Mapping and Legal Implications of Future Flooding in the Lamprey River Watershed of New Hampshire Due to Changes in Land Use and Climate

2012 NH Water & Watershed Conference

Cameron Wake & Fay Rubin, EOS, University of New Hampshire
Steve Miller, Great Bay National Estuarine Research Reserve
Robert Roseen, Ann Scholz, Tom Ballestero, UNH Stormwater Center
Michael Simpson, Antioch University New England
Julia Peterson, Lisa Townson, UNH Cooperative Extension
John Echeverria, Katherine Garvey, Peg Elmer, Vermont Law School

http://100yearfloods.org

Funded by NOAA Cooperative Institute for Coastal & Estuarine Environmental Technology
Lamprey River Watershed, New Hampshire
5 Decades of Population Growth and Development

Population (all towns with at least a portion of their area in the watershed)

Urban & Developed Land (Lamprey River Watershed)
4 Inch Precipitation Events by Decade 1948 - 2007

Durham, NH

Lawrence, MA
100-year Rainfall Estimates

TP-40 Rainfall Frequency Atlas used for effective conditions = 6.3” (1938-1957)

Northeast Regional Climate Center Atlas for Extreme Precipitation for current conditions = 8.5”

http://precip.eas.cornell.edu/
Daily Discharge, Lamprey River 1934 - 2012

FIS 100 year flood 1935-1987 (7,300 cfs)

- 4/17-18 2007 Patriots Day Nor'easter
- 5/15-16 2006 Mothers Day Storm
- 3/15-17 2010 Nor'easter
- 4/7 1987 FIS 100 year flood 1935-1987 (7,300 cfs)
Costs from Presidentially Declared Disasters in NH
Changing Floodplains with Changing Climate & Land Use

- FEMA 100 yr floodplain
- FEMA 100 yr floodplain (‘05 conditions)
- Revised 100 yr floodplain with climate change
- Revised 100 yr floodplain with buildout
- Revised 100 yr floodplain with climate change and buildout

Stream Channel
## Land Use & Climate Scenarios

<table>
<thead>
<tr>
<th>Land Use Conditions</th>
<th>Max Daily Precipitation (inches)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FIS Conditions</td>
<td>Current Climate</td>
<td>2050*</td>
</tr>
<tr>
<td>FIS</td>
<td>6.3</td>
<td>8.5</td>
<td></td>
</tr>
<tr>
<td>2005</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Build-out</td>
<td></td>
<td>8.5, 11.4</td>
<td>8.5, 11.4</td>
</tr>
<tr>
<td>Build-out with LID</td>
<td></td>
<td>8.5, 11.4</td>
<td>8.5, 11.4</td>
</tr>
</tbody>
</table>

* high value for future precipitation represent maximum value from downscaling output from four GCM (CCSM, GFDL, HadCM3, PCM) for a high emissions scenario (A1Fi)
Lamprey River Watershed - Build Out Rates

- Residential Development (239 acres per year)
- Commercial and Industrial Development (35 acres per year)
Mapping Buildout

Starting with total watershed acreage, eliminate:

- Developed land
- Hydric soils/wetlands/surface water
- Steep slopes (> 15%, based on soils)
- Conservation lands; public water supply protection areas

Build out flat terrains first, moving incrementally to steeper slopes

Within a slope category, build out areas closest to roads first
Hydrologic Methodology

- **FIS**: Annual peak flow frequency analysis
  - peak annual stream flow
  - standard deviation
  - weighted coefficient of skewness
- **Lamprey River Project**: Rainfall-Runoff Model
  - Watershed area
  - Time of concentration
  - Runoff curve number (CN)

**Hydrologic Modeling**: HEC-GeoHMS & HEC-HMS

**Hydraulic Modeling**: HED-GeoRAS & HEC-RAS
Curve Number: Rainfall – Runoff Equation

Curves on this sheet are for the case $I_0 = 0.2S$, so that

$$Q = \frac{(P-0.2S)^2}{P + 0.8S}$$
Curve Number based on Land Use and Soil Type

<table>
<thead>
<tr>
<th>Subbasin</th>
<th>CN</th>
</tr>
</thead>
<tbody>
<tr>
<td>W6510</td>
<td>62.5</td>
</tr>
<tr>
<td>W8600</td>
<td>63.0</td>
</tr>
<tr>
<td>W11900</td>
<td>64.2</td>
</tr>
<tr>
<td>W10910</td>
<td>61.2</td>
</tr>
<tr>
<td>W8380</td>
<td>63.5</td>
</tr>
<tr>
<td>W11020</td>
<td>62.5</td>
</tr>
<tr>
<td>W6730</td>
<td>65.4</td>
</tr>
<tr>
<td>W7060</td>
<td>63.9</td>
</tr>
<tr>
<td>W7920</td>
<td>67.7</td>
</tr>
<tr>
<td>W10250</td>
<td>66.0</td>
</tr>
<tr>
<td>W8590</td>
<td>71.0</td>
</tr>
</tbody>
</table>
Hydraulic Calibration – Results for RT108

Durham Boat House
April 2007: modeled = 34.4’ observed = 34.1’
March 2010: modeled = 33.6’ observed = 33.3’

Current 100 yr flood = 35.8’
FIS 100 yr flood = 33.0’

• 45% increase in the 100-year flood flow from USGS gage: 7,300 cfs (FIS) to 10,649 cfs (NRCC)
• An increase in the base flood elevations by an average of 2.7 feet along the 36 mile study reach.
Implementing LID

- Influence of LID is minimal below 3-7% IC and greatest for high IC and poor soils.


- Break in lines is for commercial and industrial land cover.

24
## Watershed Scale CN and Runoff

<table>
<thead>
<tr>
<th>Sub Basin</th>
<th>Current 2005 CN</th>
<th>2050 Conventional Build-out CN</th>
<th>2050 LID Build-out CN</th>
<th>ΔRunoff Depth (in) Conv-LID</th>
</tr>
</thead>
<tbody>
<tr>
<td>RT27, Raymond</td>
<td>62.5</td>
<td>64.9</td>
<td>64.2</td>
<td>0.08</td>
</tr>
<tr>
<td>Langford Rd, Raymond</td>
<td>63.0</td>
<td>66.4</td>
<td>65.2</td>
<td>0.14</td>
</tr>
<tr>
<td>Downstream Raymond</td>
<td>64.2</td>
<td>68.3</td>
<td>67.5</td>
<td>0.10</td>
</tr>
<tr>
<td>West limit, Epping</td>
<td>61.2</td>
<td>67.3</td>
<td>65.3</td>
<td>0.24</td>
</tr>
<tr>
<td>Blake Road, Epping</td>
<td>63.5</td>
<td>65.4</td>
<td>64.9</td>
<td>0.06</td>
</tr>
<tr>
<td>RT 101, Epping</td>
<td>62.5</td>
<td>65.8</td>
<td>65.0</td>
<td>0.09</td>
</tr>
<tr>
<td>Northern limit, Epping</td>
<td>65.4</td>
<td>68.3</td>
<td>67.4</td>
<td>0.11</td>
</tr>
<tr>
<td>USGS Gage 01073500</td>
<td>63.9</td>
<td>66.2</td>
<td>65.0</td>
<td>0.14</td>
</tr>
<tr>
<td>Durham &amp; Newmarket</td>
<td>67.7</td>
<td>70.2</td>
<td>69.5</td>
<td>0.08</td>
</tr>
<tr>
<td>Pisscassic River</td>
<td>66.0</td>
<td>70.4</td>
<td>68.7</td>
<td>0.20</td>
</tr>
<tr>
<td>Macallen Dam</td>
<td>71.0</td>
<td>75.3</td>
<td>74.9</td>
<td>0.05</td>
</tr>
</tbody>
</table>

Conventional build-out increases flood flow by 4.3% (0.3’ BFE)  
LID build increases flood flow by 2.8% increase
# Urban Scale CN, Runoff, and Discharge

<table>
<thead>
<tr>
<th>Sub-Basin</th>
<th>Current 2005 CN</th>
<th>2050 Conventional Build-out CN</th>
<th>2050 LID Build-out CN</th>
<th>Δ Conv-LID</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Moonlight Brook (0.9 sq. miles)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CN</td>
<td>66.8</td>
<td>78.0</td>
<td>69.5</td>
<td>8.5</td>
</tr>
<tr>
<td>Runoff Depth (in)</td>
<td>4.5</td>
<td>5.9</td>
<td>4.8</td>
<td>1.1</td>
</tr>
<tr>
<td>Disharge (cfs)</td>
<td>655</td>
<td>852</td>
<td>704</td>
<td>148</td>
</tr>
<tr>
<td><strong>Intermittent Stream, Epping (1.2 sq. miles)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CN</td>
<td>70</td>
<td>81.7</td>
<td>69.4</td>
<td>12.3</td>
</tr>
<tr>
<td>Runoff Depth (in)</td>
<td>4.9</td>
<td>6.3</td>
<td>4.8</td>
<td>1.5</td>
</tr>
<tr>
<td>Disharge (cfs)</td>
<td>1,031</td>
<td>1,320</td>
<td>1,016</td>
<td>304</td>
</tr>
<tr>
<td><strong>Intermittent Stream, Raymond (0.9 sq. miles)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CN</td>
<td>65.8</td>
<td>79</td>
<td>66.6</td>
<td>12.4</td>
</tr>
<tr>
<td>Runoff Depth (in)</td>
<td>4.4</td>
<td>6</td>
<td>4.5</td>
<td>1.5</td>
</tr>
<tr>
<td>Disharge (cfs)</td>
<td>508</td>
<td>696</td>
<td>520</td>
<td>176</td>
</tr>
</tbody>
</table>
Forested Type D soil CN = 77

Forested Type C soil CN = 70

Comm./Ind. Type D soil CN = 94

Residential Type D soil CN = 80

Residential Type D soil CN = 84

Comm./Ind. Type D soil CN = 80

Comm./Ind. Type D soil CN = 94

Current Conditions CN=66.8

LID Build-Out CN=69.5

Conventional Build-Out CN=78.0
New Flood Plain Maps and Questions of Legal Authority, Measures and Consequences
In Collaboration with Vermont Law School

1. What is the potential liability of government if they fail to reduce vulnerability to flood risk based on UNH’s information?

2. What legal and policy approaches may communities adopt to reduce flood risks in the expanded flood hazard area?

3. Do NH communities have the legal authority under state legislation to design and implement regulatory controls based on current and projected flooding levels?

4. What legal standard of scientific and technical reliability must be met to support regulatory measures based on current and future environmental conditions?

5. What is the potential regulatory takings exposure of communities if they impose regulatory controls that are designed to address anticipated future environmental conditions?
FEMA and Current Conditions – Lower Lamprey

1 June 2012
Lamprey River Watershed
http://100yearfloods.org
cameron.wake@unh.edu
Newmarket Effective 100 Year Floodplain
Assessing Flood Risk - Lamprey River Watershed

Advisory Committee
municipal, regional, state, federal and non-profit representation

Cliff Sinnott, Rockingham Planning Commission (Chair)
Joanne Cassulo, NH Office of Energy and Planning
David Cedarholm, Durham Public Works
Cynthia Copeland, Strafford Regional Planning Commission
Michael Goetz, FEMA Region 1
Diane Hardy, Newmarket Planning Department
Sharon Meeker, Lamprey River Advisory Committee
Jack Munn, Southern New Hampshire Planning Commission
Jennifer Perry, Exeter Public Works
Ron Poltak & Becky Weidman, NEIWPC
Keith Robinson, USGS
Carl Spang/Dawn Genes, Lamprey River Watershed Association
Eric Williams, NH Department of Environmental Services
Assessing Flood Risk - Lamprey River Watershed

Technical Analysis
- Construct hydrologic and hydraulic model
- Develop land use and climate change scenarios
- Run model; plot cross-sections; map results

Dissemination
- Advisory Group & Focus Groups
- Community Workshops
- Municipal & Regional Planners
- NH GRANIT website

Evaluation and Feedback
Assessing Flood Risk - Lamprey River Watershed

Project Objectives:

• Assess flood risk associated with combined land use and climate change scenarios out to 2100

• Produce maps of the 100-year flood risk boundaries and river discharge at specific locations

• Demonstrate the use of our products to support land use decision-making in coastal communities

• Serve as a model for other New England watersheds

• Address legal issues of using projected flood information
Projecting Future Climate Change for the Northeast: Greenhouse Gas Emission Scenarios
## Projecting Future Climate Change for the Northeast: Downscale Global Projections to Regional Level

<table>
<thead>
<tr>
<th>GCM</th>
<th>Max Daily Precip - A1Fi</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Durham, NH</td>
</tr>
<tr>
<td>CCSM</td>
<td>6.3&quot;</td>
</tr>
<tr>
<td>GFDL</td>
<td>6.5&quot;</td>
</tr>
<tr>
<td>HADCM3</td>
<td>7.8&quot;</td>
</tr>
<tr>
<td>PCM</td>
<td>7.5&quot;</td>
</tr>
</tbody>
</table>