Effingham, NH: Culvert Assessment for Aquatic Habitat Connectivity and Flood Vulnerability

NR 775 Senior Project – Fall 2006
University of New Hampshire - Department of Natural Resources
Durham, New Hampshire

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Abstract

We, Mary Dellenbaugh, Kirsten Nelson, Brett Newman, Logan Reese, and Anthony Jackson, completed a culvert analysis for the town of Effingham for our Natural Resources Senior Project. We first identified, georeferenced, mapped and photographed all culverts on main roads within the town boundaries of Effingham, New Hampshire in the fall of 2006. We then downloaded this information to ArcView 3.3 and delineated the area draining to each culvert. This was performed so that we could estimate and predict discharge rates, flood stage elevation, and capacity of the culverts and bridges to handle a 25-year event. While we were in the field, we also used a Nature Conservancy methodology to assess impacts of bridges and culverts to fish and wildlife movement and aquatic habitat fragmentation. After analyzing this data, we prioritized the culverts on a relative 3-point scale (Good, Moderate, Bad) by which culverts can be compared individually for flood stage vulnerability and wildlife impacts. We then made our recommendation to the Effingham Conservation Commission on which culverts should be examined for further remediation.

Introduction

River systems and their riparian zones play key roles in the regulation and maintenance of biodiversity in the landscapes. As the most important natural corridors through the landscape, they have a fundamental role in the movement of organisms and dead matter (Forman and Godron 1986). The expansion of human populations and activities has resulted in extensive damming, regulation, and diversion of the world's rivers on a large scale and even more significant impacts to small-scale water bodies and riparian zones. Damming and stream diversions have greatly changed the conditions for riparian and aquatic organisms in standing as well as flowing waters in three major ways: the habitats for organisms adapted to natural discharge and water-level regimes become impoverished (Petts 1984, Bain et al. 1988, Baxter and Glaude 1980), the ability of each river to serve as a corridor is reduced (Petts et al. 1989, Malanson 1993), and the function of the riparian zone as a filter between upland and aquatic systems is greatly modified (Ward and Stanford 1993).

Natural riparian zones are also effective pathways for plant dispersal; the rivers carry large numbers of plant diaspores over long distances, and riparian zones are rich in water-dispersed plants (Johansson et al. 1996). In free-flowing rivers, floating diaspores are rapidly transported far downstream, effectively dispersing the species. This dispersal is hypothesized to homogenize the floristic composition among riverbank sites, colonizing the riverbank with species from a large portion of the river valley (Jansson et al. 2000). However, the prevention of long distance dispersal by dams and culverts for plants and animals localizes and fragments populations, perhaps eventually altering natural selection by cutting off effective gene flow.

The geographic distributions of organisms show patterns of abundance that are dependent on abiotic and biotic factors. Today, there are many intervening areas that consist of physically unsuitable habitat for organisms, e.g., water surrounding terrestrial islands or fragmented riparian zones due to human development. In other natural communities without intervening areas that contain suitable habitat, gaps in the distribution of the organisms still occur due to negative biotic interactions, such as competition and predation (Brown 1984, Jeffries and Lawton 1984). Therefore it is essential to maintain natural communities without fragmentation to limit abiotic factors of disturbance. Small stream fish sometimes show multimodal types of distributions, with high densities in the tributaries of a river but rarity in the river itself. Fraser et al. (1995) determined that prey distribution is dependent on piscivore (predator) distribution. The presence of piscivores in the third-order stream reduced prey densities both by killing the prey and inducing the prey to ascend cascades to enter the tributaries (Fraser et al. 1995). This dispersal by fish communities can be stressed by the onset of tributaries being blocked or diverted from their natural course, creating situations where prey cannot disperse, and ultimately be decimated by a predator population.

The fragmentation due to dams and culverts could have smaller impacts on the plant and animal community. Monitoring of this information requires ecological and environmental evaluations conducted before and after the building of the culvert, a practice that is not yet common. Many culverts in New England were put in place long before humans were aware of the devastating impacts of such structures. These situations can be amended, however.

Millions of culverts, dikes, water diversions, dams, and other artificial barriers were constructed to impound and redirect water for irrigation, flood control, electricity, drinking water, and transportation, all of which have the potential to change the natural features of rivers and streams. Culverts that funnel water beneath roads and train tracks often pose insurmountable barriers to fish that migrate between feeding and spawning areas and make other seasonal movements to important habitats. As a result, some populations of native fish are extinct and others are on the brink of disappearing (US FWS 2006).

In 1999, the U.S. Fish and Wildlife Service initiated the National Fish Passage Program to work with towns and conservation commissions to address this problem. The National Fish Passage Program uses a voluntary, non-regulatory approach to remove and bypass barriers. The Program addresses the problem of fish barriers on a national level, working with local communities and partner agencies to restore natural flows and fish migration (US FWS 2006). After more than two centuries of building dams and other barriers on rivers and streams, many towns are starting to become concerned about their effects on fish and other aquatic species.

One such town is Effingham, New Hampshire. In the fall of 2006, the Effingham Conservation Commission asked a UNH Natural Resources senior project team consisting of Mary Dellenbaugh, Anthony Jackson, Kirsten Nelson, Brett Newman, and Logan Reese, to assess the effects of culverts in Effingham on wildlife migration, aquatic habitat continuity, and flood vulnerability.

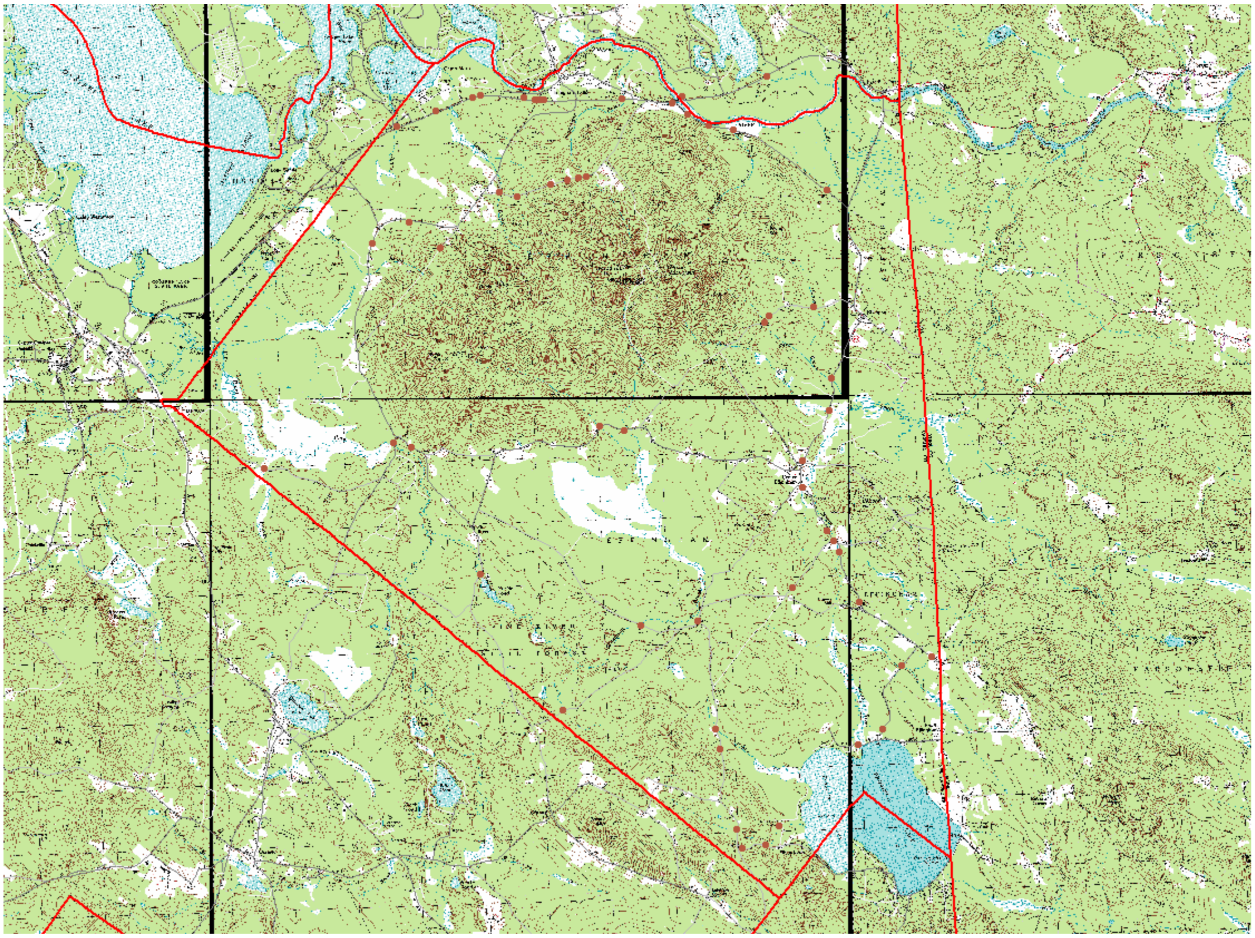
Our team geolocated, photographed, and documented the condition of all culverts on major roads. We then assessed the impact of the culverts and bridges on wildlife by scoring each culvert based on its primary attributes. We used this data again with topography and soils information to predict which culverts would be at risk for flood damage. This portion of the project quantified the amount of potential surface water runoff from select watersheds of Effingham. The major watersheds are the Ossipee, the Pine, and the South Rivers and are delineated on the project topographic map of Effingham. The culverts we selected for remediation encompass sections of these major watersheds.

Materials and Methods

Data collection

Before collecting culvert data in Effingham, NH, we located approximately thirty likely locations for culverts by overlapping the town's hydrology information with road information using ArcView 3.3. This map served as a reference for where we should focus our data collection and served as a guide for which culverts we would try to locate.

Figure 1. Topographic map of Effingham, NH showing roads as gray lines and assessed culverts as dark red dots.



In groups of two, we located culverts using the map we had created and visual assessment (Figure 1). Each culvert was assigned an arbitrary number, often based on either the road or the closest telephone pole number, and the point was entered into a Garmin12XL GPS device. At each culvert, we used a Road-Stream Crossing Inventory datasheet from the Department of Fisheries, Wildlife and Environmental Law Enforcement in Massachusetts (Appendix 2). We also measured the height, width, and length of each culvert with a distance tape.

Aquatic Connectivity

Once all culvert points were recorded, we downloaded the GPS points saved in the Garmin 12XL to a computer and uploaded them to ArcView 3.3. We then quantified this data using a scoring rubric (Appendix 3). We assigned a binary value (0 or 1) for attributes that were present or absent, such as curbs, and a graduated scale for attributes with variable characteristics, such as inlet drop. This scoring rubric was designed so that lower numbered scores reflected lower impact to the stream, and vice versa.

Figure 2. Team member Kirsten Nelson assesses a culvert.

Flood Vulnerability

Based on our visual assessment of culverts in the course of our fieldwork, we selected several culverts for further numerical analysis. We used this information in conjunction with inferences about likely flood-vulnerable areas in the town of Effingham to choose culverts for further analysis.

We chose these culverts because of topographic indicators such as steep slopes and wetlands, perceived watershed funneling, and existing stress conditions such as scour pools, excessive debris, and perched outlets.

In the field, we measured the culvert dimensions and used them to calculate area, velocity and flow capacity. Since slope was not measured, we used a typical culvert slope of 3% for all the calculations. We then used the USDA Agricultural Handbook number 590 to calculate watershed peak discharge for an approximate 25-year rain event. We determined the approximate 25-year rain event from daily precipitation data at Hubbard Brook Research Station, just west of Effingham, which dates back to 1978. We determined watershed by visually measuring acreage using a scaled grid with a USGS topographic map.

Results and Discussion

Aquatic Connectivity

The results from our scoring rubric showed that out of 54 total culverts, 15 were in good condition in relation to habitat and riparian corridors. To receive a "good" denotation, the culvert had to score less than or equal to 19. The 31 moderate culverts, each of which had a score between 20 and 29, comprise the largest proportion of those that we measured. The last 8 culverts that received scores of 29 and greater had significant impacts on aquatic connectivity (Figure 2). The lowest score possible was 7, for a 2 lane unpaved road with a bridge and no barriers present. The highest score possible is 56, for a 2 lane paved road with a multiple culvert and every barrier present in the highest degree possible.

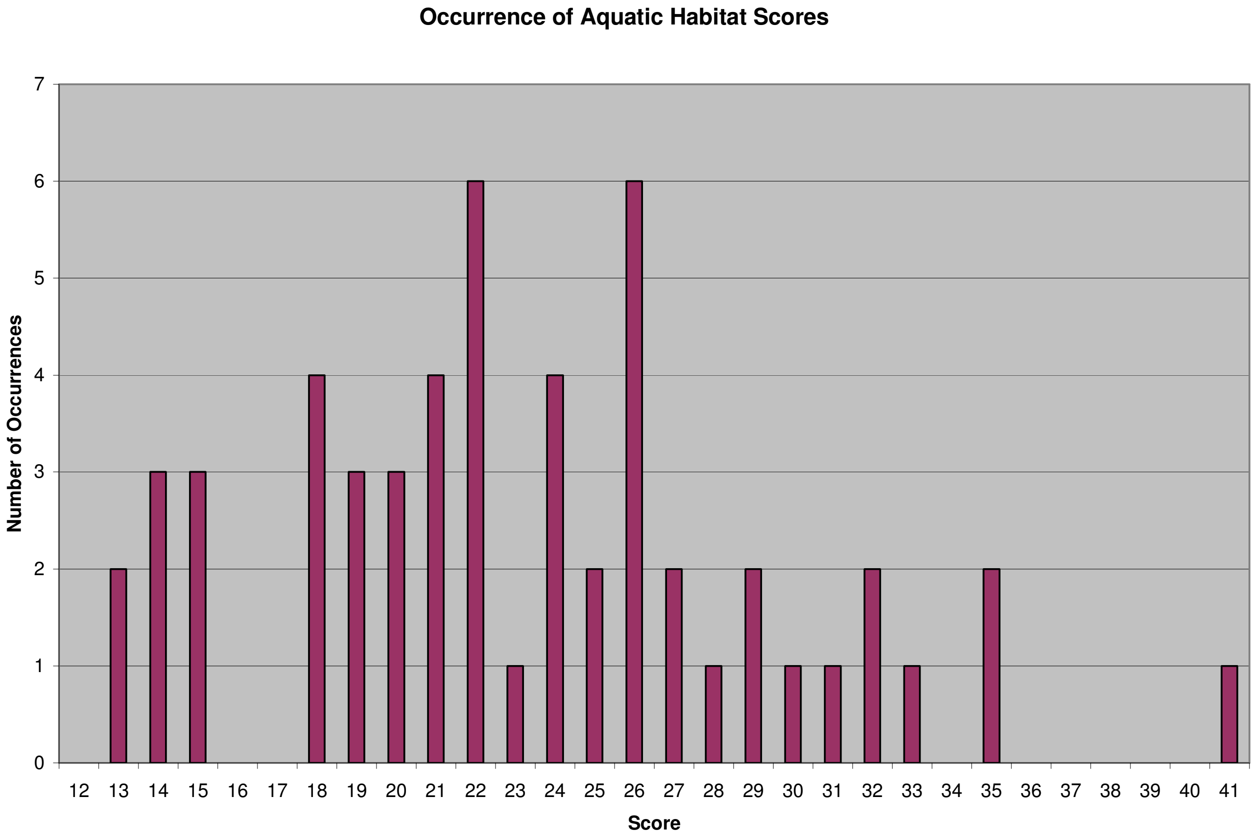


Figure 3. Graph of the occurrence of aquatic habitat scores.

Culverts 116, 129, 127, 142, 148, 150, 152, and 114 each received a score above 30, indicating the need for restoration (Appendix 4).

Culvert 116 is located on Green Mountain Road at telephone pole number 320-26. It scored 30 on the scale from 0 to 41. It is a 2 lane paved road with a shoulder. Steep embankments and a retaining wall flank this older single concrete culvert. The stream was flowing under average conditions when the team recorded this culvert. The presence of a 0-6" cascading outlet perch, as well as extensive tailwater armoring and a large tailwater scour pool place this culvert firmly in the "bad" category. In addition, there was no substrate in the crossing span. The water velocity was significantly faster within the channel than it was on either side of the culvert, indicating flow constriction, an inference supported by the low minimum structure height at low water and narrow crossing span.

Culvert 129 is located one of the intersections of Green Mountain Road and Leavitt Brook. It scored a 31 on the scoring rubric. Again, this culvert is located on a 2 lane paved road with a shoulder. Again, the single culvert is flanked by steep embankments and retaining walls both upstream and downstream. This culvert is made of steel, in old but decent condition, with average flow going through it. It has a freefalling outlet perch, as well as flow contraction and a large tailwater scour pool. There is no substrate in the crossing span. The water depth does not match that of the stream, and the velocity is faster than that of the surrounding water. The culvert constricts the channel, with a minimum height at low water of between 4 and 6 feet.

Culvert 127 is located on Highwatch Road, a two lane paved road without a shoulder. Steep embankments and retaining walls, both of which show significant erosion with boulders, are collapsing into the stream. The stream was flowing at typical low flow. There was no inlet drop, but the cascading outlet perch was more than 24 inches above the downstream level. This culvert is also characterized by flow contraction, extensive tailwater armoring, a small tailwater scour pool, permanent physical barriers, and a lack of substrate in the span crossing. The crossing spanned the active channel, but had a minimum height at low water of less than 4 feet. This culvert scored a 32 on the scoring rubric.

Culvert 142 is located at another intersection of Leavitt Brook and Green Mountain Road, at telephone pole number 320-55. This culvert passes under a 2 lane paved road with a shoulder, and is flanked by steep embankments and very steep retaining walls. It is an older single concrete culvert in good condition with average flow. It has a 12 to 24 inch outlet perch, a large tailwater scour pool, and a natural dam. There is no substrate in the crossing, and the water depth does not match that of the stream. The water velocity in the culvert is faster than that of the surrounding stream, and the span constricts the channel, with a minimum height at low water of less than 4 feet. This culvert scored a 32 on the scoring rubric.

Culvert 148 is located on Green Mountain Road at telephone pole number 320-60. This culvert passes beneath a paved two-lane road with a shoulder. Steep embankments and a retaining wall on the upstream side flank this culvert. It is an older plastic single culvert in good condition. This culvert is characterized by a freefalling medium-sized outlet perch, flow contraction, a large tailwater scour pool, and no substrate in the crossing. The water depth is different from that of the surrounding stream, and the water passes more slowly through the culvert than it does the rest of the stream. The crossing spans the active channel, but minimum height at low water is less than 4 feet. This culvert scored 33 on the scoring rubric.

Culvert 150 is located on Remick Road, a two lane paved road without a shoulder. The single concrete and steel culvert is flanked by retaining walls and steep embankments. The stream is flowing in the channel, but there is a significant freefalling outlet perch, flow contraction, a tailwater scour pool, and permanent barriers. The freefall from this culvert is particularly steep. There is no substrate in the crossing. The water depth in the crossing is shallower and faster than that of the surrounding stream. The culvert constricts flow, with a minimum height at low flow of less than 4 feet. All these attributes resulted in a score of 35.

Culvert 152 is located at an intersection of Town House Road and Wilkinson Brook, a two lane paved road with no shoulder. Major barriers to wildlife include steep embankments, retaining walls, and a guard rail. Further complicating this culvert's effects on wildlife movement, it is situated near a wetland, prime habitat for a variety of species. This is an older single aluminum culvert in good condition. The stream is flowing, but the water level at the time of data collection was quite low. There is a cascading outlet perch, flow contraction, a small amount of tailwater armoring, a small tailwater scour pool, and temporary physical barriers. There is no substrate in the crossing, and the water is shallower and faster than observed in the natural channel nearby. The slope of the crossing is steeper than the natural channel. This culvert constricts flow, with a minimum height at low water of less than 4 feet. All of these traits earned it a score of 35.

Culvert 114 is by far the worst we saw in Effingham, with a score of 41. It is located on Highwatch road, a paved, 2-lane road with a shoulder. Steep embankments and retaining walls made of large boulders provide additional barriers to wildlife movement. This culvert is an older steel and stone single culvert with an inlet drop between 12 and 24 inches. There was an outlet perch of 12 to 24 inch freefall, and a cascade for another 2 and a half feet down a large boulder. This is a significant barrier to fish and amphibian dispersal. This culvert also shows signs of flow contraction, extensive tailwater armoring, a large tailwater scour pool, and permanent physical barriers. The crossing span constricts water flow with a minimum crossing height in low water of less than 4 feet. The water in the crossing span is shallower and faster than the surrounding stream, and has effectively washed any substrate in the crossing away.

Flood Vulnerability

In our meetings with Frank Mitchell, we discussed the necessity of delineating each subwatershed. In the end, we decided, due to limited resources, the complex topography of Effingham, and the lack of accurate and readily-available precipitation and flow data, to forgo delineation and floodwater calculation in favor of a more targeted approach. In order to satisfy the spirit of the Memorandum of Understanding, as discussed further with Commission contact Kamalendu Nath, we decided that our limited resources would be better spent investigating culverts we had previously identified as possibly problematic.

Culvert 155

Visual assessment: Culvert 155 connects Peavey Brook beneath Pine River road. There are large wetlands on either side of the road, and this culvert lies at the bottom of the Pine River watershed. The soils in this area are classified as predominantly high permeability soils associated with NRCS soil hydrologic group A. There was debris blocking the upstream side of the larger culvert when this data was collected. In an effort to keep stream flow constant, a long and narrow pipe was placed through the debris mat blocking the culvert.

Post calculation assessment: The gentle slope of this watershed coupled with a composition of highly permeable soil groups actually results in a low runoff rate well below the flow capacity of the culvert when calculated at the greatest rain event recorded since 1978 for Hubbard Brook Research Area, 3.11inches/24hrs on Aug 30, 2004. Debris clogging remains a problem.

Culvert Dimensions:

- Embedded elliptical culvert with upstream and downstream dimensions of 6 ft wide and 4.5 ft tall
- Length of stream through crossing is 31 ft.
- Watershed area is 790 acres above the culvert.
- Watershed length is 9600 ft above the culvert.
- NRCS weighted watershed soil hydrologic curve number is 27 (Appendix 6)
- Average watershed slope is 1% above the culvert
- Peak discharge for 25 year rain event (3.11in/24hrs) is 23 cubic feet/sec.
- Flow capacity of existing culvert is 784 cubic feet/sec at bank full.

Culvert 114

Visual Assessment: Culvert 114 connects Hodgedon Brook beneath Highwatch road. The soils within this watershed are classified as shallow with a low permeability. Large boulders are used for the retaining wall, and the steel culvert extends only the length of the road, with further extension on either side maintained by a stone bridge. This culvert received the highest score on the aquatic connectivity scale, which indicates the worst condition. Due to the topographic location of this culvert as well as the current condition, this culvert may not be able to handle the capacity of a flooding event which could lead to mass erosion and road washout conditions. Hodgedon Brook continues down slope to pass beneath route 25 and School Street.

Post calculation assessment: This watershed is steep, relatively narrow and contains a high percentage of low permeable soils. These soils are predominantly of the Hollis phase of Hollis/Charlton associations and therefore are no more than 20 inches deep over hard bedrock, characteristic of steep, mountainside soils. Little permeability is possible through the bedrock resulting in high runoff rates. Here, peak discharge for the 3.11 inch/24hour period rainfall recorded Aug 2004 at Hubbard Brook comes very close to the maximum flow rate of the installed culvert.

Culvert Dimensions:

- Round culvert with upstream and downstream dimensions of 48 inches
- Length of stream through crossing is 62.5 ft.
- Watershed area is 433 acres above the culvert.
- Watershed length is 5600 ft above the culvert.
- NRCS weighted watershed soil hydrologic curve number is 75 (Appendix 6)
- Average watershed slope is 18% above the culvert
- Peak discharge for 25 year rain event (3.11in/24hrs) is 374 cubic feet/sec.
- Flow capacity of existing culvert is 426 cubic feet/sec at bank full.

Culverts 152 & 106

Visual assessment: Culverts 152 and 106 are within close proximity of each other and both connect tributaries of Wilkinson Brook beneath Townhouse road. These culverts lie at the southern base of the Effingham mountains in the Pine River watershed and have wetlands on either side of the road. The soils within this watershed are mixed, with some bedrock and some glacial till. Though these culverts are described as in new condition, it is our opinion that a flooding event could exceed their capacity and washout the road.

Post calculation assessment: This watershed is by far the largest of the three assessed here. The culverts drain two mirror image watersheds that converge on Townhouse Road within about 1600 feet of each other. The culverts are identical and this assessment treated the watersheds as a single watershed with two culverts handling the flow. A mixture of soils within the greater watershed included shallow to bedrock soils in the higher elevations and predominantly permeable glacial till soils in the lower two thirds of the watershed. Overall, permeability is moderately high resulting in moderate runoff that is approximately one fourth the capacity of the combined culverts. This runoff rate is for the highest rainfall event recorded at Hubbard Brook research area from 1978-2005, 3.11inches/24hours on Aug 30, 2006.

Culvert Dimensions:

- Round culvert, up and downstream same dimensions of 29 inches.
- Length of stream through crossing is 39 ft 6 inches.
- Combined watershed area is 1179 acres above the culvert and evenly divided.
- Watershed length is 8000 ft for each tributary above the culverts.
- NRCS weighted watershed soil hydrologic curve number is 50 (Appendix 6)
- Average watershed slope is 14% above the culvert
- Peak discharge for 25 year rain event (3.11in/24hrs) is 56 cubic feet/sec.
- Flow capacity of existing culverts is 224 cubic feet/sec at bank full.

Conclusion and Recommendation

In conclusion, the team recommends, based on our limited assessment, that the Effingham Conservation Commission propose the restoration of culverts 106, 114, 116, 127, 129, 142, 148, 150, 152, and 155 (Appendix 4 & 5).

One the biggest hurdles that an extension of this project faces is the location of the remaining culverts in Effingham. Many small culverts remain undiscovered on side streets, and are not readily available on the main source of GIS data in New Hampshire, GRANIT. Also, delineation of subwatersheds and location of ephemeral, intermittent and non-major streams will require large amounts of fieldwork on private land, including groud-truthing with a GPS unit or surveying equipment.

We believe that the assessment that we have provided is a good starting place for in depth investigation. Dr. Nath's grant will provide the funding necessary for the continuation of our work.

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Appendices

Appendix 1. Original Memorandum of Understanding about the Effingham Culvert analysis, signed by Mary Dellenbaugh, Kamalendu Nath, and Paul Johnson.

Memorandum of Understanding
UNH Department of Natural Resources
NR775
Effingham Culvert Analysis

Parties Involved

We, the undersigned, agree to the terms of the project outlined herein, including the various responsibilities noted, the products to be produced, and the financial commitment detailed in the budget. Any modification of this Memorandum of Understanding must be agreed to in writing by all the parties involved.

Effingham Conservation Commission, represented by Kamalendu Nath

____ _________
Date

NR775 Project Team, Mary Dellenbaugh, Project Manager

____ _________
Date

Team Members: Anthony Jackson, Kirsten Nelson, Brett Newman, Logan Reese
Faculty Advisors: Doug Bechtel, Jeff Lougee, Rick Van de Poll, Frank Mitchell

UNH Department of Natural Resources, Paul C. Johnson, NR775 Instructor

____ _________
Date

Project Objectives

Objective 1. Identify, georeference, map & photograph all culverts within the town boundaries of Effingham, New Hampshire.

The team will first identify all points where roads cross streams in the town of Effingham, New Hampshire using ArcView 3.3 and GIS layers from GRANIT. We will then visit each culvert to obtain the geographic coordinates for further GIS manipulation and photograph the culvert and immediate area.

Objective 2. Delineate the area (subwatershed) draining to each culvert.

Using the information obtained in Objective 1, we will use ArcView to delineate the subwatershed of each culvert.

Objective 3. Estimation and prediction of discharge rates, flood stage elevation, and capacity of the culverts and bridges to handle a 50-year event.

Using the Natural Resources Conservation Service method for predicting flow given the area of the watershed, we will use the data calculated in Objective 2 and the observed status of individual culverts from Objective 1 to predict flow and discharge rates. We will use this information to predict flood stage elevation and the ability of the culverts to handle a 50-year precipitation event. The team will rely on the expertise of Dr. Rick Van de Poll of Ecosystem Management Consultants for existing data and advice.

Objective 4. Assess impacts of bridges and culverts to fish and wildlife movement and aquatic habitat fragmentation.

The team will use the provided Nature Conservancy Field Data Sheet to analyze the impacts of individual culverts and bridges on wildlife migration and habitat fragmentation. We will rely on the expertise of Doug Bechtel and Jeff Lougee of the Nature Conservancy for advice and field training in this method.

Objective 5. Prioritize the culverts for further remediation.

Using the information gathered in Objectives 3 and 4, the team will devise a relative 3-point scale (Good, Moderate, Bad) by which culverts can be compared individually for flood stage vulnerability and wildlife impacts. Using this scale, the team will prioritize the culverts for remediation, recommending most strongly those that score "Bad" for both categories.

Responsibilities of Parties

Effingham Conservation Commission

The Effingham Conservation Commission (ECC) is responsible for providing the team with background information, such as existing maps, needed to complete the project as stated. The ECC will also aid in the location of culverts. The ECC is also responsible for organizing the meetings at which the oral presentations will be given.

NR775 Project Team

The NR775 Project Team will be responsible for planning the project, completing the research and site data collection necessary to produce the desired products and achieve the stated goals, and preparation and delivery of the final report, educational brochure, and oral report.

UNH Department of Natural Resources

The department is responsible for providing advice and expertise as needed by each project and, through Dr. Paul Johnson, administrative oversight of the project.

Project Timeline

DATE	TASK TO BE COMPLETED
September 3 - 9	Familiarize team with project. Choose advisors.
September 10 - 16	Contact advisors. Meet with Frank Mitchell (Cooperative Extension). Draft Memorandum of Understanding.
September 17 - 23	Meet with Effingham Conservation Commission. Finalize MOU and have it signed by Dr. Nath & Dr. Johnson. Fieldwork training with Jeff Lougee and Doug Bechtel. Office work & initial visit towards Objective 1.
September 24 - 30	Complete Objective 1.
October 1 - 28	Work on objective 2. Fieldwork towards Objectives 3 & 4.
Oct. 29 - Nov. 4	Complete Objective 2. Finish fieldwork.
November 5 - 18	Completion of Objectives 3, 4, & 5.
Nov. 19 – Dec. 2	Preparation of report & brochure.
December 3 - 8	Completion of report and brochure. Summary presentation to the town officials December 4th or 6th. Delivery of hard copy of report and files.

Product Description

The team will create a report detailing the findings of the culvert assessment. We will produce 3 copies of the report for the Effingham Conservation Commission, one copy for Cooperative Extension, one copy for the UNH Natural Resources Department, and one copy for each member of the team, for a total of 10 copies.

The team will create an educational brochure in conjunction with the ECC to educate the town on this project as part of Natural Resources Inventory. We will produce the brochure in digital form only.

The team will deliver all files used in the creation of the report and brochure (including GIS data layers and drafts of the report) on a CDR. We will include hard copies of the data collection sheets as well, if needed.

The project manager will present this information first to the Effingham town officials in early December, and again to the town of Effingham in late February/early March

Appendix 2. Field Data sheet for aquatic habitat analysis. (Adapted from University of Massachusetts and Scott Jackson; http://www.streamcontinuity.org/introduction/index.htm)

Field Data Form: Road-Stream Crossing Inventory

Crossing ID#

Date: _________ **Stream/River:** ___________________ **Road:** _____________________________ **Town:** __________________

Location:____ ____

Observer: _________________________ **Phone #:** ________________ **Email address:** __________________________________

Photo IDs:____**Bearing US**___________**Bearing DS**___________ ___________

Road/Railway Characteristics

1. Number of Travel Lanes:____ **Shoulder/ Breakdown lanes:** Yes No **Road Surface:** Paved Unpaved

2. Are any of the following conditions present that would significantly inhibit wildlife crossing over the road?

High traffic volume (> 50 cars per minute) Yes No

Steep embankments Yes No

Retaining walls Yes No

Jersey barriers Yes No

Fencing Yes No

Guard Rail Yes No

Curbs Yes No

Other (specify)____

CROSSING/STREAM CHARACTERISTICS (DURING GENERALLY LOW-FLOW CONDITIONS)

3. **Crossing Type:** Ford Bridge Open Bottom Arch Single Culvert Multiple culverts (# of culverts)______

3a. **Construction material** Plastic Concrete Stone Steel Other_________________________

4. **Condition of crossing:** New Old Collapsing Eroding Rusted

Describe condition

____

5. **Is the stream flowing (in the natural channel)?** Flowing Ponded ______ Dry

6. **Flow conditions are:** Unusually low Typical low-flow Average flow Higher than average

7. **Are any of the following conditions present? (see attached glossary and illustrations)**

Inlet drop _______ in. 0-6” 6-12” 12-24” >24” NONE

Outlet perch _______ in. 0-6” 6-12” 12-24” >24” NONE

With a perched outlet, circle one: Cascade Freefall

Flow contraction Yes No

8. **Tailwater armoring:** Extensive Not Extensive None

9. **Tailwater scour pool:** Large Small None

10. Physical barriers to fish and wildlife passage: Permanent Temporary None

Describe any barriers:

11. Substrate in crossing? No substrate Partial substrate Substrate < 1' Substrate > 1'

12. Crossing substrate: Natural Non-natural Contrasting Comparable

Substrate comments:____

13. Water depth matches that of the stream? Yes (comparable) No (significantly deeper) No (significantly shallower)

14. Water velocity matches that of the stream? Yes (comparable) No (significantly faster) No (significantly slower)

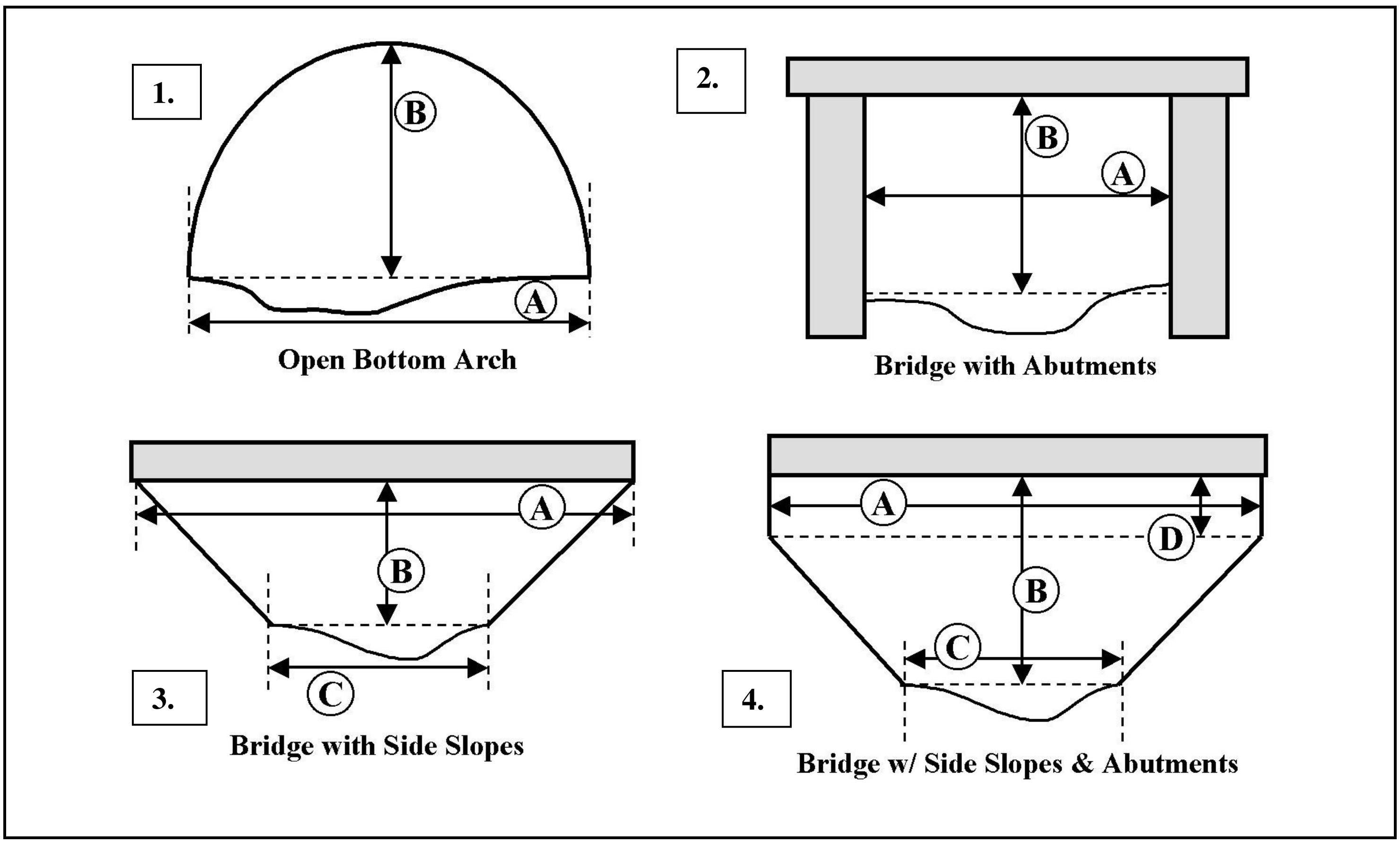
15. Crossing slope matches that of the stream? Yes (comparable) No (significantly steeper) No (significantly flatter)

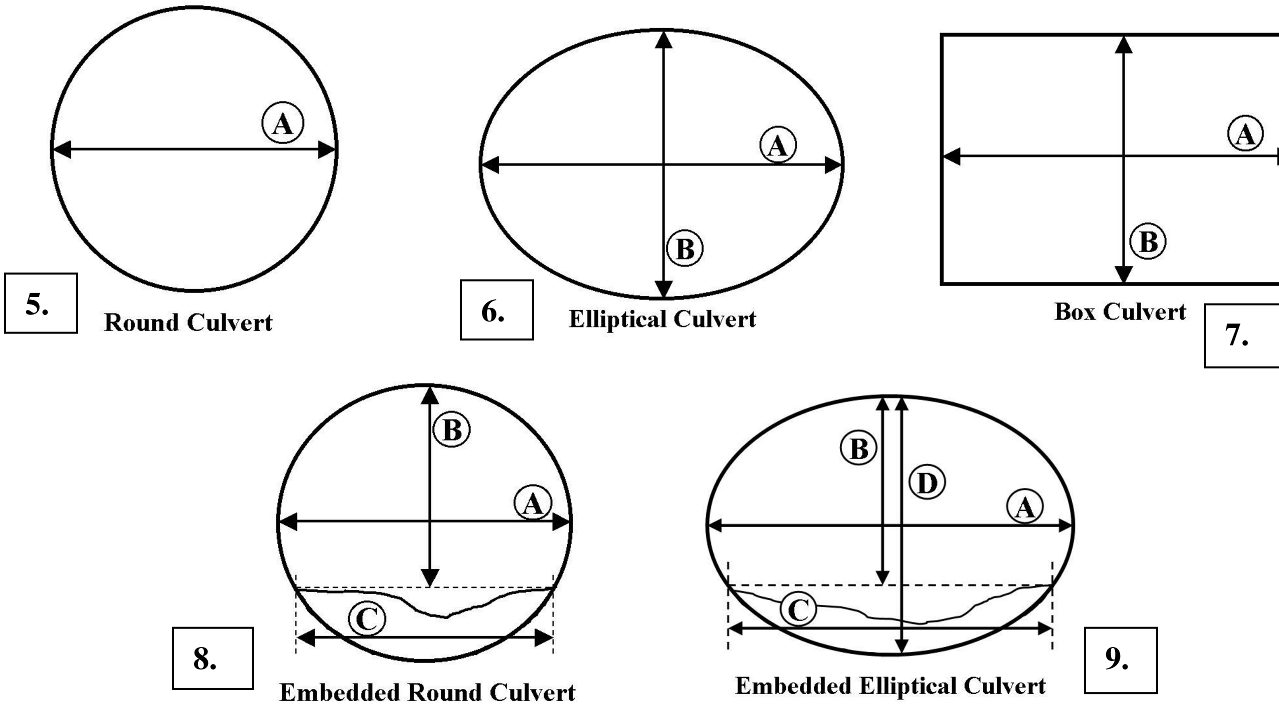
16. Crossing span: Constricts channel Spans active channel Spans bankfull width Spans channel & banks

17. Minimum structure height at low water (from water level to the roof inside the structure) > 6 ft. 4-6 ft. < 4 ft.

18. Comments

Crossing Dimensions





Crossing Type (from above): 1. 2. 3. 4. 5. 6. 7. 8. 9. Ford

Upstream Dimensions (ft.): A) ______________ B) ______________ C) ______________ D) ______________

Downstream Dimensions (ft.): A) ______________ B) ______________ C) ______________ D) ______________

Length of stream through crossing (ft.): _________________________

DIMENSIONS WORKSHEET FOR MULTIPLE CULVERT CROSSINGS

Crossing ID# ___________

NOTE: WHEN INVENTORYING MULTIPLE CULVERTS, LABEL LEFT CULVERT 1 AND GO IN INCREASING ORDER FROM LEFT TO RIGHT FROM DOWNSTREAM END (OUTLET) LOOKING UPSTREAM.

NUMBER OF CULVERTS OR BRIDGE CELLS

Culvert or Bridge Cell 2 of _____

Crossing Type (from above): 1. 2. 3. 4. 5. 6. 7. 8. 9. Ford

Upstream Dimensions (ft.): A) ______________ B) ______________ C) ______________ D) ______________

Downstream Dimensions (ft.): A) ______________ B) ______________ C) ______________ D) ______________

Length of stream through crossing (ft.): _________________________

Culvert or Bridge Cell 3 of _____

Crossing Type (from above): 1. 2. 3. 4. 5. 6. 7. 8. 9. Ford

Upstream Dimensions (ft.): A) ______________ B) ______________ C) ______________ D) ______________

Downstream Dimensions (ft.): A) ______________ B) ______________ C) ______________ D) ______________

Length of stream through crossing (ft.): _________________________

Culvert or Bridge Cell 4 of _____

Crossing Type (from above): 1. 2. 3. 4. 5. 6. 7. 8. 9. Ford

Upstream Dimensions (ft.): A) ______________ B) ______________ C) ______________ D) ______________

Downstream Dimensions (ft.): A) ______________ B) ______________ C) ______________ D) ______________

Length of stream through crossing (ft.): _________________________

Culvert or Bridge Cell 5 of _____

Crossing Type (from above): 1. 2. 3. 4. 5. 6. 7. 8. 9. Ford

Upstream Dimensions (ft.): A) ______________ B) ______________ C) ______________ D) ______________

Downstream Dimensions (ft.): A) ______________ B) ______________ C) ______________ D) ______________

Length of stream through crossing (ft.): _________________________

Culvert or Bridge Cell 6 of _____

Crossing Type (from above): 1. 2. 3. 4. 5. 6. 7. 8. 9. Ford

Upstream Dimensions (ft.): A) ______________ B) ______________ C) ______________ D) ______________

Downstream Dimensions (ft.): A) ______________ B) ______________ C) ______________ D) ______________

Length of stream through crossing (ft.): _________________________

Appendix 3. Scoring rubric for aquatic connectivity data sheet.

Question No.	Question Description	Score				
1	Number of lanes	Number of lanes				
	Shoulder present?	no=0	yes=1			
	Surface?	unpaved=0	paved=1			
2	High traffic?	no=0	yes=1			
	Steep embankments?	no=0	yes=1			
	Retaining wall?	no=0	yes=1			
	Jersey barrier?	no=0	yes=1			
	Fencing?	no=0	yes=1			
	Guard rail?	no=0	yes=1			
	Curbs?	no=0	yes=1			
3	Crossing type?	bridge=1	open bottom=2	Single culvert=3	multi culvert=4	
4	Condition?	new=1	old=2	eroded/rusted=3	collapsing=4	
5	Stream flowing?	flowing=1	ponded=2	dry=3		
7	Inlet drop?	none=0	0-6 inches=1	6-12 inches=2	12-24 inches=3	>24 inches=4
	Outlet perch?	none=0	0-6 inches=1	6-12 inches=2	12-24 inches=3	>24 inches=4
	Perched outlet: cascade or freefall?	if cascade present, add 1	if freefall present, add 2	if both cascade & freefall present, add 3		
	Contraction?	no=0	yes=1			
8	Tailwater armoring?	no=0	not extensive=1	extensive=2		
9	Tailwater scour pool?	none=0	small=1	large=2		
10	Physical barriers?	none=0	temporary=1	permanent=2		
11	Substrate in crossing?	>1 ft=1	<1 ft=2	partial=3	none=4	
12	Substrate natural or non-natural?	natural=0	non-natural=1			
13	Water depth matches stream?	yes=0	no=1			
14	Water velocity matches stream?	yes=0	no, faster=2	no, slower=1		
15	Slope similar?	yes=0	no, steeper=2	no, flatter = 1		
16	Crossing span?	spans all=0	spans bankfull=1	spans active channel=2	constricts =3	
17	Minimum structure height at low water?	>6 ft=1	4-6 ft=2	<4 ft=3		

Appendix 4. Summary of Aquatic Habitat data sheet results with general locational data.

ID	Score	Stream (when known)	Road (when known)	Phone pole number	Other location data
111	13		Elm Road		
113	13		Rte 25		
101	14		Stevens Road	324-6	
103	14	Province Lake Tributary	Molly Philbrick Rd.		
115	14		Rte. 153		
102	15		Rte. 153		
135	15		Hobbs Rd.	3221-21	
158	15		Huckins Rd		
118	18		Rte. 153	32-249	
128	18	Hodgedon Brook	Rte 25		
133	18		School Street	SCL09	Corner of School St and Symmes Rd
134	18		Rte. 153		
107	19	Hodgedon Brook	School Street 10		By Effingham Elementary School
145	19		Green Mountain Rd	320-65	
157	19		Rte 25		
105	20		Rte 25		At Rte. 8
136	20		Rte. 153		
139	20		Rte. 153	322/4	
104	21	Seep Drainage	Iron Works Road		79 Iron Works Road
106	21	Wilkinson Brook	Town House Road		
141	21	Wilkinson Brook	Clough rd		
146	21	Leavitt Brook	Rte 25		
112	22		Rte. 153	322-25	
121	22	Red Brook	Green Mountain Rd		
122	22		Rte. 153	32-327	Just before Maine
144	22	Hobbs Brook	Molly Philbrick Rd		
153	22		Hobbs		
156	22		Hobbs		
151	23		Rte. 153		
109	24		WS		
117	24		WR		
131	24	Intermittent Stream	Iron Works Road		77 Iron Works Road
140	24			328/3	
147	25		Simon Hill		
155	25		Pine River		

110	26		Green Mountain Rd	320-58	
119	26		Green Mountain Rd	320-16	
124	26		Rte 25		
126	26		Rt 153	32-377	By a large river
130	26			325-27	By lake, marsh area
143	26		Nutter Rd	323-12	
132	27	Wilkinson Brook	Clough Rd		Corner of Clough/Granite/Molly Philbrick
138	27	Leavitt Brook	Highwatch Rd		
123	28		Green Mountain Rd		
125	29		Green Mountain Rd		
154	29		Rte. 153		
116	30		Green Mountain Rd	320-26	
129	31	Leavitt Brook	Green Mountain Rd		
127	32		Highwatch Rd		
142	32	Leavitt Brook	Green Mountain Rd	320-55	
148	33		Green Mountain Rd	320-60	
150	35		Remick Rd		
152	35	Wilkinson Brook	Town House Road		
114	41		Highwatch Rd		

Appendix 5. GPS coordinate reference table.

ID	Latitude	Longitude
136	43.79157364	-71.03369781
102	43.78846765	-71.02643439
134	43.78777564	-71.02164933
154	43.77909064	-71.00340494
151	43.75231683	-71.00285240
128	43.79227638	-71.04347714
113	43.79248023	-71.03154668
157	43.79531801	-71.01508864
146	43.78849447	-71.08748146
105	43.79298449	-71.07100197
124	43.79249632	-71.06260666
126	43.72767806	-71.00149521
115	43.72936249	-71.00255736
118	43.73692095	-71.00861915
122	43.71281326	-70.98371753
139	43.74067605	-71.00872644
153	43.76134515	-71.01486334
135	43.76036882	-71.01585575
156	43.76258433	-71.00621589
112	43.74785900	-71.00341567
143	43.72272670	-71.01072737
101	43.71161163	-70.98954865
130	43.70035708	-70.99819073
140	43.70256186	-70.99327692
132	43.71802747	-71.02933117
141	43.70552838	-71.05574020
111	43.74366939	-71.08862408
121	43.77200425	-71.09235772
138	43.77910674	-71.06747755
127	43.78080189	-71.05417916
114	43.78123105	-71.05039188
158	43.72491002	-71.07183882
103	43.70280325	-71.02593550
144	43.69987428	-71.02525958
155	43.74022543	-71.11382076
150	43.68897915	-71.01377436
147	43.68844807	-71.02207848
152	43.74590635	-71.04817637
106	43.74524653	-71.04337522
117	43.77123177	-71.07923099
109	43.71759832	-71.04051062
125	46-11-58.26	60-44-26
123	46-11-48.57	60-44-36.5
129	46-11-05.49	60-45-12.43
142	46-10-14.93	60-46-22.67
110	46-09-51.27	60-46-59.58
148	46-09-46.9	60-47-11.9
145	46-10-45.1	60-48-18.09

Appendix 6. From Agricultural Handbook 590, curve numbers. Runoff depth in inches.

Rainfall (inches)	Curve Number 60	65	70	75	80	85	90
1	0	0	0	0.03	0.08	0.17	0.32
1.2	0	0	0.03	0.07	0.15	0.28	0.46
1.4	0	0.02	0.06	0.13	0.24	0.39	0.61
1.6	0.01	0.05	0.11	0.2	0.34	0.52	0.76
1.8	0.03	0.09	0.17	0.29	0.44	0.65	0.93
2	0.06	0.14	0.24	0.38	0.56	0.8	1.09
2.5	0.17	0.3	0.46	0.65	0.889	1.18	1.53
3	0.33	0.51	0.72	0.96	1.25	1.59	1.98
4	0.76	1.03	1.33	1.67	2.04	2.46	2.92
5	1.3	1.65	2.04	2.45	2.89	3.37	3.88
6	1.92	2.35	2.87	3.28	3.78	4.31	4.85
7	2.6	3.1	3.62	4.15	4.69	5.36	5.82
8	3.33	3.9	4.47	5.04	5.62	6.22	6.81
9	4.1	4.72	5.34	5.95	6.57	7.19	7.79
10	4.9	5.57	6.23	6.88	7.52	8.16	8.78
11	5.72	6.44	7.13	7.82	8.48	9.14	9.77
12	6.56	7.32	8.05	8.76	9.45	10.12	10.76

Reproduced from USDA Agriculture Handbook 590 "Ponds -- Planning, Design, Construction".

Runoff depth in inches can be obtained from this table if amount of rainfall is known or estimated.