Gray fine to medium Sand with trace coarse Sand			55-60			Water Loss: Poor
60										

-65		Gray fine to medium Sand with trace coarse Sand	60-67		Water Loss: Poor
-70		Gray fine to coarse sand with trace fine Gravel	67-74		Water Loss: Good
-75		Gray fine to coarse sand with trace fine Gravel	74-84		Water Loss: Excellent
-80		Gray fine to coarse Sand with fine Gravel	84-89		Water Loss: Excellent
-85		Gray fine to coarse Gravel	89-95		Well Construction Details: TW1-21: 10' screen: 80-Slot SS screen: 89-94' bgs; 60- slot PVC: 84-89' bgs Developed with diaphragm pump
-90		Probable Bedrock	95		
-95					

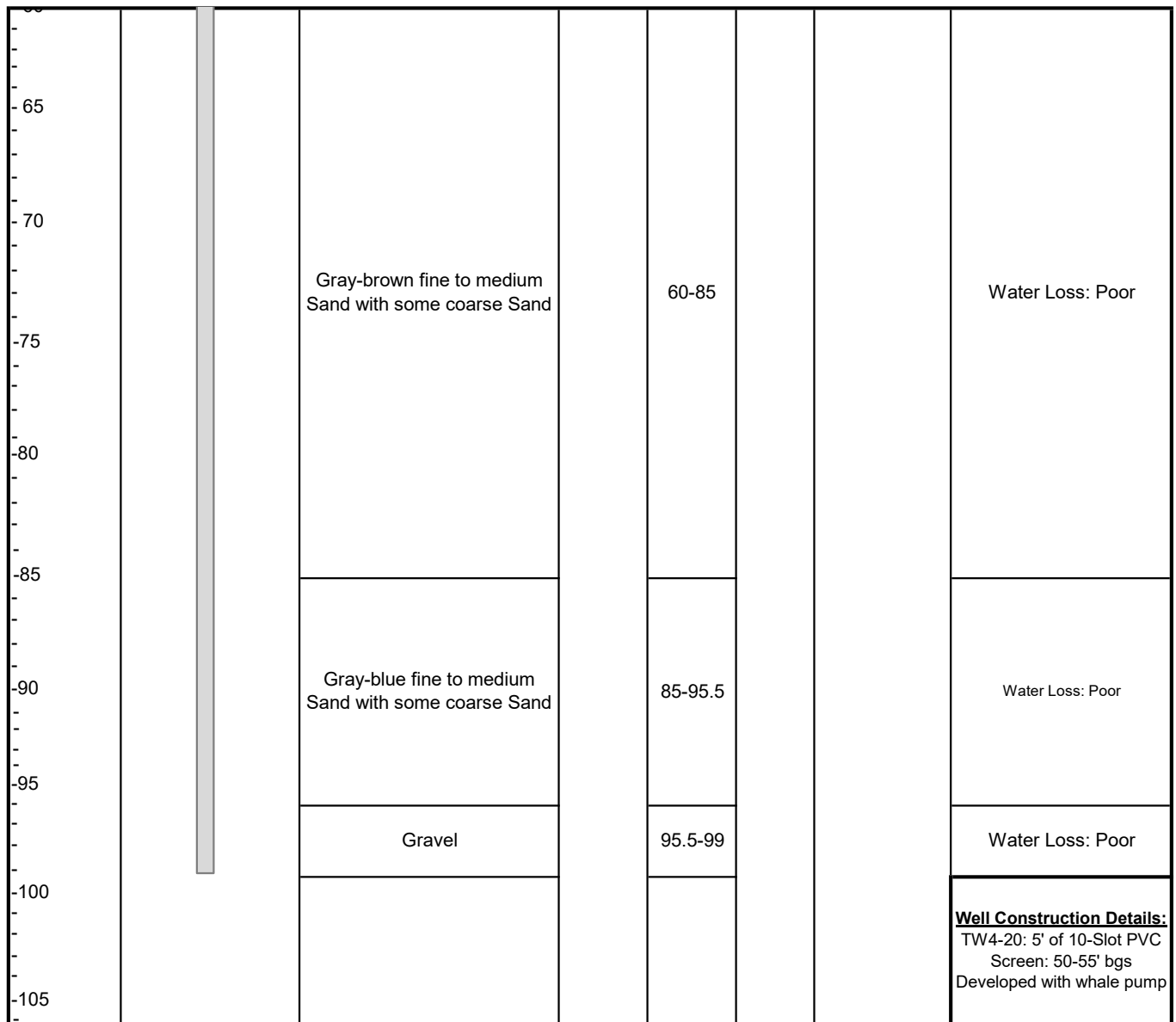
 WRIGHT-PIERCE Engineering a Better Environment					250 Commercial Street, Suite 4014 Manchester, NH 03101 Telephone: 603-430-3728 Fax: 603-430-4083 Website: www.wright-pierce.com				TW 2-21	
PROJECT: Lebanon New Water Source Study					JOB NO. 20604A				100 ft NE of TW1-21	
CLIENT: City of Lebanon					DATE STARTED: 5/20/21					
CONTRACTOR: East Coast Explorations					DATE FINISHED: 5/24/21					
	CAS.	SAMP.	CORE	TUBE	ELEVATION: Approx. NA					
TYPE	Steel		-	-	ELEVATION (PVC): NA					
DIAMETER			-	-	GROUNDWATER (ft bgs): 11					
WEIGHT		-	-	-	DRILLER: Chris Palmer					
FALL		-	-	-	INSPECTOR: Greg Smith, Lauern Thistle					
DEPTH (ft)	WELL CONSTRUCTION		FORMATION CLASSIFICATION		SAMPLE				Notes	
					NO.	INTER. (ft)	REC. (ft)	BLOWS/6"		
0							N/A	N/A		
5			Brown silt			0-8			No water loss	
10			Ligh brown fine to coarse Sand and fine Gravel			8-14			Water Loss: Poor	
15			Brown coarse Gravel with fine to coarse Sand			14-21			Water Loss: Poor	
20										
25			Coarse to cobble gravel with trace sand and pyrite			21-32			Water Loss: Poor	
30										
35										
40			Gray fine to medium Sand with trace fine Gravel			32-49			Water Loss: Poor	
45										
50										
55			Gray fine to coarse Sand and fine to medium Gravel			49-59			Water Loss: Fair	
60										

Page 164 of 234

 WRIGHT-PIERCE Engineering a Better Environment					250 Commercial Street, Suite 4014 Manchester, NH 03101 Telephone: 603-430-3728 Fax: 603-430-4083 Website: www.wright-pierce.com				TW 3-21	
PROJECT: Lebanon New Water Source Study					JOB NO. 20604A				South area; 90 ft from River	
CLIENT: City of Lebanon					DATE STARTED: 5/26/2021					
CONTRACTOR: East Coast Explorations					DATE FINISHED: 5/26/2021					
	CAS.	SAMP.	CORE	TUBE	ELEVATION: Approx. NA					
TYPE	Steel		-	-	ELEVATION (PVC): NA					
DIAMETER			-	-	GROUNDWATER (ft bgs): 11					
WEIGHT		-	-	-	DRILLER: Chris Palmer					
FALL		-	-	-	INSPECTOR: Greg Smith, Lauern Thistle					
DEPTH (ft)		WELL CONSTRUCTION		FORMATION CLASSIFICATION		SAMPLE				Notes
						NO.	INTER. (ft)	REC. (ft)	BLOWS/6"	
0								N/A	N/A	
5				Fine to medium Sand and coarse Gravel			0-8			No water loss
10				Gray fine to medium Sand			8-16			Water Loss: Poor
15				Gray fine to medium Sand and trace Gravel			16-18			
20										
25										
30				Gray fine to medium Sand			18-40			Water Loss: Poor
35										
40										
45				Brown medium Sand with trace fine and course Sand			40-55			No water loss
50										
55				Gray-brown fine to medium Sand			55-60			
60										



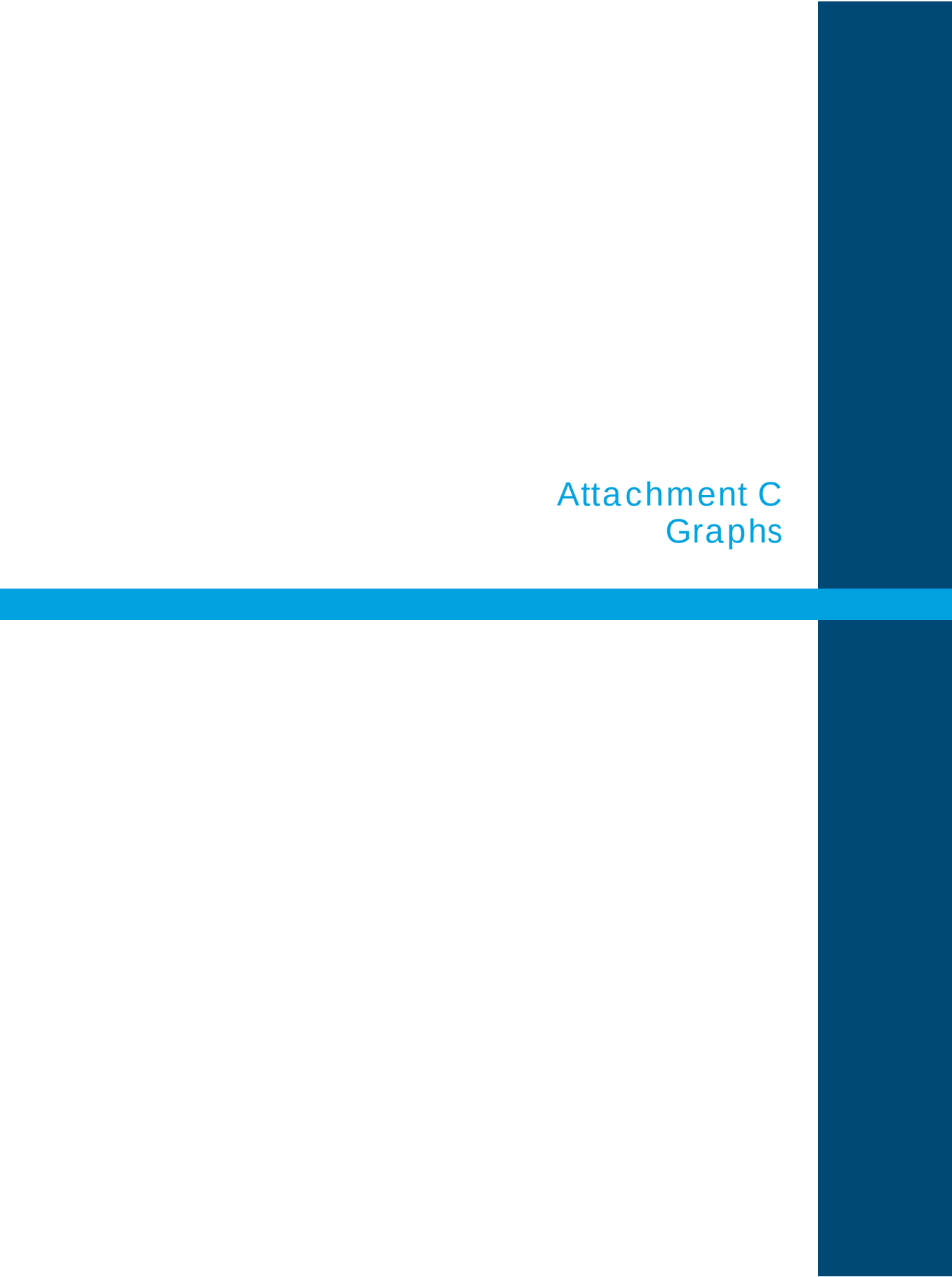
 WRIGHT-PIERCE Engineering a Better Environment						250 Commercial Street, Suite 4014 Manchester, NH 03101 Telephone: 603-430-3728 Fax: 603-430-4083 Website: www.wright-pierce.com				TW 4-21																										
PROJECT: Lebanon New Water Source Study CLIENT: City of Lebanon CONTRACTOR: East Coast Explorations						JOB NO. 20604A DATE STARTED: 5/28/2021 DATE FINISHED: 6/2/2021				South Area (off parking lot); ~100 ft SE of TW3-21																										
<table border="1"> <tr> <th></th> <th>CAS.</th> <th>SAMP.</th> <th>CORE</th> <th>TUBE</th> </tr> <tr> <td>TYPE</td> <td>Steel</td> <td></td> <td>-</td> <td>-</td> </tr> <tr> <td>DIAMETER</td> <td></td> <td></td> <td>-</td> <td>-</td> </tr> <tr> <td>WEIGHT</td> <td></td> <td>-</td> <td>-</td> <td>-</td> </tr> <tr> <td>FALL</td> <td></td> <td>-</td> <td>-</td> <td>-</td> </tr> </table>							CAS.	SAMP.	CORE			TUBE	TYPE	Steel		-	-	DIAMETER			-	-	WEIGHT		-	-	-	FALL		-	-	-	ELEVATION: Approx. NA ELEVATION (PVC): NA GROUNDWATER (ft bgs): 11 DRILLER: Chris Palmer INSPECTOR: Greg Smith, Lauern Thistle			
	CAS.	SAMP.	CORE	TUBE																																
TYPE	Steel		-	-																																
DIAMETER			-	-																																
WEIGHT		-	-	-																																
FALL		-	-	-																																
<table border="1"> <tr> <th>DEPTH (ft)</th> <th>WELL CONSTRUCTION</th> <th>FORMATION CLASSIFICATION</th> <th colspan="4">SAMPLE</th> <th rowspan="2">Notes</th> </tr> <tr> <th></th> <th></th> <th></th> <th>NO.</th> <th>INTER. (ft)</th> <th>REC. (ft)</th> <th>BLOWS/6"</th> </tr> </table>						DEPTH (ft)	WELL CONSTRUCTION	FORMATION CLASSIFICATION	SAMPLE				Notes				NO.	INTER. (ft)	REC. (ft)	BLOWS/6"																
DEPTH (ft)	WELL CONSTRUCTION	FORMATION CLASSIFICATION	SAMPLE				Notes																													
			NO.	INTER. (ft)	REC. (ft)	BLOWS/6"																														
0		Coarse Gravel with some brown Sand		0-8	N/A	N/A																														
5																																				
10																																				
15		Light brown fine to medium Sand with trace coarse Sand		8-20																																
20																																				
25																																				
30		Brown fine to medium Sand with trace coarse Sand		20-40																																
35																																				
40																																				
45		Brown fine to medium Sand with some coarse Sand		40-55																																
50																																				
55																																				
60		Gray-brown fine to medium Sand with some coarse Sand		55-60			Water Loss: Poor																													



 WRIGHT-PIERCE Engineering a Better Environment					250 Commercial Street, Suite 4014 Manchester, NH 03101 Telephone: 603-430-3728 Fax: 603-430-4083 Website: www.wright-pierce.com			TW 5-21	
PROJECT: Lebanon New Water Source Study					JOB NO. 20604A			North Area (Solar Array Area)	
CLIENT: City of Lebanon					DATE STARTED: 6/3/2021				
CONTRACTOR: East Coast Explorations					DATE FINISHED: 6/7/2021				
	CAS.	SAMP.	CORE	TUBE	ELEVATION: Approx. NA				
TYPE	Steel		-	-	ELEVATION (PVC): NA				
DIAMETER			-	-	GROUNDWATER (ft bgs): 30'				
WEIGHT		-	-	-	DRILLER: Chris Palmer				
FALL		-	-	-	INSPECTOR: Greg Smith, Lauern Thistle				
DEPTH (ft)	WELL CONSTRUCTION		FORMATION CLASSIFICATION	SAMPLE				Notes	
				NO.	INTER. (ft)	REC. (ft)	BLOWS/6"		
0						N/A	N/A		
-5			Brown fine to medium Sand with trace fine Gravel		0-15				
-10									
-15			Brown fine Sand with trace medium Sand		15-55				
-20									
-25									
-30									
-35			Gray fine Sand with trace medium Sand		55-60				
-40									
-45									
-50									
-55									
-60									

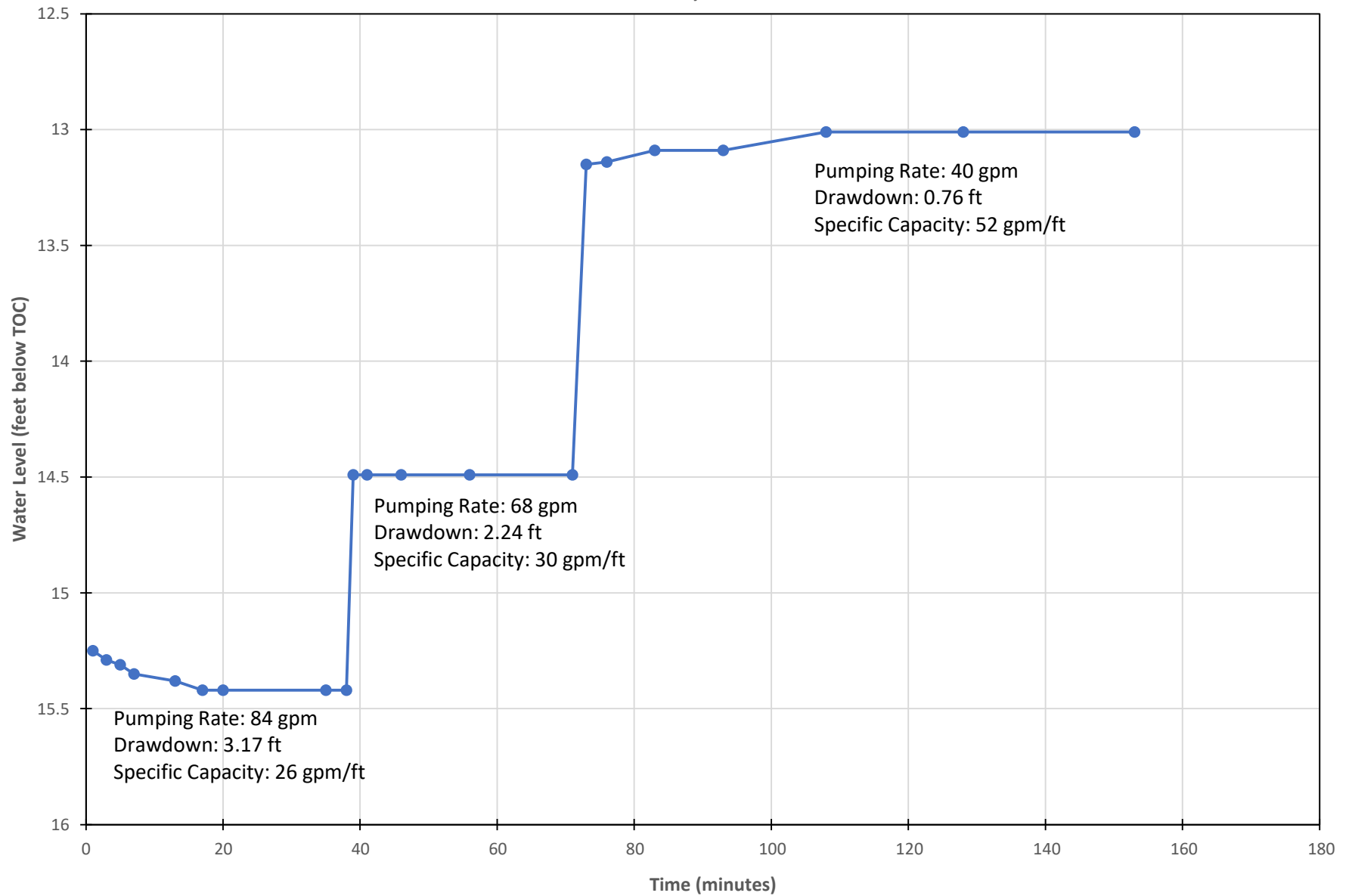
-65		Gray fine Sand with trace medium Sand	60-74			
-70						
-75		Fine to medium Sand with trace fine Gravel	74-78			Water Loss: Poor-Fair
-80		Sandy Gravel	78-81			Water Loss: Fair
-85		Gravel	81-85.5			Water Loss: Excellent; pump test sanded in
-85		Probable Bedrock	85.5-86.5			
-90		Bedrock Fracture	86.5-88			BR Fracture - taking all water
-95						Well Construction Details: TW5-21: 5' of 20-Slot PVC Screen: 75-80' bgs Developed with whale pump

PROJECT: Lebanon New Water Source Study					JOB NO. 20604A			West and adjacent to WWTP
CLIENT: City of Lebanon					DATE STARTED: 6/7/2021			
CONTRACTOR: East Coast Explorations					DATE FINISHED: 6/9/2021			
	CAS.	SAMP.	CORE	TUBE	ELEVATION: Approx. NA			
TYPE	Steel		-	-	ELEVATION (PVC): NA			
DIAMETER			-	-	GROUNDWATER (ft bgs): 11'			
WEIGHT		-	-	-	DRILLER: Chris Palmer			
FALL		-	-	-	INSPECTOR: Greg Smith, Lauern Thistle			
DEPTH (ft)	WELL CONSTRUCTION	FORMATION CLASSIFICATION	SAMPLE				Notes	
			NO.	INTER. (ft)	REC. (ft)	BLOWS/6"		
0		Light brown Sand and fine Gravel		0-6	N/A	N/A		
5								
10		Brown fine to medium Sand with trace fine Gravel		6-13				
15								
20			Brown fine to coarse Sand and fine Gravel		13-20			Water Loss: Good
25			Brown fine to coarse Sand and fine to coarse Gravel with trace Cobbles		20-24			Taking all water
30			Sandy Gravel and Cobbles		24-35			Water Loss: Poor
35			Fine to coarse Sand		35-38			
40			Brown fine to coarse Sand and some fine Gravel		38-45			Water Loss: Fair
45			Fine to coarse Sand and fine to coarse Gravel		45-49			
50			Probable Bedrock		49-52			
55								Well Construction Details: TW6-21: 25' of 10-Slot PVC Screen: 24-49' bgs Developed with whale pump
60								

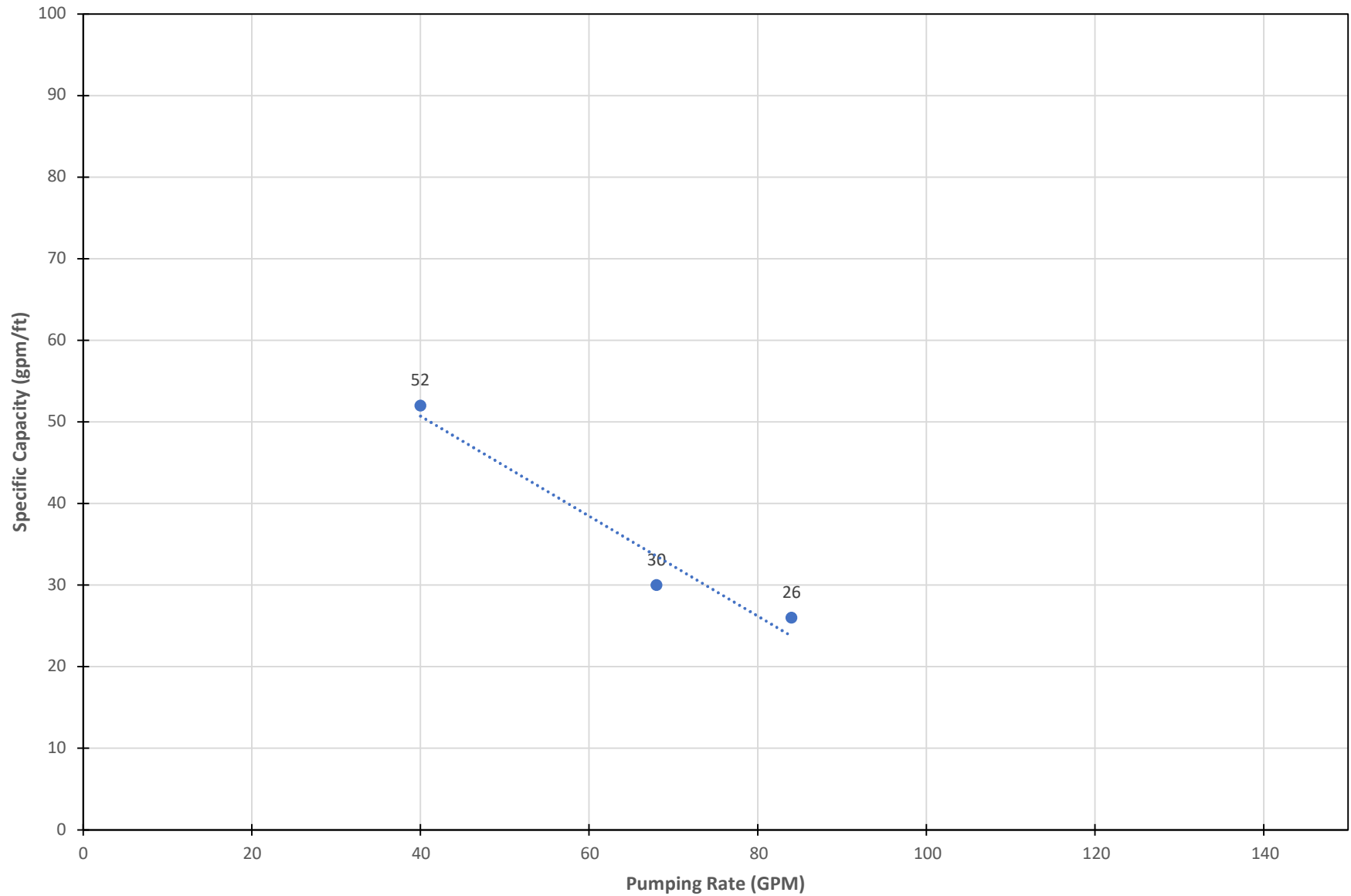


Attachment C Graphs

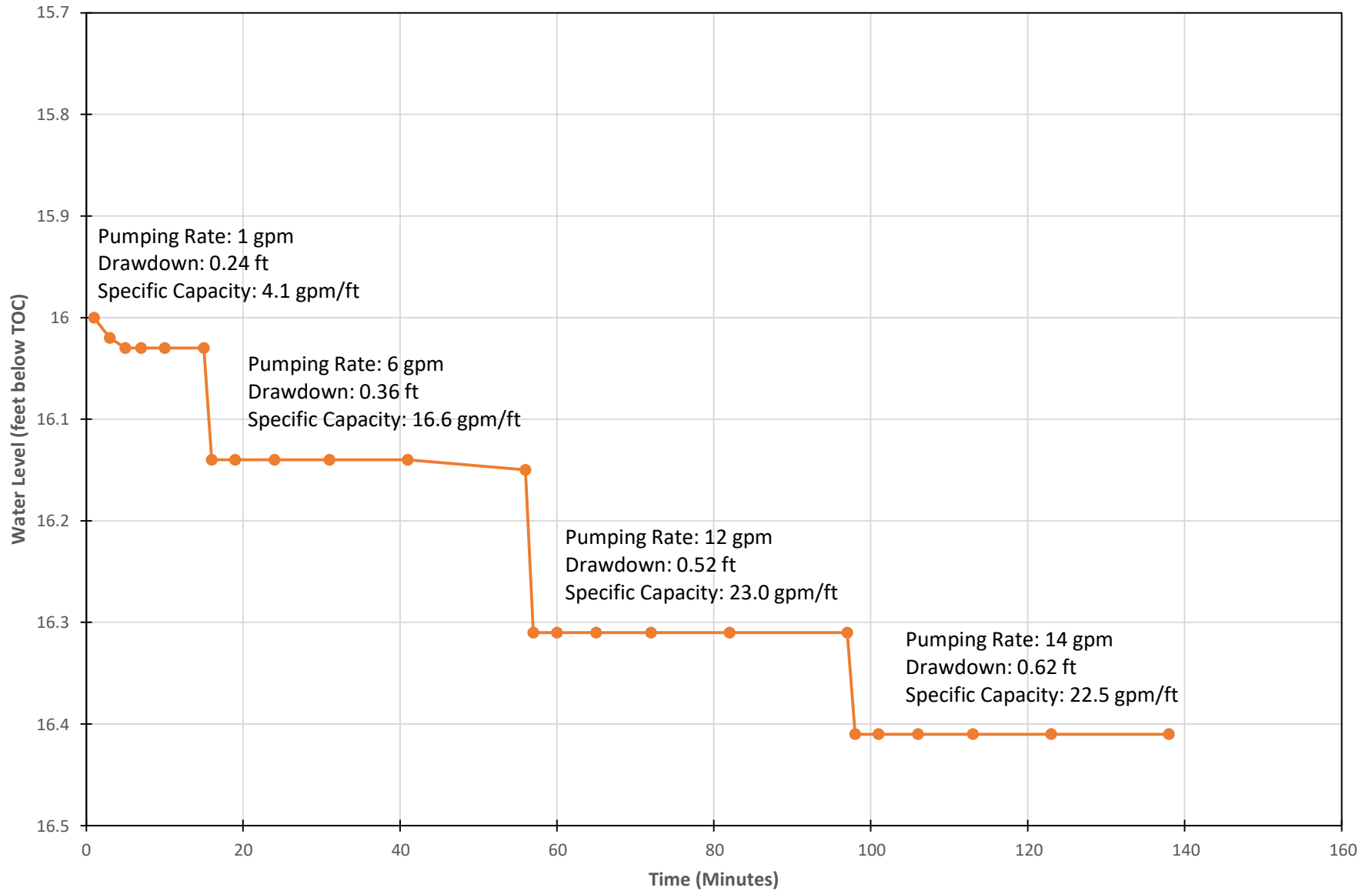
**Graph 1: Short Term Step Pumping Test on TW 1-21
Lebanon, NH**

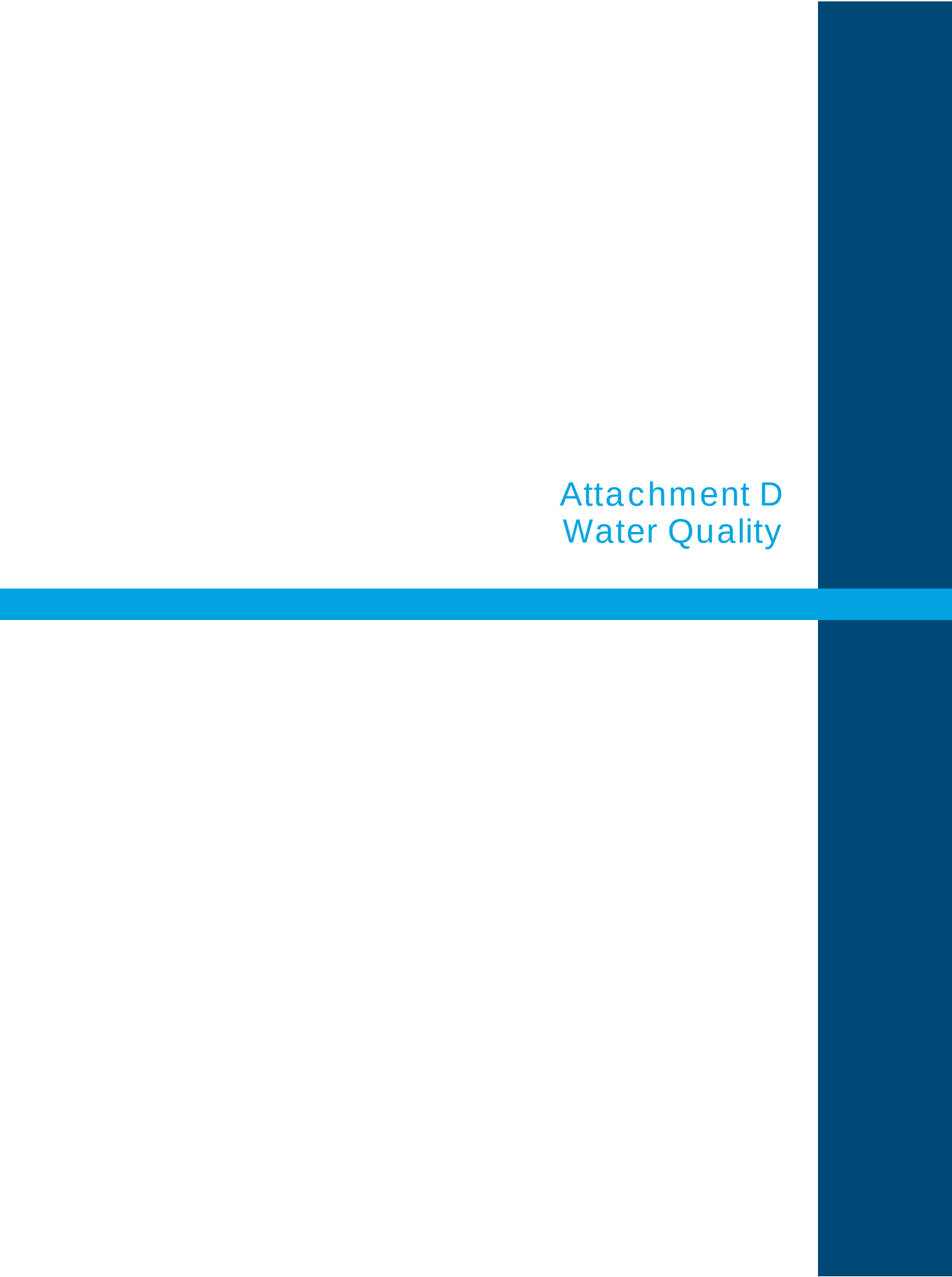


**Graph 2: Well Efficiency during Step Pumping Test on TW 1-21
Lebanon, NH**



**Graph 3: Short Term Step Pumping Test on TW 2-21
Lebanon, NH**





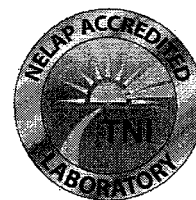
Attachment D Water Quality



Eastern Analytical, Inc.

professional laboratory and drilling services

Lauren Thistle
Wright-Pierce (Manchester)
250 Commercial Street, Suite 4014
Manchester, NH 03101



Laboratory Report for:

Eastern Analytical, Inc. ID: 226586
Client Identification: Lebanon Exploration | 20604A
Date Received: 5/21/2021

Enclosed are the analytical results per the Chain of Custody for sample(s) in the referenced project. All analyses were performed in accordance with our QA/QC Program, NELAP and other applicable state requirements. All quality control criteria was within acceptance criteria unless noted on the report pages. Results are for the exclusive use of the client named on this report and will not be released to a third party without consent.

The following information is contained within this report: Sample Conditions summary, Analytical Results/Data, Quality Control data (if requested) and copies of the Chain of Custody. This report may not be reproduced except in full, without the written approval of the laboratory.

The following standard abbreviations and conventions apply to all EAI reports:

- < : "less than" followed by the reporting limit
- > : "greater than" followed by the reporting limit
- %R : % Recovery

Certifications:

Eastern Analytical, Inc. maintains certification in the following states: Connecticut (PH-0492), Maine (NH005), Massachusetts (M-NH005), New Hampshire/NELAP (1012), Rhode Island (269), Vermont (VT1012), New York (12072), West Virginia (9910C) and Alabama (41620). Please refer to our website at www.easternanalytical.com for a copy of our certificates and accredited parameters.

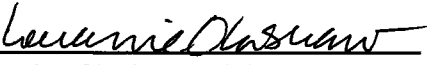
References:

- EPA 600/4-79-020, 1983
- Standard Methods for Examination of Water and Wastewater, 20th, 21st, 22nd & 23rd edition or noted revision year.
- Test Methods for Evaluating Solid Waste SW 846 3rd Edition including updates IVA and IVB
- Hach Water Analysis Handbook, 4th edition, 1992

If you have any questions regarding the results contained within, please feel free to contact customer service. Unless otherwise requested, we will dispose of the sample(s) 6 weeks from the sample receipt date.

We appreciate this opportunity to be of service and look forward to your continued patronage.

Sincerely,


Lorraine Olashaw, Lab Director

6.8.21
Date

21
of pages (excluding cover letter)



SAMPLE CONDITIONS PAGE

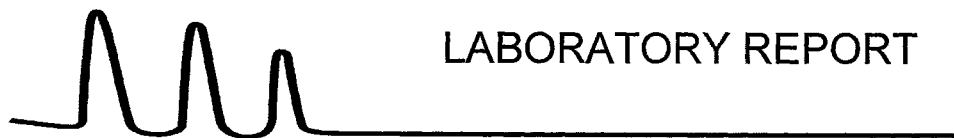
EAI ID#: 226586

Client: **Wright-Pierce (Manchester)**
Client Designation: **Lebanon Exploration | 20604A**

Temperature upon receipt (°C): 2.9			Received on ice or cold packs (Yes/No): Y		
Acceptable temperature range (°C): 0-6					
Lab ID	Sample ID	Date Received	Date/Time Sampled	Sample Matrix	Exceptions/Comments (other than thermal preservation)
226586.01	TW1-21	5/21/21	5/19/21 14:45	aqueous	Adheres to Sample Acceptance Policy

All results contained in this report relate only to the above listed samples.

- Unless otherwise noted:
- Hold times, preservation, container types, and sample conditions adhered to EPA Protocol.
 - Solid samples are reported on a dry weight basis, unless otherwise noted. pH/Corrosivity, Flashpoint, Ignitability, Paint Filter, Conductivity and Specific Gravity are always reported on an "as received" basis.
 - Analysis of pH, Total Residual Chlorine, Dissolved Oxygen and Sulfite were performed at the laboratory outside of the recommended 15 minute hold time.
 - Samples collected by Eastern Analytical, Inc. (EAI) were collected in accordance with approved EPA procedures.



LABORATORY REPORT

EAI ID#: 226586

Client: **Wright-Pierce (Manchester)**

Client Designation: **Lebanon Exploration | 20604A**

Sample ID: TW1-21

Lab Sample ID: 226586.01
Matrix: aqueous
Date Sampled: 5/19/21
Date Received: 5/21/21
Units: ug/L
Date of Analysis: 5/21/21
Analyst: AM
Method: 524.2
Dilution Factor: 1

Dichlorodifluoromethane	< 0.5
Chloromethane	< 0.5
Vinyl chloride	< 0.5
Bromomethane	< 0.5
Chloroethane	< 0.5
Trichlorofluoromethane	< 0.5
Diethyl Ether	< 5
Acetone	< 10
1,1-Dichloroethene	< 0.5
tert-Butyl Alcohol (TBA)	< 30
Methylene chloride	< 0.5
Carbon disulfide	< 2
Methyl-t-butyl ether(MTBE)	< 0.5
Ethyl-t-butyl ether(ETBE)	< 0.5
Isopropyl ether(DIPE)	< 0.5
tert-amyl methyl ether(TAME)	< 0.5
trans-1,2-Dichloroethene	< 0.5
1,1-Dichloroethane	< 0.5
2,2-Dichloropropane	< 0.5
cis-1,2-Dichloroethene	< 0.5
2-Butanone(MEK)	< 5
Bromochloromethane	< 0.5
Tetrahydrofuran(THF)	< 5
Chloroform	< 0.5
1,1,1-Trichloroethane	< 0.5
Carbon tetrachloride	< 0.5
1,1-Dichloropropene	< 0.5
Benzene	< 0.5
1,2-Dichloroethane	< 0.5
Trichloroethene	< 0.5
1,2-Dichloropropane	< 0.5
Dibromomethane	< 0.5
Bromodichloromethane	< 0.5
4-Methyl-2-pentanone(MIBK)	< 5
cis-1,3-Dichloropropene	< 0.3
Toluene	< 0.5
trans-1,3-Dichloropropene	< 0.3
1,1,2-Trichloroethane	< 0.5
2-Hexanone	< 5
Tetrachloroethene	< 0.5
1,3-Dichloropropane	< 0.5
Dibromochloromethane	< 0.5
1,2-Dibromoethane(EDB)	< 0.5
Chlorobenzene	< 0.5
1,1,1,2-Tetrachloroethane	< 0.5
Ethylbenzene	< 0.5



LABORATORY REPORT

EAI ID#: 226586

Client: **Wright-Pierce (Manchester)**

Client Designation: **Lebanon Exploration | 20604A**

Sample ID: TW1-21

Lab Sample ID: 226586.01

Matrix: aqueous

Date Sampled: 5/19/21

Date Received: 5/21/21

Units: ug/L

Date of Analysis: 5/21/21

Analyst: AM

Method: 524.2

Dilution Factor: 1

mp-Xylene < 0.5

o-Xylene < 0.5

Styrene < 0.5

Bromoform < 0.5

IsoPropylbenzene < 0.5

Bromobenzene < 0.5

1,1,2,2-Tetrachloroethane < 0.5

1,2,3-Trichloropropane < 0.5

n-Propylbenzene < 0.5

2-Chlorotoluene < 0.5

4-Chlorotoluene < 0.5

1,3,5-Trimethylbenzene < 0.5

tert-Butylbenzene < 0.5

1,2,4-Trimethylbenzene < 0.5

sec-Butylbenzene < 0.5

1,3-Dichlorobenzene < 0.5

p-Isopropyltoluene < 0.5

1,4-Dichlorobenzene < 0.5

1,2-Dichlorobenzene < 0.5

n-Butylbenzene < 0.5

1,2-Dibromo-3-chloropropane < 0.5

1,3,5-Trichlorobenzene < 0.5

1,2,4-Trichlorobenzene < 0.5

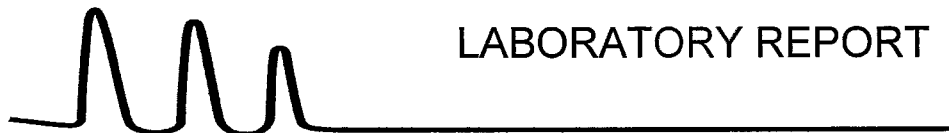
Hexachlorobutadiene < 0.5

Naphthalene < 0.5

1,2,3-Trichlorobenzene < 0.5

4-Bromofluorobenzene (surr) 85 %R

1,2-Dichlorobenzene-d4 (surr) 111 %R



LABORATORY REPORT

EAI ID#: 226586

Client: **Wright-Pierce (Manchester)**

Client Designation: **Lebanon Exploration | 20604A**

Sample ID: TW1-21

Lab Sample ID: 226586.01

Matrix: aqueous

Date Sampled: 5/19/21

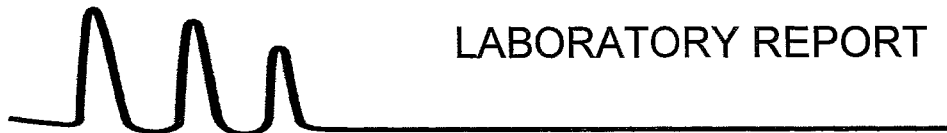
Date Received: 5/21/21

Solids Dissolved	660
Sulfate	40
Chloride	220
Nitrite-N	< 0.5
Nitrate-N	< 0.5
Alkalinity Total (CaCO ₃)	210
Sulfide	< 0.05
TOC	< 0.5
pH	7.59

Units	Analysis		Method	Analyst
	Date	Time		
mg/L	5/25/21	14:20	2540C-11	KJD
mg/L	5/24/21	22:22	300.0	ATA
mg/L	5/21/21	15:15	4500CIE-11	ATA
mg/L	5/21/21	14:11	353.2	ATA
mg/L	5/21/21	14:11	353.2	ATA
mg/L	5/26/21	13:41	2320B-11	RB
mg/L	5/24/21	9:25	8131HACH	RB
mg/L	5/26/21	12:24	5310C-00	LO
SU	5/21/21	15:04	4500H+B-11	AMB

The matrix spike duplicate for TOC associated with this sample was outside of the control limits. The matrix spike and all other QC were in control.

The sample for pH was received and analyzed by the laboratory past hold time.



LABORATORY REPORT

EAI ID#: 226586

Client: **Wright-Pierce (Manchester)**

Client Designation: **Lebanon Exploration | 20604A**

Sample ID: TW1-21

Lab Sample ID: 226586.01

Matrix: aqueous

Date Sampled: 5/19/21

Date Received: 5/21/21

Arsenic 0.0038
Manganese 0.42
Uranium 7.1
Calcium 100
Iron 0.45
Sodium 100
Total Hardness (as CaCO₃) 300

Analytical Matrix	Units	Date of Analysis	Method	Analyst
AqDis	mg/L	5/24/21	200.8	DS
AqDis	mg/L	5/24/21	200.8	DS
AqDis	ug/L	5/24/21	200.8	DS
AqDis	mg/L	5/25/21	200.7	RJ
AqDis	mg/L	5/25/21	200.7	RJ
AqDis	mg/L	5/25/21	200.7	RJ
AqTot	mg/L	5/25/21	200.7	RJ



June 07, 2021

Vista Work Order No. 2105245

Ms. Jennifer Laramie
Eastern Analytical, Inc.
25 Chennell Drive
Concord, NH 03301

Dear Ms. Laramie,

Enclosed are the results for the sample set received at Vista Analytical Laboratory on May 27, 2021 under your Project Name '226586 NH'.

Vista Analytical Laboratory is committed to serving you effectively. If you require additional information, please contact me at 916-673-1520 or by email at mmaier@vista-analytical.com.

Thank you for choosing Vista as part of your analytical support team.

Sincerely,

A handwritten signature in cursive script that reads "Oliver Cawdell For".

Martha Maier
Laboratory Director



Vista Analytical Laboratory certifies that the report herein meets all the requirements set forth by NELAP for those applicable test methods. Results relate only to the samples as received by the laboratory. This report should not be reproduced except in full without the written approval of Vista.

Vista Work Order No. 2105245**Case Narrative****Sample Condition on Receipt:**

One aqueous sample was received and stored securely in accordance with Vista standard operating procedures and EPA methodology. The sample was received in good condition and within the method temperature requirements.

Analytical Notes:**EPA Method 537.1**

The sample was extracted and analyzed for a selected list of six analytes using EPA Method 537.1. The results for PFHxS, PFOA and PFOS include both linear and branched isomers. Results for the other analytes include the linear isomer only.

Holding Times

The sample was extracted and analyzed within the method hold times.

Quality Control

The Initial Calibration and Continuing Calibration Verifications met the acceptance criteria.

Two Laboratory Fortified Blanks (LFB/LFBD) and a Laboratory Reagent Blank (LRB) were extracted and analyzed with the preparation batch. No analytes were detected in the LRB above the method required limits. The LFB/LFBD recoveries were within the method acceptance criteria. The preservative added to the LRB, LFB and LFBD was from a different lot than was used in the field samples. The sample preservative lot was previously shown to have no detectable analytes.

The surrogate recoveries for all QC and field samples were within the acceptance criteria.

TABLE OF CONTENTS

Case Narrative.....	1
Table of Contents.....	3
Sample Inventory.....	4
Analytical Results.....	5
Qualifiers.....	9
Certifications.....	10
Sample Receipt.....	13

Sample Inventory Report

Vista Sample ID	Client Sample ID	Sampled	Received	Components/Containers
2105245-01	TW1-21	19-May-21 14:45	27-May-21 10:22	Polypropylene, 250mL Polypropylene, 250mL

ANALYTICAL RESULTS

Sample ID: LRB					EPA Method 537.1								
Client Data					Laboratory Data								
Name:		Eastern Analytical, Inc.		Matrix:	Aqueous		Lab Sample:		B1E0245-BLK1		Column:	BEH C18	
Project:		226586 NH											
Analyte	CAS Number	Conc. (ng/L)	NH MCL	RL	Qualifiers	Batch	Extracted	Samp Size	Analyzed	Dilution			
PFBS	375-73-5	ND	-	2.00		B1E0245	30-May-21	0.250 L	01-Jun-21 19:25	1			
PFHpA	375-85-9	ND	-	2.00		B1E0245	30-May-21	0.250 L	01-Jun-21 19:25	1			
PFHxS	355-46-4	ND	18	2.00		B1E0245	30-May-21	0.250 L	01-Jun-21 19:25	1			
PFOA	335-67-1	ND	12	2.00		B1E0245	30-May-21	0.250 L	01-Jun-21 19:25	1			
PFNA	375-95-1	ND	11	2.00		B1E0245	30-May-21	0.250 L	01-Jun-21 19:25	1			
PFOS	1763-23-1	ND	15	2.00		B1E0245	30-May-21	0.250 L	01-Jun-21 19:25	1			
Labeled Standards	Type	% Recovery	Limits		Qualifiers	Batch	Extracted	Samp Size	Analyzed	Dilution			
13C2-PFHxA	SURR	99.7	70 - 130			B1E0245	30-May-21	0.250 L	01-Jun-21 19:25	1			
13C2-PFDA	SURR	99.1	70 - 130			B1E0245	30-May-21	0.250 L	01-Jun-21 19:25	1			

RL - Reporting limit

Results reported to RL.

When reported, PFHxS, PFOA, PFOS, MeFOSAA and EtFOSAA include both linear and branched isomers. Only the linear isomer is reported for all other analytes.

Sample ID: LFBD

EPA Method 537.1

Name:	Eastern Analytical, Inc.	Lab Sample:	B1E0245-BS1/B1E0245-BSD1	Date Extracted:	30-May-21
Project:	226586 NH	QC Batch:	B1E0245	Column:	BEH C18
Matrix:	Aqueous	Samp Size:	0.250/0.250 L		

Analyte	CAS Number	LFB (ng/L)	LFB Spike	LFB % Rec	LFB Quals	LFBD (ng/L)	LFBD Spike	LFBD % Rec	LFBD RPD	LFBD Quals	%Rec Limits	RPD Limits	LFB Analyzed	LFB Dil	LFBD Analyzed	LFBD Dil
PFBS	375-73-5	37.0	35.4	104		36.7	35.4	104	0.762		70-130	30	01-Jun-21 19:36	1	01-Jun-21 19:47	1
PFHpA	375-85-9	42.9	40.0	107		43.7	40.0	109	1.77		70-130	30	01-Jun-21 19:36	1	01-Jun-21 19:47	1
PFHxS	355-46-4	39.7	36.4	109		39.8	36.4	109	0.176		70-130	30	01-Jun-21 19:36	1	01-Jun-21 19:47	1
PFOA	335-67-1	43.8	40.0	110		42.1	40.0	105	4.08		70-130	30	01-Jun-21 19:36	1	01-Jun-21 19:47	1
PFNA	375-95-1	43.3	40.0	108		43.3	40.0	108	0.125		70-130	30	01-Jun-21 19:36	1	01-Jun-21 19:47	1
PFOS	1763-23-1	38.8	37.0	105		37.8	37.0	102	2.80		70-130	30	01-Jun-21 19:36	1	01-Jun-21 19:47	1

Labeled Standards	Type	LFB % Rec	LFB Quals	LFBD % Rec	LFBD Quals	Limits	LFB Analyzed	LFB Dil	LFBD Analyzed	LFBD Dil
13C2-PFHxA	SURR	103		102		70 - 130	01-Jun-21 19:36	1	01-Jun-21 19:47	1
13C2-PFDA	SURR	103		103		70 - 130	01-Jun-21 19:36	1	01-Jun-21 19:47	1

Sample ID: TW1-21					EPA Method 537.1					
Client Data					Laboratory Data					
Name:	Eastern Analytical, Inc.		Matrix:	Aqueous	Lab Sample:	2105245-01		Column:	BEH C18	
Project:	226586 NH		Date Collected:	19-May-21 14:45	Date Received:	27-May-21 10:22				
Location:	226586									
Analyte	CAS Number	Conc. (ng/L)	NH MCL	RL	Qualifiers	Batch	Extracted	Samp Size	Analyzed	Dilution
PFBS	375-73-5	ND	-	1.97		B1E0245	30-May-21	0.253 L	01-Jun-21 19:58	1
PFHpA	375-85-9	ND	-	1.97		B1E0245	30-May-21	0.253 L	01-Jun-21 19:58	1
PFHxS	355-46-4	ND	18	1.97		B1E0245	30-May-21	0.253 L	01-Jun-21 19:58	1
PFOA	335-67-1	ND	12	1.97		B1E0245	30-May-21	0.253 L	01-Jun-21 19:58	1
PFNA	375-95-1	ND	11	1.97		B1E0245	30-May-21	0.253 L	01-Jun-21 19:58	1
PFOS	1763-23-1	ND	15	1.97		B1E0245	30-May-21	0.253 L	01-Jun-21 19:58	1
Labeled Standards	Type	% Recovery	Limits		Qualifiers	Batch	Extracted	Samp Size	Analyzed	Dilution
13C2-PFHxA	SURR	103	70 - 130			B1E0245	30-May-21	0.253 L	01-Jun-21 19:58	1
13C2-PFDA	SURR	99.9	70 - 130			B1E0245	30-May-21	0.253 L	01-Jun-21 19:58	1

RL - Reporting limit

Results reported to RL.

When reported, PFHxS, PFOA, PFOS, MeFOSAA and EtFOSAA include both linear and branched isomers. Only the linear isomer is reported for all other analytes.

B	This compound was also detected in the method blank
Conc.	Concentration
CRS	Cleanup Recovery Standard
D	Dilution
DL	Detection Limit
E	The associated compound concentration exceeded the calibration range of the instrument
H	Recovery and/or RPD was outside laboratory acceptance limits
I	Chemical Interference
IS	Internal Standard
J	The amount detected is below the Reporting Limit/LOQ
LOD	Limit of Detection
LOQ	Limit of Quantitation
M	Estimated Maximum Possible Concentration (CA Region 2 projects only)
MDL	Method Detection Limit
NA	Not applicable
ND	Not Detected
OPR	Ongoing Precision and Recovery sample
P	The reported concentration may include contribution from chlorinated diphenyl ether(s).
Q	The ion transition ratio is outside of the acceptance criteria.
RL	Reporting Limit
RL	For 537.1, the reported RLs are the MRLs.
TEQ	Toxic Equivalency, sum of the toxic equivalency factors (TEF) multiplied by the sample concentrations.
TEQMax	TEQ calculation that uses the detection limit as the concentration for non-detects
TEQMin	TEQ calculation that uses zero as the concentration for non-detects
TEQRisk	TEQ calculation that uses ½ the detection limit as the concentration for non-detects
U	Not Detected (specific projects only)
*	See Cover Letter

Unless otherwise noted, solid sample results are reported in dry weight. Tissue samples are reported in wet weight.

Vista Analytical Laboratory Certifications

Accrediting Authority	Certificate Number
Alaska Department of Environmental Conservation	17-013
Arkansas Department of Environmental Quality	21-023-0
California Department of Health – ELAP	2892
DoD ELAP - A2LA Accredited - ISO/IEC 17025:2005	3091.01
Florida Department of Health	E87777-26
Hawaii Department of Health	N/A
Louisiana Department of Environmental Quality	01977
Maine Department of Health	2020018
Massachusetts Department of Environmental Protection	M-CA413
Michigan Department of Environmental Quality	9932
Minnesota Department of Health	1980678
New Hampshire Environmental Accreditation Program	207720
New Jersey Department of Environmental Protection	CA003
New York Department of Health	11411
Ohio Environmental Protection Agency	87778
Oregon Laboratory Accreditation Program	4042-016
Pennsylvania Department of Environmental Protection	017
Texas Commission on Environmental Quality	T104704189-21-12
Vermont Department of Health	VT-4042
Virginia Department of General Services	10769
Washington Department of Ecology	C584
Wisconsin Department of Natural Resources	998036160

Current certificates and lists of licensed parameters are located in the Quality Assurance office and are available upon request.

NELAP Accredited Test Methods

MATRIX: Air	
Description of Test	Method
Determination of Polychlorinated p- Dioxins & Polychlorinated Dibenzofurans	EPA 23
Polychlorinated Dibenzodioxins in Ambient Air by GC/HRMS	EPA TO-9A

MATRIX: Biological Tissue	
Description of Test	Method
Tetra- through Octa-Chlorinated Dioxins and Furans by Isotope Dilution GC/HRMS	EPA 1613B
Brominated Diphenyl Ethers by HRGC/HRMS	EPA 1614A
Chlorinated Biphenyl Congeners in Water, Soil, Sediment, and Tissue by GC/HRMS	EPA 1668A/C
Pesticides in Water, Soil, Sediment, Biosolids, and Tissue by HRGC/HRMS	EPA 1699
Perfluorinated Alkyl Acids in Drinking Water by SPE and LC/MS/MS	EPA 537
Polychlorinated Dibenzo-p-Dioxins and Polychlorinated Dibenzofurans by GC/HRMS	EPA 8280A/B
Polychlorinated Dibenzodioxins (PCDDs) and Polychlorinated Dibenzofurans (PCDFs) by GC/HRMS	EPA 8290/8290A

MATRIX: Drinking Water	
Description of Test	Method
Tetra- through Octa-Chlorinated Dioxins and Furans by Isotope Dilution GC/HRMS	EPA 1613/1613B
Perfluorinated Alkyl Acids in Drinking Water by SPE and LC/MS/MS	EPA 537
Perfluorinated Alkyl Acids in Drinking Water by SPE and LC/MS/MS	EPA 537.1
Determination of Per- and Polyfluoroalkyl Substances in Drinking Water by Isotope Dilution Anion Exchange Solid Phase Extraction and Liquid Chromatography/Tandem Mass Spectrometry	EPA 533
Perfluorooctanesulfonate (PFOS) and Perfluorooctanoate (PFOA) - Method for Unfiltered Samples Using Solid Phase Extraction and Liquid Chromatography/Mass Spectrometry	ISO 25101 2009

MATRIX: Non-Potable Water	
Description of Test	Method
Tetra- through Octa-Chlorinated Dioxins and Furans by Isotope Dilution GC/HRMS	EPA 1613B
Brominated Diphenyl Ethers by HRGC/HRMS	EPA 1614A
Chlorinated Biphenyl Congeners in Water, Soil, Sediment, and Tissue by GC/HRMS	EPA 1668A/C
Pesticides in Water, Soil, Sediment, Biosolids, and Tissue by HRGC/HRMS	EPA 1699
Perfluorinated Alkyl Acids in Drinking Water by SPE and LC/MS/MS	EPA 537
Dioxin by GC/HRMS	EPA 613
Polychlorinated Dibenzo-p-Dioxins and Polychlorinated Dibenzofurans by GC/HRMS	EPA 8280A/B
Polychlorinated Dibenzodioxins (PCDDs) and Polychlorinated Dibenzofurans (PCDFs) by GC/HRMS	EPA 8290/8290A

MATRIX: Solids	
Description of Test	Method
Tetra-Octa Chlorinated Dioxins and Furans by Isotope Dilution GC/HRMS	EPA 1613
Tetra- through Octa-Chlorinated Dioxins and Furans by Isotope Dilution GC/HRMS	EPA 1613B
Brominated Diphenyl Ethers by HRGC/HRMS	EPA 1614A
Chlorinated Biphenyl Congeners in Water, Soil, Sediment, and Tissue by GC/HRMS	EPA 1668A/C
Pesticides in Water, Soil, Sediment, Biosolids, and Tissue by HRGC/HRMS	EPA 1699
Perfluorinated Alkyl Acids in Drinking Water by SPE and LC/MS/MS	EPA 537
Polychlorinated Dibenzo-p-Dioxins and Polychlorinated Dibenzofurans by GC/HRMS	EPA 8280A/B
Polychlorinated Dibenzodioxins (PCDDs) and Polychlorinated Dibenzofurans (PCDFs) by GC/HRMS	EPA 8290/8290A

CHAIN-OF-CUSTODY RECORD



Eastern Analytical, Inc.
professional laboratory and drilling services

EAI ID# **226586**

Page 1

Sample ID	Date Sampled	Matrix	aParameters	Sample Notes
TW1-21	5/19/2021 14:45	aqueous	Subcontract - PFAS EPA Method 537.1 (4 Compounds)	2105245 3.7°C

EAI ID# **226586**

Project State: NH

Project ID:

Company Vista Analytical Laboratory

Address 1104 Windfield Way

Address El Dorado Hills, CA 95762

Account #

Phone # (916) 673-1520

Results Needed: Preferred Date: Standard

RUSH Due Date: _____

QC Deliverables

☒ A ☐ A+ ☐ B ☐ B+ ☐ C ☐ MA MCP

Notes about project:

Email login confirmation, pdf of results and
invoice to customerservice@easternanalytical.com.

**PFAS: PFBS, PFHpA, PFHxS,
PFOA, PFOS, and PFNA**

PO #: 54994

EAI ID# **226586**

Data Deliverable (circle)

Excel NH EMD EQUIS ME EGAD

Call prior to analyzing, if RUSH charges will be applied.

Samples Collected by:

Chen J. Chen 5/24/21 1:50 PM UPS
Relinquished by Date/Time Received by
UPS 05/27/21 10:22 L. J. Hite PL

Relinquished by Date/Time Received by

Eastern Analytical, Inc. 25 Chenell Dr. Concord, NH 03301

Phone: (603) 228-0525

1-800-287-0525

customerservice@easternanalytical.com

As a subcontract lab to EAI, you will defend, indemnify and hold Eastern Analytical, Inc., its officers, employees, and agents harmless from and against any and all liability, loss, expense or claims for injury or damages arising out of the performance against this chain of custody but only in proportion to and to the extent such liability, loss, expense, or claims for injury or damages are caused by or result from the negligent or intentional acts or omissions of you as a subcontract lab, your officers, agents or employees

Work Order 2105245

Page 13 of 15

Page 195 of 234

Sample Log-In Checklist

 Page # 1 of 1

 Vista Work Order #: 2105245

 TAT 14 days

Samples Arrival:	Date/Time 05/27/21 10:22	Initials: Vh	Location: WR-2
			Shelf/Rack: N/A
Delivered By:	FedEx	<u>UPS</u>	On Trac
		GLS	DHL
		Hand Delivered	Other
Preservation:	<u>Ice</u>	Blue Ice	Techni Ice
		Dry Ice	None
Temp °C: 2.8 (uncorrected)	Probe used: Y / <u>N</u>		Thermometer ID: <u>FL-4</u>
Temp °C: 2.7 (corrected)			

	YES	NO	NA
Shipping Container(s) Intact?	☒	☐	☐
Shipping Custody Seals Intact?	☐	☐	☒
Airbill <u> </u> Trk # <u>12 X 46 598 01 9808 9804</u>	☒	☐	☐
Shipping Documentation Present?	☒	☐	☐
Shipping Container <u>Vista</u> Client <u>Retain</u> Return Dispose			
Chain of Custody / Sample Documentation Present?	☒	☐	☐
Chain of Custody / Sample Documentation Complete?	☒	☐	☐
Holding Time Acceptable?	☒	☐	☐
Logged In:	Date/Time 05/27/21 1145	Initials: WWS	Location: R-13, WR-2
			Shelf/Rack: 2-3, E-7
COC Anomaly/Sample Acceptance Form completed?		☐	☒

Comments:

CoC/Label Reconciliation Report WO# 2105245

LabNumber	CoC Sample ID		SampleAlias	Sample Date/Time		Container	BaseMatrix	Sample Comments
2105245-01	A TW1-21	☒ <i>DL</i>	226586	19-May-21 14:45	☒	Polypropylene, 250mL	Aqueous	
2105245-01	B TW1-21	☒ <i>↓</i>	226586	19-May-21 14:45	☒	Polypropylene, 250mL	Aqueous	

Checkmarks indicate that information on the COC reconciled with the sample label.
Any discrepancies are noted in the following columns.

	Yes	No	NA
Sample Container Intact?	☒	☐	☐
Sample Custody Seals Intact?	☐	☐	☒
Adequate Sample Volume?	☒	☐	☐
Container Type Appropriate for Analysis(es)	☒	☐	☐

Comments: *Handwritten on the cap "T2"*

Preservation Documented: Na2S2O3 *Trizma* NH4CH3CO2 None Other

Verified by/Date: *VA 05/27/21*

BOLD FIELDS REQUIRED. PLEASE CIRCLE REQUESTED ANALYSIS.

[illegible]

PROJECT MANAGER: Lauren Thistle
COMPANY: Wright-Pierce
ADDRESS: 250 Commercial St. Suite 4014
CITY: Manchester STATE: NH ZIP: 03101
PHONE: 778-758-3516 EXT.: -
FAX: -
E-MAIL: lauren.thistle@wright-pierce.com
SITE NAME: Lebanon Exploration
PROJECT #: 20604A
STATE: (NH) MA ME VT OTHER: _____
REGULATORY PROGRAM: NPDES: RGP POTW STORMWATER OR
GWP, OIL FUND, BROWNFIELD OR OTHER: _____
QUOTE #: 1018552 PO #: 8339

DATE NEEDED: _____

QA/QC		REPORTING LEVEL	
A	B	C	

OR

MA MCP

REPORTING OPTIONS
PRELIMS: YES or NO

ELECTRONIC OPTIONS
E-MAIL PDE **EQUIS** **EXCEL**

TEMP. 29°
ICE? (YES) No

METALS: 8 RCRA 13 PP (Fe, Mn) Pb, Cu

OTHER METALS: As, V, Ca, Na

SAMPLES FIELD FILTERED? ☒ YES ☐ NO

NOTES: (IE: SPECIAL DETECTION LIMITS, BILLING INFO, IF DIFFERENT)

SAMPLER(S): Lauren Thistle

Home Fri 5-21-21 1:00pm

RELINQUISHED BY: DATE: TIME: RECEIVED BY:

RELINQUISHED BY: FUGS DATE: 5/21/21 TIME: 1300 RECEIVED BY: Chyu

RELINQUISHED BY: _____ DATE: _____ TIME: _____ RECEIVED BY: _____

* per Client - Total Hardness

SUSPECTED CONTAMINATION:

FIELD READINGS:

PA-5(24)21



Eastern Analytical, Inc.
professional laboratory and drilling services

25 CHENELL DRIVE | CONCORD, NH 03301 | TEL: 603.228.0525 | 1.800.287.0525 | E-MAIL: CUSTOMERSERVICE@EASTERNANALYTICAL.COM | WWW.EASTERNANALYTICAL.COM

(WHITE: ORIGINAL GREEN: PROJECT MANAGER)



Eastern Analytical, Inc.

professional laboratory and drilling services

Greg Smith
Wright-Pierce (Manchester)
250 Commercial Street, Suite 4014
Manchester, NH 03101



Laboratory Report for:

Eastern Analytical, Inc. ID: 227747
Client Identification: Lebanon, NH
Date Received: 6/16/2021

Enclosed are the analytical results per the Chain of Custody for sample(s) in the referenced project. All analyses were performed in accordance with our QA/QC Program, NELAP and other applicable state requirements. All quality control criteria was within acceptance criteria unless noted on the report pages. Results are for the exclusive use of the client named on this report and will not be released to a third party without consent.

The following information is contained within this report: Sample Conditions summary, Analytical Results/Data, Quality Control data (if requested) and copies of the Chain of Custody. This report may not be reproduced except in full, without the written approval of the laboratory.

The following standard abbreviations and conventions apply to all EAI reports:

- < : "less than" followed by the reporting limit
- > : "greater than" followed by the reporting limit
- %R : % Recovery

Certifications:

Eastern Analytical, Inc. maintains certification in the following states: Connecticut (PH-0492), Maine (NH005), Massachusetts (M-NH005), New Hampshire/NELAP (1012), Rhode Island (269), Vermont (VT1012), New York (12072), West Virginia (9910C) and Alabama (41620). Please refer to our website at www.easternanalytical.com for a copy of our certificates and accredited parameters.

References:

- EPA 600/4-79-020, 1983
- Standard Methods for Examination of Water and Wastewater, 20th, 21st, 22nd & 23rd edition or noted revision year.
- Test Methods for Evaluating Solid Waste SW 846 3rd Edition including updates IVA and IVB
- Hach Water Analysis Handbook, 4th edition, 1992

If you have any questions regarding the results contained within, please feel free to contact customer service. Unless otherwise requested, we will dispose of the sample(s) 6 weeks from the sample receipt date.

We appreciate this opportunity to be of service and look forward to your continued patronage.

Sincerely,


Lorraine Olashaw, Lab Director

7.12.21
Date

23
of pages (excluding cover letter)



SAMPLE CONDITIONS PAGE

EAI ID#: 227747

Client: **Wright-Pierce (Manchester)**

Client Designation: **Lebanon, NH**

Temperature upon receipt (°C): **4.7**

Received on ice or cold packs (Yes/No): **Y**

Acceptable temperature range (°C): 0-6

Lab ID	Sample ID	Date Received	Date/Time Sampled	Sample Matrix	% Dry Weight	Exceptions/Comments (other than thermal preservation)
227747.01	TW 6-21	6/16/21	6/16/21 10:00	aqueous		Adheres to Sample Acceptance Policy
227747.02	TW 2-21	6/16/21	6/16/21 11:00	aqueous		Adheres to Sample Acceptance Policy
227747.03	Trip Blank	6/16/21	6/16/21 00:00	aqueous		Adheres to Sample Acceptance Policy

All results contained in this report relate only to the above listed samples.

Unless otherwise noted:

- Hold times, preservation, container types, and sample conditions adhered to EPA Protocol.
- Solid samples are reported on a dry weight basis, unless otherwise noted. pH/Corrosivity, Flashpoint, Ignitability, Paint Filter, Conductivity and Specific Gravity are always reported on an "as received" basis.
- Analysis of pH, Total Residual Chlorine, Dissolved Oxygen and Sulfite were performed at the laboratory outside of the recommended 15 minute hold time.
- Samples collected by Eastern Analytical, Inc. (EAI) were collected in accordance with approved EPA procedures.



LABORATORY REPORT

EAI ID#: 227747

Client: **Wright-Pierce (Manchester)**

Client Designation: **Lebanon, NH**

Sample ID:	TW 6-21	TW 2-21	Trip Blank
Lab Sample ID:	227747.01	227747.02	227747.03
Matrix:	aqueous	aqueous	aqueous
Date Sampled:	6/16/21	6/16/21	6/16/21
Date Received:	6/16/21	6/16/21	6/16/21
Units:	ug/L	ug/L	ug/L
Date of Analysis:	6/17/21	6/17/21	6/17/21
Analyst:	AM	AM	AM
Method:	524.2	524.2	524.2
Dilution Factor:	1	1	1
Dichlorodifluoromethane	< 0.5	< 0.5	< 0.5
Chloromethane	< 0.5	< 0.5	< 0.5
Vinyl chloride	< 0.5	< 0.5	< 0.5
Bromomethane	< 0.5	< 0.5	< 0.5
Chloroethane	< 0.5	< 0.5	< 0.5
Trichlorofluoromethane	< 0.5	< 0.5	< 0.5
Diethyl Ether	< 5	< 5	< 5
Acetone	< 10	< 10	< 10
1,1-Dichloroethene	< 0.5	< 0.5	< 0.5
tert-Butyl Alcohol (TBA)	< 30	< 30	< 30
Methylene chloride	< 0.5	< 0.5	< 0.5
Carbon disulfide	< 2	< 2	< 2
Methyl-t-butyl ether(MTBE)	< 0.5	< 0.5	< 0.5
Ethyl-t-butyl ether(ETBE)	< 0.5	< 0.5	< 0.5
Isopropyl ether(DIPE)	< 0.5	< 0.5	< 0.5
tert-amyl methyl ether(TAME)	< 0.5	< 0.5	< 0.5
trans-1,2-Dichloroethene	< 0.5	< 0.5	< 0.5
1,1-Dichloroethane	< 0.5	< 0.5	< 0.5
2,2-Dichloropropane	< 0.5	< 0.5	< 0.5
cis-1,2-Dichloroethene	< 0.5	< 0.5	< 0.5
2-Butanone(MEK)	< 5	< 5	< 5
Bromochloromethane	< 0.5	< 0.5	< 0.5
Tetrahydrofuran(THF)	< 5	< 5	< 5
Chloroform	< 0.5	< 0.5	< 0.5
1,1,1-Trichloroethane	< 0.5	< 0.5	< 0.5
Carbon tetrachloride	< 0.5	< 0.5	< 0.5
1,1-Dichloropropene	< 0.5	< 0.5	< 0.5
Benzene	< 0.5	< 0.5	< 0.5
1,2-Dichloroethane	< 0.5	< 0.5	< 0.5
Trichloroethene	< 0.5	< 0.5	< 0.5
1,2-Dichloropropane	< 0.5	< 0.5	< 0.5
Dibromomethane	< 0.5	< 0.5	< 0.5
Bromodichloromethane	< 0.5	< 0.5	< 0.5
4-Methyl-2-pentanone(MIBK)	< 5	< 5	< 5
cis-1,3-Dichloropropene	< 0.3	< 0.3	< 0.3
Toluene	< 0.5	< 0.5	< 0.5
trans-1,3-Dichloropropene	< 0.3	< 0.3	< 0.3
1,1,2-Trichloroethane	< 0.5	< 0.5	< 0.5
2-Hexanone	< 5	< 5	< 5
Tetrachloroethene	< 0.5	< 0.5	< 0.5
1,3-Dichloropropane	< 0.5	< 0.5	< 0.5
Dibromochloromethane	< 0.5	< 0.5	< 0.5
1,2-Dibromoethane(EDB)	< 0.5	< 0.5	< 0.5
Chlorobenzene	< 0.5	< 0.5	< 0.5
1,1,1,2-Tetrachloroethane	< 0.5	< 0.5	< 0.5
Ethylbenzene	< 0.5	< 0.5	< 0.5



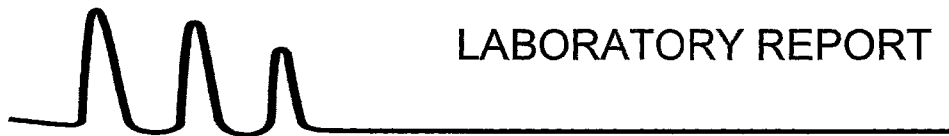
LABORATORY REPORT

EAI ID#: 227747

Client: **Wright-Pierce (Manchester)**

Client Designation: **Lebanon, NH**

Sample ID:	TW 6-21	TW 2-21	Trip Blank
Lab Sample ID:	227747.01	227747.02	227747.03
Matrix:	aqueous	aqueous	aqueous
Date Sampled:	6/16/21	6/16/21	6/16/21
Date Received:	6/16/21	6/16/21	6/16/21
Units:	ug/L	ug/L	ug/L
Date of Analysis:	6/17/21	6/17/21	6/17/21
Analyst:	AM	AM	AM
Method:	524.2	524.2	524.2
Dilution Factor:	1	1	1
mp-Xylene	< 0.5	< 0.5	< 0.5
o-Xylene	< 0.5	< 0.5	< 0.5
Styrene	< 0.5	< 0.5	< 0.5
Bromoform	< 0.5	< 0.5	< 0.5
IsoPropylbenzene	< 0.5	< 0.5	< 0.5
Bromobenzene	< 0.5	< 0.5	< 0.5
1,1,2,2-Tetrachloroethane	< 0.5	< 0.5	< 0.5
1,2,3-Trichloropropane	< 0.5	< 0.5	< 0.5
n-Propylbenzene	< 0.5	< 0.5	< 0.5
2-Chlorotoluene	< 0.5	< 0.5	< 0.5
4-Chlorotoluene	< 0.5	< 0.5	< 0.5
1,3,5-Trimethylbenzene	< 0.5	< 0.5	< 0.5
tert-Butylbenzene	< 0.5	< 0.5	< 0.5
1,2,4-Trimethylbenzene	< 0.5	< 0.5	< 0.5
sec-Butylbenzene	< 0.5	< 0.5	< 0.5
1,3-Dichlorobenzene	< 0.5	< 0.5	< 0.5
p-Isopropyltoluene	< 0.5	< 0.5	< 0.5
1,4-Dichlorobenzene	< 0.5	< 0.5	< 0.5
1,2-Dichlorobenzene	< 0.5	< 0.5	< 0.5
n-Butylbenzene	< 0.5	< 0.5	< 0.5
1,2-Dibromo-3-chloropropane	< 0.5	< 0.5	< 0.5
1,3,5-Trichlorobenzene	< 0.5	< 0.5	< 0.5
1,2,4-Trichlorobenzene	< 0.5	< 0.5	< 0.5
Hexachlorobutadiene	< 0.5	< 0.5	< 0.5
Naphthalene	< 0.5	< 0.5	< 0.5
1,2,3-Trichlorobenzene	< 0.5	< 0.5	< 0.5
4-Bromofluorobenzene (surr)	97 %R	98 %R	98 %R
1,2-Dichlorobenzene-d4 (surr)	113 %R	112 %R	112 %R



LABORATORY REPORT

EAI ID#: 227747

Client: **Wright-Pierce (Manchester)**

Client Designation: **Lebanon, NH**

Sample ID: TW 6-21 TW 2-21

Lab Sample ID: 227747.01 227747.02

Matrix: aqueous aqueous

Date Sampled: 6/16/21 6/16/21

Date Received: 6/16/21 6/16/21

Solids Dissolved 860 630

Sulfate 51 41

Chloride 360 230

Nitrite-N < 0.5 < 0.5

Nitrate-N < 0.5 < 0.5

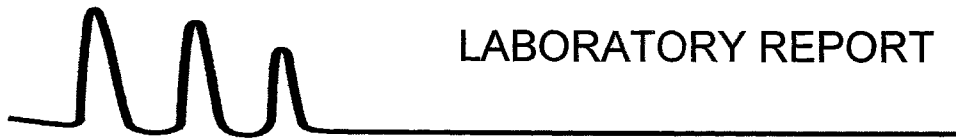
Alkalinity Total (CaCO₃) 180 210

TOC 0.58 < 0.5

pH 7.43 7.61

Specific Conductance 1500 1200

Analysis				
Units	Date	Time	Method	Analyst
mg/L	6/17/21	14:50	2540C-11	KJD
mg/L	6/16/21	20:37	300.0	ATA
mg/L	6/17/21	17:29	4500CIE-11	ATA
mg/L	6/17/21	15:28	353.2	ATA
mg/L	6/17/21	15:28	353.2	ATA
mg/L	6/18/21	11:25	2320B-11	RB
mg/L	6/23/21	12:12	5310C-00	LO
SU	6/16/21	16:24	4500H+B-11	AMB
uS/cm	6/22/21	11:15	2510B-97	RB



LABORATORY REPORT

EAI ID#: 227747

Client: Wright-Pierce (Manchester)

Client Designation: Lebanon, NH

Sample ID:	TW 6-21	TW 2-21				
Lab Sample ID:	227747.01	227747.02				
Matrix:	aqueous	aqueous				
Date Sampled:	6/16/21	6/16/21	Analytical Matrix	Units	Date of Analysis	Method Analyst
Date Received:	6/16/21	6/16/21				
Arsenic	0.0012	0.0056	AqDis	mg/L	6/17/21	200.8 DS
Calcium	150	98	AqDis	mg/L	6/17/21	200.8 DS
Iron	0.33	0.52	AqDis	mg/L	6/17/21	200.8 DS
Manganese	3.2	0.27	AqDis	mg/L	6/17/21	200.8 DS
Sodium	110	110	AqDis	mg/L	6/17/21	200.8 DS
Uranium	2.3	5.8	AqDis	ug/L	6/17/21	200.8 DS



July 07, 2021

Vista Work Order No. 2106134

Ms. Jennifer Laramie
Eastern Analytical, Inc.
25 Chennell Drive
Concord, NH 03301

Dear Ms. Laramie,

Enclosed are the results for the sample set received at Vista Analytical Laboratory on June 18, 2021 under your Project Name '227747 NH'.

Vista Analytical Laboratory is committed to serving you effectively. If you require additional information, please contact me at 916-673-1520 or by email at mmaier@vista-analytical.com.

Thank you for choosing Vista as part of your analytical support team.

Sincerely,

 for

Martha Maier
Laboratory Director



Vista Analytical Laboratory certifies that the report herein meets all the requirements set forth by NELAP for those applicable test methods. Results relate only to the samples as received by the laboratory. This report should not be reproduced except in full without the written approval of Vista.

Vista Work Order No. 2106134**Case Narrative****Sample Condition on Receipt:**

Two aqueous samples were received and stored securely in accordance with Vista standard operating procedures and EPA methodology. The samples were received in good condition and within the method temperature requirements. The samples were collected in 125-mL containers and were not preserved with Trizma. As directed, the samples were preserved with Trizma in the laboratory at the time of extraction. The collection date for sample "TW 6-21" has been reported as it was listed on the Chain of Custody.

Analytical Notes:**EPA Method 537.1**

The samples were extracted and analyzed for a selected list of PFAS using EPA Method 537.1.

Holding Times

The samples were extracted and analyzed within the method hold times.

Quality Control

The Initial Calibration and Continuing Calibration Verifications met the method acceptance criteria.

Two Laboratory Fortified Blanks (LFB/LFBD) and a Laboratory Reagent Blank (LRB) were extracted and analyzed with the preparation batch. No analytes were detected in the LRB above the method required limits. The LFB/LFBD recoveries were within the method acceptance criteria.

The surrogate recoveries for all QC and field samples were within the acceptance criteria.

TABLE OF CONTENTS

Case Narrative.....	1
Table of Contents.....	3
Sample Inventory.....	4
Analytical Results.....	5
Qualifiers.....	10
Certifications.....	11
Sample Receipt.....	14

Sample Inventory Report

Vista Sample ID	Client Sample ID	Sampled	Received	Components/Containers
2106134-01	TW 6-21	16-Jun-21 10:00	18-Jun-21 09:37	HDPE Bottle, 125 mL HDPE Bottle, 125 mL
2106134-02	TW 2-21	16-Jun-21 11:00	18-Jun-21 09:37	HDPE Bottle, 125 mL HDPE Bottle, 125 mL

ANALYTICAL RESULTS

Sample ID: LRB					EPA Method 537.1					
Client Data					Laboratory Data					
Name: Eastern Analytical, Inc.		Matrix: Aqueous		Lab Sample: B1F0147-BLK1		Column: BEH C18				
Project: 227747 NH										
Analyte	CAS Number	Conc. (ng/L)	NH MCL	RL	Qualifiers	Batch	Extracted	Samp Size	Analyzed	Dilution
PFBS	375-73-5	ND	-	2.00		B1F0147	27-Jun-21	0.250 L	29-Jun-21 20:47	1
PFHpA	375-85-9	ND	-	2.00		B1F0147	27-Jun-21	0.250 L	29-Jun-21 20:47	1
PFHxS	355-46-4	ND	18	2.00		B1F0147	27-Jun-21	0.250 L	29-Jun-21 20:47	1
PFOA	335-67-1	ND	12	2.00		B1F0147	27-Jun-21	0.250 L	29-Jun-21 20:47	1
PFNA	375-95-1	ND	11	2.00		B1F0147	27-Jun-21	0.250 L	29-Jun-21 20:47	1
PFOS	1763-23-1	ND	15	2.00		B1F0147	27-Jun-21	0.250 L	29-Jun-21 20:47	1
Labeled Standards	Type	% Recovery	Limits		Qualifiers	Batch	Extracted	Samp Size	Analyzed	Dilution
13C2-PFHxA	SURR	94.8	70 - 130			B1F0147	27-Jun-21	0.250 L	29-Jun-21 20:47	1
13C2-PFDA	SURR	98.8	70 - 130			B1F0147	27-Jun-21	0.250 L	29-Jun-21 20:47	1

RL - Reporting limit

Results reported to RL.

When reported, PFHxS, PFOA, PFOS, MeFOSAA and EtFOSAA include both linear and branched isomers. Only the linear isomer is reported for all other analytes.

Sample ID: LFBD
EPA Method 537.1

Name:	Eastern Analytical, Inc.	Lab Sample:	B1F0147-BS1/B1F0147-BSD1	Date Extracted:	27-Jun-21
Project:	227747 NH	QC Batch:	B1F0147	Column:	BEH C18
Matrix:	Aqueous	Samp Size:	0.250/0.250 L		

Analyte	CAS Number	LFB (ng/L)	LFB Spike	LFB % Rec	LFB Quals	LFBD (ng/L)	LFBD Spike	LFBD % Rec	RPD	LFBD Quals	%Rec Limits	RPD Limits	LFB Analyzed	LFB Dil	LFBD Analyzed	LFBD Dil
PFBS	375-73-5	33.7	35.4	95.3		29.2	35.4	82.6	14.3		70-130	30	29-Jun-21 20:58	1	29-Jun-21 21:09	1
PFHpA	375-85-9	37.8	40.0	94.5		34.6	40.0	86.6	8.73		70-130	30	29-Jun-21 20:58	1	29-Jun-21 21:09	1
PFHxS	355-46-4	33.7	36.4	92.6		31.8	36.4	87.5	5.72		70-130	30	29-Jun-21 20:58	1	29-Jun-21 21:09	1
PFOA	335-67-1	36.0	40.0	89.9		33.6	40.0	83.9	6.89		70-130	30	29-Jun-21 20:58	1	29-Jun-21 21:09	1
PFNA	375-95-1	35.7	40.0	89.4		32.5	40.0	81.2	9.59		70-130	30	29-Jun-21 20:58	1	29-Jun-21 21:09	1
PFOS	1763-23-1	33.3	37.0	90.0		31.0	37.0	83.7	7.22		70-130	30	29-Jun-21 20:58	1	29-Jun-21 21:09	1
Labeled Standards		Type		LFB % Rec	LFB Quals			LFBD % Rec		LFBD Quals	Limits		LFB Analyzed	LFB Dil	LFBD Analyzed	LFBD Dil
13C2-PFHxA		SURR		97.1				89.5			70 - 130		29-Jun-21 20:58	1	29-Jun-21 21:09	1
13C2-PFDA		SURR		94.4				93.8			70 - 130		29-Jun-21 20:58	1	29-Jun-21 21:09	1

Sample ID: TW 6-21

EPA Method 537.1

Client Data					Laboratory Data					
Name:	Eastern Analytical, Inc.		Matrix:	Aqueous	Lab Sample:	2106134-01		Column:	BEH C18	
Project:	227747 NH		Date Collected:	16-Jun-21 10:00	Date Received:	18-Jun-21 09:37				
Location:	227747									
Analyte	CAS Number	Conc. (ng/L)	NH MCL	RL	Qualifiers	Batch	Extracted	Samp Size	Analyzed	Dilution
PFBS	375-73-5	ND	-	4.33		B1F0147	27-Jun-21	0.116 L	29-Jun-21 21:20	1
PFHpA	375-85-9	ND	-	4.33		B1F0147	27-Jun-21	0.116 L	29-Jun-21 21:20	1
PFHxS	355-46-4	32.9	18	4.33		B1F0147	27-Jun-21	0.116 L	29-Jun-21 21:20	1
PFOA	335-67-1	ND	12	4.33		B1F0147	27-Jun-21	0.116 L	29-Jun-21 21:20	1
PFNA	375-95-1	ND	11	4.33		B1F0147	27-Jun-21	0.116 L	29-Jun-21 21:20	1
PFOS	1763-23-1	ND	15	4.33		B1F0147	27-Jun-21	0.116 L	29-Jun-21 21:20	1
Labeled Standards	Type	% Recovery	Limits		Qualifiers	Batch	Extracted	Samp Size	Analyzed	Dilution
13C2-PFHxA	SURR	99.7	70 - 130			B1F0147	27-Jun-21	0.116 L	29-Jun-21 21:20	1
13C2-PFDA	SURR	94.9	70 - 130			B1F0147	27-Jun-21	0.116 L	29-Jun-21 21:20	1

RL - Reporting limit

Results reported to RL.

When reported, PFHxS, PFOA, PFOS, MeFOSAA and EtFOSAA include both linear and branched isomers. Only the linear isomer is reported for all other analytes.

Sample ID: TW 2-21					EPA Method 537.1					
Client Data					Laboratory Data					
Name:	Eastern Analytical, Inc.		Matrix:	Aqueous	Lab Sample:	2106134-02		Column:	BEH C18	
Project:	227747 NH		Date Collected:	16-Jun-21 11:00	Date Received:	18-Jun-21 09:37				
Location:	227747									
Analyte	CAS Number	Conc. (ng/L)	NH MCL	RL	Qualifiers	Batch	Extracted	Samp Size	Analyzed	Dilution
PFBS	375-73-5	ND	-	4.31		B1F0147	27-Jun-21	0.116 L	29-Jun-21 21:31	1
PFHpA	375-85-9	ND	-	4.31		B1F0147	27-Jun-21	0.116 L	29-Jun-21 21:31	1
PFHxS	355-46-4	ND	18	4.31		B1F0147	27-Jun-21	0.116 L	29-Jun-21 21:31	1
PFOA	335-67-1	ND	12	4.31		B1F0147	27-Jun-21	0.116 L	29-Jun-21 21:31	1
PFNA	375-95-1	ND	11	4.31		B1F0147	27-Jun-21	0.116 L	29-Jun-21 21:31	1
PFOS	1763-23-1	ND	15	4.31		B1F0147	27-Jun-21	0.116 L	29-Jun-21 21:31	1
Labeled Standards	Type	% Recovery	Limits	Qualifiers	Batch	Extracted	Samp Size	Analyzed	Dilution	
13C2-PFHxA	SURR	110	70 - 130		B1F0147	27-Jun-21	0.116 L	29-Jun-21 21:31	1	
13C2-PFDA	SURR	97.7	70 - 130		B1F0147	27-Jun-21	0.116 L	29-Jun-21 21:31	1	

RL - Reporting limit

Results reported to RL.

When reported, PFHxS, PFOA, PFOS, MeFOSAA and EtFOSAA include both linear and branched isomers. Only the linear isomer is reported for all other analytes.

B	This compound was also detected in the method blank
Conc.	Concentration
CRS	Cleanup Recovery Standard
D	Dilution
DL	Detection Limit
E	The associated compound concentration exceeded the calibration range of the instrument
H	Recovery and/or RPD was outside laboratory acceptance limits
I	Chemical Interference
IS	Internal Standard
J	The amount detected is below the Reporting Limit/LOQ
LOD	Limit of Detection
LOQ	Limit of Quantitation
M	Estimated Maximum Possible Concentration (CA Region 2 projects only)
MDL	Method Detection Limit
NA	Not applicable
ND	Not Detected
OPR	Ongoing Precision and Recovery sample
P	The reported concentration may include contribution from chlorinated diphenyl ether(s).
Q	The ion transition ratio is outside of the acceptance criteria.
RL	Reporting Limit
RL	For 537.1, the reported RLs are the MRLs.
TEQ	Toxic Equivalency, sum of the toxic equivalency factors (TEF) multiplied by the sample concentrations.
TEQMax	TEQ calculation that uses the detection limit as the concentration for non-detects
TEQMin	TEQ calculation that uses zero as the concentration for non-detects
TEQRisk	TEQ calculation that uses ½ the detection limit as the concentration for non-detects
U	Not Detected (specific projects only)
*	See Cover Letter

Unless otherwise noted, solid sample results are reported in dry weight. Tissue samples are reported in wet weight.

Vista Analytical Laboratory Certifications

Accrediting Authority	Certificate Number
Alaska Department of Environmental Conservation	17-013
Arkansas Department of Environmental Quality	21-023-0
California Department of Health – ELAP	2892
DoD ELAP - A2LA Accredited - ISO/IEC 17025:2005	3091.01
Florida Department of Health	E87777-26
Hawaii Department of Health	N/A
Louisiana Department of Environmental Quality	01977
Maine Department of Health	2020018
Massachusetts Department of Environmental Protection	M-CA413
Michigan Department of Environmental Quality	9932
Minnesota Department of Health	1980678
New Hampshire Environmental Accreditation Program	207720
New Jersey Department of Environmental Protection	CA003
New York Department of Health	11411
Ohio Environmental Protection Agency	87778
Oregon Laboratory Accreditation Program	4042-016
Pennsylvania Department of Environmental Protection	017
Texas Commission on Environmental Quality	T104704189-21-12
Vermont Department of Health	VT-4042
Virginia Department of General Services	10769
Washington Department of Ecology	C584
Wisconsin Department of Natural Resources	998036160

Current certificates and lists of licensed parameters are located in the Quality Assurance office and are available upon request.

NELAP Accredited Test Methods

MATRIX: Air	
Description of Test	Method
Determination of Polychlorinated p- Dioxins & Polychlorinated Dibenzofurans	EPA 23
Polychlorinated Dibenzodioxins in Ambient Air by GC/HRMS	EPA TO-9A

MATRIX: Biological Tissue	
Description of Test	Method
Tetra- through Octa-Chlorinated Dioxins and Furans by Isotope Dilution GC/HRMS	EPA 1613B
Brominated Diphenyl Ethers by HRGC/HRMS	EPA 1614A
Chlorinated Biphenyl Congeners in Water, Soil, Sediment, and Tissue by GC/HRMS	EPA 1668A/C
Pesticides in Water, Soil, Sediment, Biosolids, and Tissue by HRGC/HRMS	EPA 1699
Perfluorinated Alkyl Acids in Drinking Water by SPE and LC/MS/MS	EPA 537
Polychlorinated Dibenzo-p-Dioxins and Polychlorinated Dibenzofurans by GC/HRMS	EPA 8280A/B
Polychlorinated Dibenzodioxins (PCDDs) and Polychlorinated Dibenzofurans (PCDFs) by GC/HRMS	EPA 8290/8290A

MATRIX: Drinking Water	
Description of Test	Method
Tetra- through Octa-Chlorinated Dioxins and Furans by Isotope Dilution GC/HRMS	EPA 1613/1613B
Perfluorinated Alkyl Acids in Drinking Water by SPE and LC/MS/MS	EPA 537
Perfluorinated Alkyl Acids in Drinking Water by SPE and LC/MS/MS	EPA 537.1
Determination of Per- and Polyfluoroalkyl Substances in Drinking Water by Isotope Dilution Anion Exchange Solid Phase Extraction and Liquid Chromatography/Tandem Mass Spectrometry	EPA 533
Perfluorooctanesulfonate (PFOS) and Perfluorooctanoate (PFOA) - Method for Unfiltered Samples Using Solid Phase Extraction and Liquid Chromatography/Mass Spectrometry	ISO 25101 2009

MATRIX: Non-Potable Water	
Description of Test	Method
Tetra- through Octa-Chlorinated Dioxins and Furans by Isotope Dilution GC/HRMS	EPA 1613B
Brominated Diphenyl Ethers by HRGC/HRMS	EPA 1614A
Chlorinated Biphenyl Congeners in Water, Soil, Sediment, and Tissue by GC/HRMS	EPA 1668A/C
Pesticides in Water, Soil, Sediment, Biosolids, and Tissue by HRGC/HRMS	EPA 1699
Perfluorinated Alkyl Acids in Drinking Water by SPE and LC/MS/MS	EPA 537
Dioxin by GC/HRMS	EPA 613
Polychlorinated Dibenzo-p-Dioxins and Polychlorinated Dibenzofurans by GC/HRMS	EPA 8280A/B
Polychlorinated Dibenzodioxins (PCDDs) and Polychlorinated Dibenzofurans (PCDFs) by GC/HRMS	EPA 8290/8290A

MATRIX: Solids	
Description of Test	Method
Tetra-Octa Chlorinated Dioxins and Furans by Isotope Dilution GC/HRMS	EPA 1613
Tetra- through Octa-Chlorinated Dioxins and Furans by Isotope Dilution GC/HRMS	EPA 1613B
Brominated Diphenyl Ethers by HRGC/HRMS	EPA 1614A
Chlorinated Biphenyl Congeners in Water, Soil, Sediment, and Tissue by GC/HRMS	EPA 1668A/C
Pesticides in Water, Soil, Sediment, Biosolids, and Tissue by HRGC/HRMS	EPA 1699
Perfluorinated Alkyl Acids in Drinking Water by SPE and LC/MS/MS	EPA 537
Polychlorinated Dibenzo-p-Dioxins and Polychlorinated Dibenzofurans by GC/HRMS	EPA 8280A/B
Polychlorinated Dibenzodioxins (PCDDs) and Polychlorinated Dibenzofurans (PCDFs) by GC/HRMS	EPA 8290/8290A

CHAIN-OF-CUSTODY RECORD

EAI ID# **227747**

Page 1

Sample ID	Date Sampled	Matrix	aParameters	Sample Notes
TW 6-21	6/16/2021 10:00	aqueous	Subcontract - PFAS EPA Method 537.1 (4 Compounds) 6 (5)	2166134 3.8°C
TW 2-21	6/16/2021 11:00	aqueous	Subcontract - PFAS EPA Method 537.1 (4 Compounds) 6 (2)	

EAI ID# **227747**

Project State: NH

Project ID:

Company Vista Analytical Laboratory

Address 1104 Windfield Way

Address El Dorado Hills, CA 95762

Account #

Phone # (916) 673-1520

Results Needed: Preferred Date: Standard

RUSH Due Date: _____

QC Deliverables

☒ A ☐ A+ ☐ B ☐ B+ ☐ C ☐ MA MCP

Notes about project:

Email login confirmation, pdf of results and invoice to customerservice@easternanalytical.com.

PFAS: PFBS, PFHpA, PFHxS, PFOA, PFOS, and PFNA

PO #:55140

EAI ID# **227747**

Data Deliverable (circle)

Excel NH EMD EQUIS ME EGAD

Call prior to analyzing, if RUSH charges will be applied.

Samples Collected by:

Relinquished by	Date/Time	Received by
UPS	6/17/21 1630 UPS	Sam. H. V.
Relinquished by	Date/Time	Received by
	6/18/21 0937	

Eastern Analytical, Inc. 25 Chenell Dr. Concord, NH 03301

Phone: (603)228-0525

1-800-287-0525

customerservice@easternanalytical.com

As a subcontract lab to EAI, you will defend, indemnify and hold Eastern Analytical, Inc., its officers, employees, and agents harmless from and against any and all liability, loss, expense or claims for injury or damages arising out of the performance against this chain of custody but only in proportion to and to the extent such liability, loss, expense, or claims for injury or damages are caused by or result from the negligent or intentional acts or omissions of you as a subcontract lab, your officers, agents or employees

Work Order 2106134

Sample Log-In Checklist

 Page # 1 of 1

 Vista Work Order #: 2106134 TAT 14 days

Samples Arrival:	Date/Time <u>06/18/21 0937</u>		Initials: <u>SH</u>		Location: <u>WR-2</u>		
	Shelf/Rack: <u>NA</u>						
Delivered By:	FedEx	<u>UPS</u>	On Trac	GLS	DHL	Hand Delivered	Other
Preservation:	<u>Ice</u>		Blue Ice		Techni Ice	Dry Ice	None
Temp °C: <u>3.9</u> (uncorrected)	Probe used: Y / <u>N</u>		Thermometer ID: <u>IR-3</u>				
Temp °C: <u>3.8</u> (corrected)							

	YES	NO	NA		
Shipping Container(s) Intact?	☒	☐	☐		
Shipping Custody Seals Intact?	☒	☐	☐		
Airbill <u> </u> Trk # <u>1Z X46 599 01 9338 9930</u>	☒	☐	☐		
Shipping Documentation Present?	☒	☐	☐		
Shipping Container	Vista	<u>Client</u>	Retain	<u>Return</u>	Dispose
Chain of Custody / Sample Documentation Present?	☒	☐	☐	☐	☐
Chain of Custody / Sample Documentation Complete?	☒	☐	☐	☐	☐
Holding Time Acceptable?	☒	☐	☐	☐	☐

Logged In:	Date/Time <u>06/18/21 1624</u>		Initials: <u>SH</u>		Location: <u>R-15 WR-2</u>	
	Shelf/Rack: <u>A-4 F-5</u>					
COC Anomaly/Sample Acceptance Form completed?						☒

Comments:

CoC/Label Reconciliation Report WO# 2106134

21

LabNumber	CoC Sample ID	SampleAlias	Sample Date/Time	Container	BaseMatrix	Sample Comments
2106134-01	A TW 6-21	227747	16-Jun-21 10:00	HDPE Bottle, 125 mL	Aqueous	
2106134-01	B TW 6-21	227747	16-Jun-21 10:00	HDPE Bottle, 125 mL	Aqueous	
2106134-02	A TW 2-21	227747	16-Jun-21 11:00	HDPE Bottle, 125 mL	Aqueous	
2106134-02	B TW 2-21	227747	16-Jun-21 11:00	HDPE Bottle, 125 mL	Aqueous	

Checkmarks indicate that information on the COC reconciled with the sample label.
Any discrepancies are noted in the following columns.

	Yes	No	NA
Sample Container Intact?	✓		
Sample Custody Seals Intact?		✓	✓
Adequate Sample Volume?		✓	
Container Type Appropriate for Analysis(es)	✓		

Preservation Documented: Na2S2O3 Trizma NH4CH3CO2

None
A/C

Other

Verified by/Date: 06/22/21 *

Comments:

* originally labeled and reconciled on 06/18/21

A: Collection date listed as 06/10/21; No collection time present reconciled by Sample ID

B: No collection time or date on sample label reconciled by sample ID.

C: No Vista Trizma label present



ANOMALY FORM

Vista Work Order 2106134

Initial/Date The following checked issues were noted during sample receipt and login:

- 06/23/21 ☐ 1. The samples were received out of temperature at (WI-PHT): _____
Was Ice present: Yes No Melted Blue Ice
- 06/23/21 ☐ 2. The Chain-of-Custody (CoC) was not relinquished properly.
- 06/23/21 ☐ 3. The CoC did not include collection time(s). 00:00 will be used unless notified otherwise.
- 06/23/21 ☐ 4. The sample(s) did not include a sample collection time. All or Sample Name: _____
- 06/23/21 ☐ 5. A sample ID discrepancy was found. See the Reconciliation report.
The CoC Sample ID will be used unless notified otherwise.
- 06/23/21 ☒ 6. A sample date and/or time discrepancy was found. See the Reconciliation report.
The CoC Sample date/time will be used unless notified otherwise.
- 06/23/21 ☐ 7. The CoC did not include a sample matrix. The following sample matrix will be used: _____
- 06/23/21 ☒ 8. Insufficient volume received for analysis. All or Sample Name: _____
- 06/23/21 ☐ 9. The backup bottle was received broken. Sample Name: _____
- 06/23/21 ☐ 10. CoC not received, illegible or destroyed.
- 06/23/21 ☐ 11. The sample(s) were received out of holding time. All or Sample Name: _____
- 06/23/21 ☐ 12. The CoC did not include an analysis. All or Sample Name: _____
- 06/23/21 ☐ 13. Sample(s) received without collection date. All or Sample Name: _____
- 06/23/21 ☐ 14. Sample(s) not received. All or Sample Name: _____
- 06/23/21 ☐ 15. Sample(s) received broken. All or Sample Name: _____
- 06/23/21 ☐ 16. An incorrect container-type was used. All or Sample Name: _____
- 06/23/21 ☒ 17. Other:

No documentation of TriZma present on CoC and sample label.

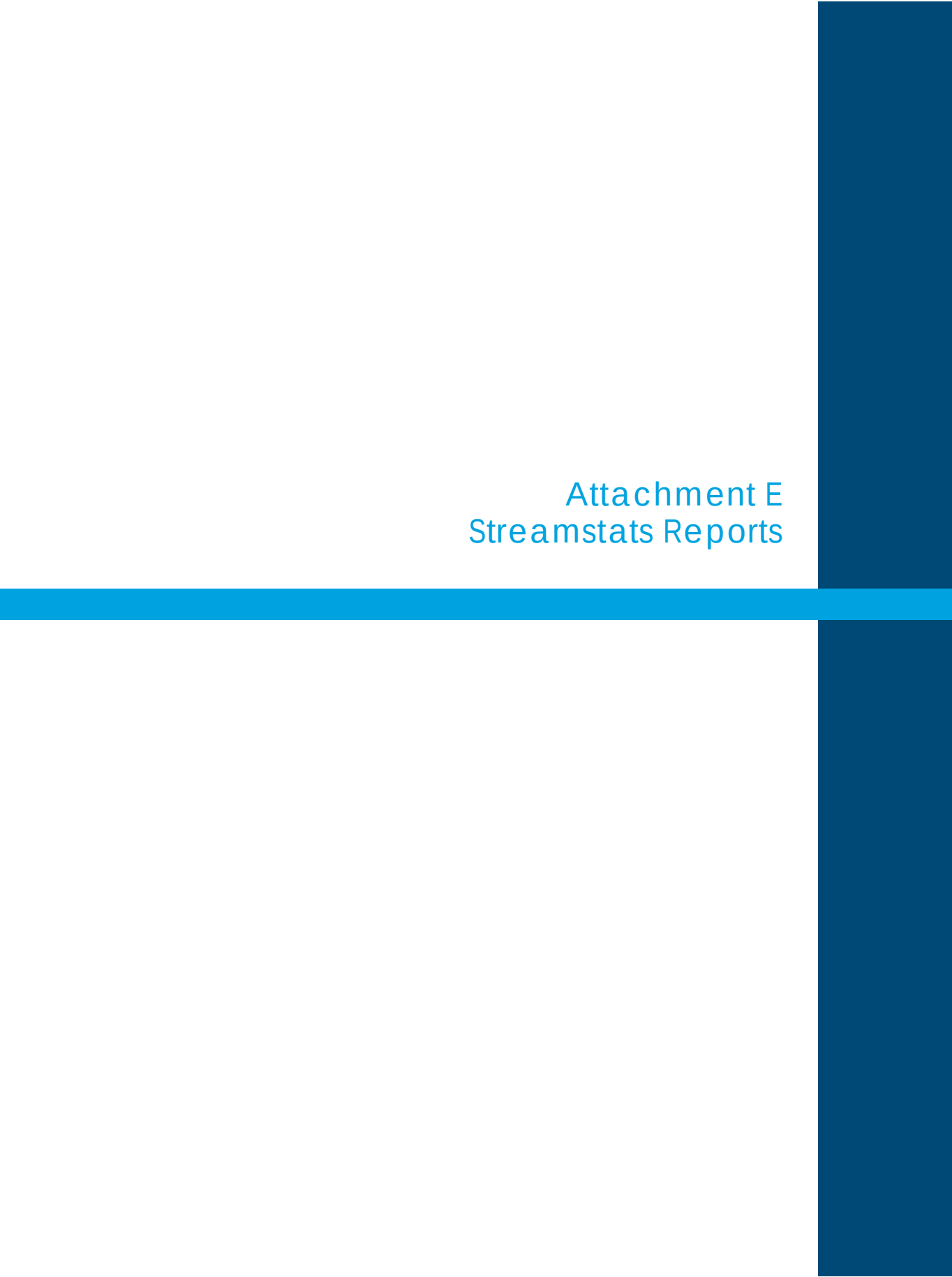
Bolded items require sign-off

Client Contacted: Jenn Laramie

Date of Contact: 06/21/21

Vista Client Manager: KJR

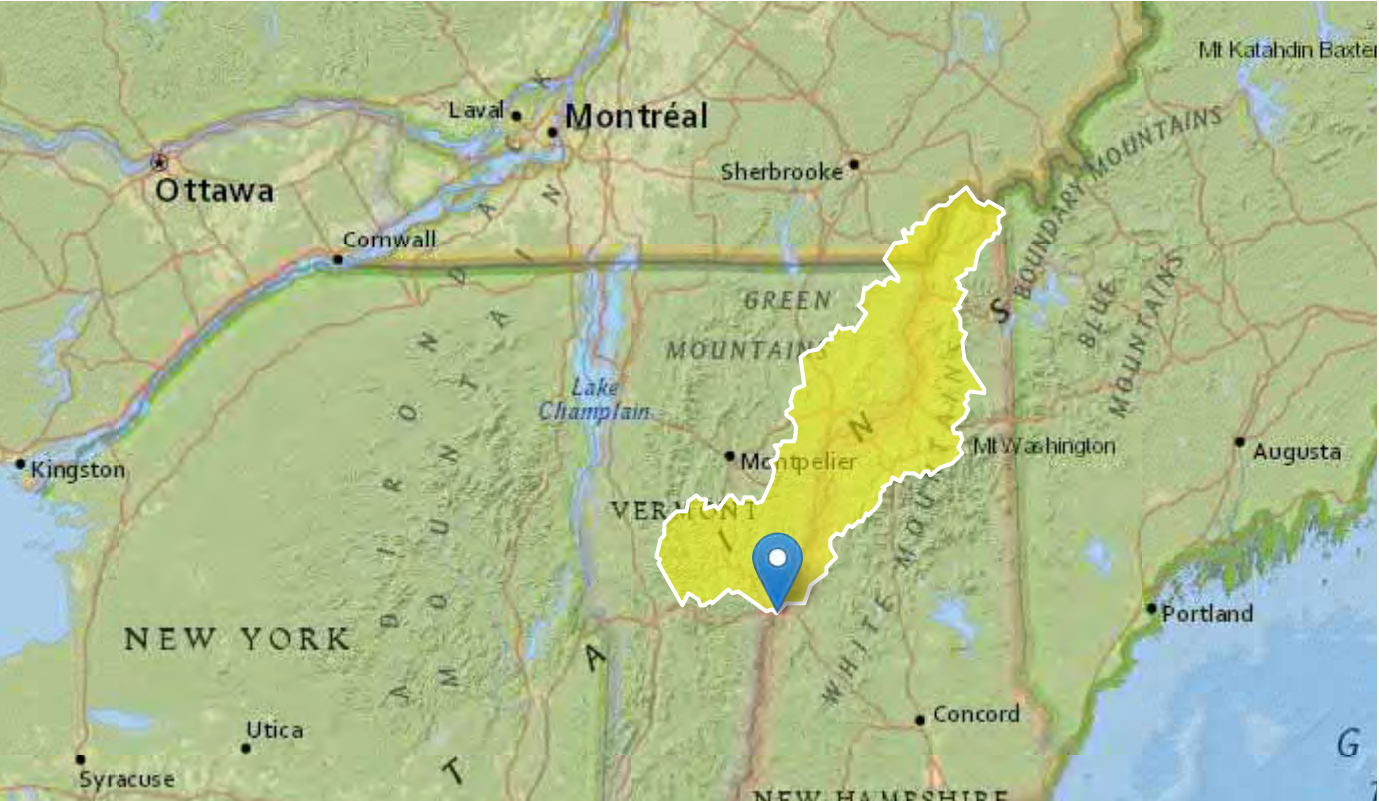
Resolution: client consented to adding TriZma preservation to samples in the lab and to proceed despite the volume provided.



Attachment E Streamstats Reports

StreamStats Report - Connecticut River - Lebanon, New Hampshire

Region ID: NH
Workspace ID: NH20210630154655727000
Clicked Point (Latitude, Longitude): 43.63671, -72.32600
Time: 2021-06-30 11:47:16 -0400



Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
PRECIPOUT	Mean annual precip at the stream outlet (based on annual PRISM precip data in inches from 1971-2000)	36.3	inches
TEMP	Mean Annual Temperature	39.67	degrees F
MINTEMP_W	Mean winter minimum air temperature over basin surface area	7.423	degrees F
CONIF	Percentage of land surface covered by coniferous forest	16.1005	percent

Parameter Code	Parameter Description	Value	Unit
PREG_03_05	Mean precipitation at gaging station location for March 16 to May 31 spring period	7.5	inches
SNOFALL	Mean Annual Snowfall	10.823	inches
PREG_06_10	Mean precipitation at gaging station location for June to October summer period	16.4	inches
MIXFOR	Percentage of land area covered by mixed deciduous and coniferous forest	30.4946	percent
PREBC_1112	Mean annual precipitation of basin centroid for November 1 to December 31 period	6.57	inches
PRECIPCENT	Mean Annual Precip at Basin Centroid	37.1	inches
DRNAREA	Area that drains to a point on a stream	4091.35	square miles
PREBC0103	Mean annual precipitation of basin centroid for January 1 to March 15 winter period	6.14	inches
BSLDEM30M	Mean basin slope computed from 30 m DEM	15.831	percent
TEMP_06_10	Basinwide average temperature for June to October summer period	57.777	degrees F
ELEVMAX	Maximum basin elevation	6283.808	feet
APRAVPRE	Mean April Precipitation	3.203	inches
WETLAND	Percentage of Wetlands	3.1856	percent
CSL10_85	Change in elevation divided by length between points 10 and 85 percent of distance along main channel to basin divide - main channel method not known	2.93	feet per mi

General Disclaimers

The delineation point is in an exclusion area. WARNING! The Connecticut River is regulated. The regression equations are not applicable to this location

Recharge Statistics Parameters [100.0 Percent (4090 square miles) Groundwater Recharge Statewide 2004 5019]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
PRECIPOUT	Mean Annual Precip at Gage	36.3	inches	35.83	53.11
TEMP	Mean Annual Temperature	39.67	degrees F	36.05	48.69
MINTEMP_W	Mean Winter Min Temperature	7.423	degrees F	0.8	19.88
CONIF	Percent Coniferous Forest	16.1005	percent	3.07	56.18
PREG_03_05	Mar to May Gage Precipitation	7.5	inches	6.83	11.54
SNOFALL	Mean Annual Snowfall	10.823	inches	54.46	219.07
PREG_06_10	Jun to Oct Gage Precipitation	16.4	inches	16.46	23.11
MIXFOR	Percent Mixed Forest	30.4946	percent	6.21	46.13
PREBC_1112	Nov to Dec Basin Centroid Precip	6.57	inches	6.57	15.2
PRECIPCENT	Mean Annual Precip at Basin Centroid	37.1	inches	37.44	75.91

Recharge Statistics Disclaimers [100.0 Percent (4090 square miles) Groundwater Recharge Statewide 2004 5019]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors

Recharge Statistics Flow Report [100.0 Percent (4090 square miles) Groundwater Recharge Statewide 2004 5019]

Statistic	Value	Unit
GW_Recharge_Jan_to_Mar15	2.91	in
GW_Recharge_Mar16_to_May	3.84	in
GW_Recharge_Jun_to_Oct	3.09	in
GW_Recharge_Nov_to_Dec	2.88	in
GW_Recharge_Ann	17.1	in

Recharge Statistics Citations

Flynn, R.H. and Tasker, G.D., 2004, Generalized Estimates from Streamflow Data of Annual and Seasonal Ground-Water-Recharge Rates for Drainage Basins in New Hampshire, U.S. Geological Survey Scientific Investigations Report 2004-5019, 67 p.
[\(http://pubs.usgs.gov/sir/2004/5019/http://pubs.usgs.gov/sir/2004/5019/\)](http://pubs.usgs.gov/sir/2004/5019/http://pubs.usgs.gov/sir/2004/5019/)

Seasonal Flow Statistics Parameters [100.0 Percent (4090 square miles) Low Flow Statewide]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	4091.35	square miles	3.26	689
CONIF	Percent Coniferous Forest	16.1005	percent	3.07	56.2
PREBC0103	Jan to Mar Basin Centroid Precip	6.14	inches	5.79	15.1
BSLDEM30M	Mean Basin Slope from 30m DEM	15.831	percent	3.19	38.1
MIXFOR	Percent Mixed Forest	30.4946	percent	6.21	46.1
PREG_03_05	Mar to May Gage Precipitation	7.5	inches	6.83	11.5
TEMP	Mean Annual Temperature	39.67	degrees F	36	48.7
TEMP_06_10	Jun to Oct Mean Basinwide Temp	57.777	degrees F	52.9	64.4
PREG_06_10	Jun to Oct Gage Precipitation	16.4	inches	16.5	23.1
ELEVMAX	Maximum Basin Elevation	6283.808	feet	260	6290

Seasonal Flow Statistics Disclaimers [100.0 Percent (4090 square miles) Low Flow Statewide]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors

Seasonal Flow Statistics Flow Report [100.0 Percent (4090 square miles) Low Flow Statewide]

Statistic	Value	Unit
Jan to Mar15 60 Percent Flow	3270	ft ³ /s
Jan to Mar15 70 Percent Flow	2880	ft ³ /s
Jan to Mar15 80 Percent Flow	2330	ft ³ /s
Jan to Mar15 90 Percent Flow	1920	ft ³ /s
Jan to Mar15 95 Percent Flow	1530	ft ³ /s
Jan to Mar15 98 Percent Flow	1170	ft ³ /s
Jan to Mar15 7 Day 2 Year Low Flow	2400	ft ³ /s
Jan to Mar15 7 Day 10 Year Low Flow	1590	ft ³ /s
Mar16 to May 60 Percent Flow	10900	ft ³ /s

Statistic	Value	Unit
Mar16 to May 70 Percent Flow	8630	ft ³ /s
Mar16 to May 80 Percent Flow	6450	ft ³ /s
Mar16 to May 90 Percent Flow	4380	ft ³ /s
Mar16 to May 95 Percent Flow	3160	ft ³ /s
Mar16 to May 98 Percent Flow	2320	ft ³ /s
Mar16 to May 7 Day 2 Year Low Flow	3160	ft ³ /s
Mar16 to May 7 Day 10 Year Low Flow	1910	ft ³ /s
Jun to Oct 60 Percent Flow	2580	ft ³ /s
Jun to Oct 70 Percent Flow	2230	ft ³ /s
Jun to Oct 80 Percent Flow	1780	ft ³ /s
Jun to Oct 90 Percent Flow	1510	ft ³ /s
Jun to Oct 95 Percent Flow	1420	ft ³ /s
Jun to Oct 98 Percent Flow	1160	ft ³ /s
Jun to Oct 7 Day 2 Year Low Flow	1380	ft ³ /s
Jun to Oct 7 Day 10 Year Low Flow	1410	ft ³ /s
Nov to Dec 60 Percent Flow	3830	ft ³ /s
Nov to Dec 70 Percent Flow	3370	ft ³ /s
Nov to Dec 80 Percent Flow	2870	ft ³ /s
Nov to Dec 90 Percent Flow	2350	ft ³ /s
Nov to Dec 95 Percent Flow	2210	ft ³ /s
Nov to Dec 98 Percent Flow	2130	ft ³ /s
Oct to Nov 7 Day 2 Year Low Flow	2920	ft ³ /s
Oct to Nov 7 Day 10 Year Low Flow	2020	ft ³ /s

Seasonal Flow Statistics Citations

Flynn, R.H. and Tasker, G.D.,2002, Development of Regression Equations to Estimate Flow Durations and Low-Flow-Frequency Statistics in New Hampshire Streams: U.S.Geological Survey Scientific Investigations Report 02-4298, 66 p. (<http://pubs.water.usgs.gov/wrir02-4298>)

Flow-Duration Statistics Parameters [100.0 Percent (4090 square miles) Low Flow Statewide]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	4091.35	square miles	3.26	689
PREG_06_10	Jun to Oct Gage Precipitation	16.4	inches	16.5	23.1
TEMP	Mean Annual Temperature	39.67	degrees F	36	48.7

Flow-Duration Statistics Disclaimers [100.0 Percent (4090 square miles) Low Flow Statewide]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors

Flow-Duration Statistics Flow Report [100.0 Percent (4090 square miles) Low Flow Statewide]

Statistic	Value	Unit
60 Percent Duration	3050	ft ³ /s
70 Percent Duration	2520	ft ³ /s
80 Percent Duration	2230	ft ³ /s
90 Percent Duration	1940	ft ³ /s
95 Percent Duration	1780	ft ³ /s
98 Percent Duration	1670	ft ³ /s

Flow-Duration Statistics Citations

Flynn, R.H. and Tasker, G.D., 2002, Development of Regression Equations to Estimate Flow Durations and Low-Flow-Frequency Statistics in New Hampshire Streams: U.S. Geological Survey Scientific Investigations Report 02-4298, 66 p. (<http://pubs.water.usgs.gov/wrir02-4298>)

Low-Flow Statistics Parameters [100.0 Percent (4090 square miles) Low Flow Statewide]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	4091.35	square miles	3.26	689
TEMP	Mean Annual Temperature	39.67	degrees F	36	48.7

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
PREG_06_10	Jun to Oct Gage Precipitation	16.4	inches	16.5	23.1

Low-Flow Statistics Disclaimers [100.0 Percent (4090 square miles) Low Flow Statewide]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors

Low-Flow Statistics Flow Report [100.0 Percent (4090 square miles) Low Flow Statewide]

Statistic	Value	Unit
7 Day 2 Year Low Flow	1700	ft ³ /s
7 Day 10 Year Low Flow	1890	ft ³ /s

Low-Flow Statistics Citations

Flynn, R.H. and Tasker, G.D.,2002, Development of Regression Equations to Estimate Flow Durations and Low-Flow-Frequency Statistics in New Hampshire Streams: U.S.Geological Survey Scientific Investigations Report 02-4298, 66 p. (<http://pubs.water.usgs.gov/wrir02-4298>)

Peak-Flow Statistics Parameters [100.0 Percent (4090 square miles) Peak Flow Statewide SIR2008 5206]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	4091.35	square miles	0.7	1290
APRAVPRE	Mean April Precipitation	3.203	inches	2.79	6.23
WETLAND	Percent Wetlands	3.1856	percent	0	21.8
CSL10_85	Stream Slope 10 and 85 Method	2.93	feet per mi	5.43	543

Peak-Flow Statistics Disclaimers [100.0 Percent (4090 square miles) Peak Flow Statewide SIR2008 5206]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors

Peak-Flow Statistics Flow Report [100.0 Percent (4090 square miles) Peak Flow Statewide SIR2008 5206]

Statistic	Value	Unit
50-percent AEP flood	44800	ft ³ /s
20-percent AEP flood	57500	ft ³ /s
10-percent AEP flood	67300	ft ³ /s
4-percent AEP flood	79000	ft ³ /s
2-percent AEP flood	88200	ft ³ /s
1-percent AEP flood	99300	ft ³ /s
0.2-percent AEP flood	124000	ft ³ /s

Peak-Flow Statistics Citations

Olson, S.A., 2009, Estimation of flood discharges at selected recurrence intervals for streams in New Hampshire: U.S. Geological Survey Scientific Investigations Report 2008-5206, 57 p. (<http://pubs.usgs.gov/sir/2008/5206/>)

USGS Data Disclaimer: Unless otherwise stated, all data, metadata and related materials are considered to satisfy the quality standards relative to the purpose for which the data were collected. Although these data and associated metadata have been reviewed for accuracy and completeness and approved for release by the U.S. Geological Survey (USGS), no warranty expressed or implied is made regarding the display or utility of the data for other purposes, nor on all computer systems, nor shall the act of distribution constitute any such warranty.

USGS Software Disclaimer: This software has been approved for release by the U.S. Geological Survey (USGS). Although the software has been subjected to rigorous review, the USGS reserves the right to update the software as needed pursuant to further analysis and review. No warranty, expressed or implied, is made by the USGS or the U.S. Government as to the functionality of the software and related material nor shall the fact of release constitute any such warranty. Furthermore, the software is released on condition that neither the USGS nor the U.S. Government shall be held liable for any damages resulting from its authorized or unauthorized use.

USGS Product Names Disclaimer: Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

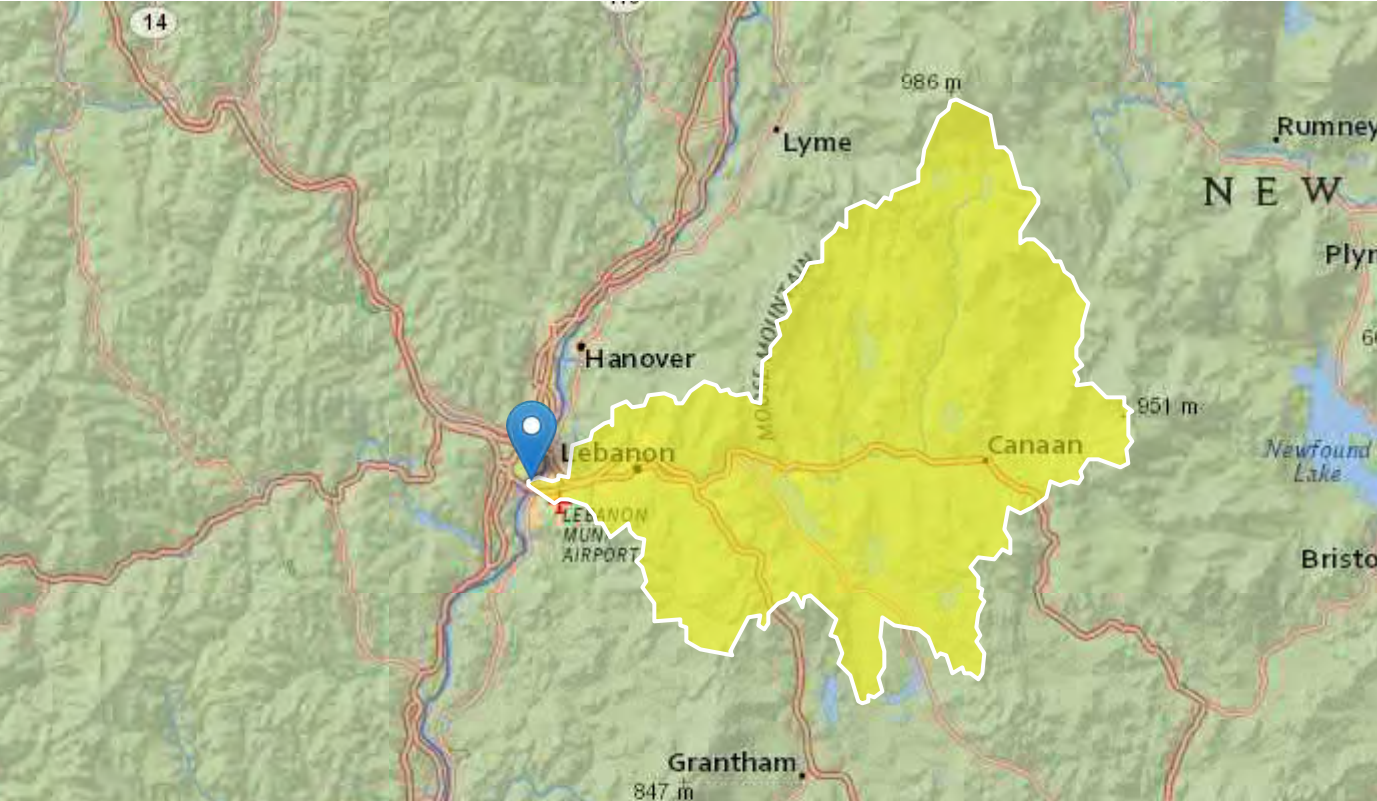
Application Version: 4.5.3

StreamStats Services Version: 1.2.22

NSS Services Version: 2.1.2

StreamStats Report - Mascoma River - Lebanon, New Hampshire

Region ID: NH
Workspace ID: NH20210630154118547000
Clicked Point (Latitude, Longitude): 43.63570, -72.32506
Time: 2021-06-30 11:41:36 -0400



Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
APRAVPRE	Mean April Precipitation	3.329	inches
BSLDEM30M	Mean basin slope computed from 30 m DEM	12.386	percent
CENTROIDX	Basin centroid horizontal (x) location in state plane coordinates	871920.8	meters
CENTROIDY	Basin centroid vertical (y) location in state plane units	424302.8	meters
CONIF	Percentage of land surface covered by coniferous forest	23.2895	percent

Parameter Code	Parameter Description	Value	Unit
CSL10_85	Change in elevation divided by length between points 10 and 85 percent of distance along main channel to basin divide - main channel method not known	26.2	feet per mi
DRNAREA	Area that drains to a point on a stream	194.7	square miles
ELEVMAX	Maximum basin elevation	3217.65	feet
LC11DEV	Percentage of developed (urban) land from NLCD 2011 classes 21-24	5.64	percent
LC11IMP	Average percentage of impervious area determined from NLCD 2011 impervious dataset	1.62	percent
MINTEMP_W	Mean winter minimum air temperature over basin surface area	11.23	degrees F
MIXFOR	Percentage of land area covered by mixed deciduous and coniferous forest	25.8158	percent
OUTLETX	Basin outlet horizontal (x) location in state plane coordinates	809955	feet
OUTLETY	Basin outlet vertical (y) location in state plane coordinates	414615	feet
PREBC0103	Mean annual precipitation of basin centroid for January 1 to March 15 winter period	6.42	inches
PREBC_1112	Mean annual precipitation of basin centroid for November 1 to December 31 period	6.89	inches
PRECIPCENT	Mean Annual Precip at Basin Centroid	38.9	inches
PRECIPOUT	Mean annual precip at the stream outlet (based on annual PRISM precip data in inches from 1971-2000)	36.1	inches
PREG_03_05	Mean precipitation at gaging station location for March 16 to May 31 spring period	7.4	inches
PREG_06_10	Mean precipitation at gaging station location for June to October summer period	16.3	inches
SNOFALL	Mean Annual Snowfall	80.916	inches
TEMP	Mean Annual Temperature	43.236	degrees F
TEMP_06_10	Basinwide average temperature for June to October summer period	59.579	degrees F
WETLAND	Percentage of Wetlands	6.6897	percent

General Disclaimers

The delineation point is in an exclusion area. WARNING! This river is regulated. The regression equations may not apply.

USGS Data Disclaimer: Unless otherwise stated, all data, metadata and related materials are considered to satisfy the quality standards relative to the purpose for which the data were collected. Although these data and associated metadata have been reviewed for accuracy and completeness and approved for release by the U.S. Geological Survey (USGS), no warranty expressed or implied is made regarding the display or utility of the data for other purposes, nor on all computer systems, nor shall the act of distribution constitute any such warranty.

USGS Software Disclaimer: This software has been approved for release by the U.S. Geological Survey (USGS). Although the software has been subjected to rigorous review, the USGS reserves the right to update the software as needed pursuant to further analysis and review. No warranty, expressed or implied, is made by the USGS or the U.S. Government as to the functionality of the software and related material nor shall the fact of release constitute any such warranty. Furthermore, the software is released on condition that neither the USGS nor the U.S. Government shall be held liable for any damages resulting from its authorized or unauthorized use.

USGS Product Names Disclaimer: Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

Application Version: 4.5.3

StreamStats Services Version: 1.2.22

NSS Services Version: 2.1.2