

CLIMATE, HYDROLOGY, & HYDRAULIC CAPACITY, NEW YORK

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LAKE PLACID SEPTEMBER 13, 2016



Evolving Project Objectives Project initiated in 2013

Estimate culvert capacity and risk of capacity exceedance

- Current climate conditions
- Future climate conditions
- Urban build-out scenarios
- Mitigation scenarios



Two Analyses

Culvert Capacity

Hydrology (Peak Runoff Rate)







Capacity



Cornell University

Soil & Water Research Group

Data Collection Project Bottleneck











Hydrology analysis based on USDA-NRCS TR-55 model

Peak Rainfall-Runoff Rate

- Land Cover
- Soils
- Watershed

Area

Response (time of concentration)

• 24-hr Rainfall





24-hr Rainfall

1day 25yr





Art DeGaetano **Northeast** Regional Climate Center

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Watershed Characterization

- Area
- Time of Concentration
 - Average slope
 - Longest flow path
- Curve Number
 - Land cover
 - Soils

(geodatabase for the Northeastern US)









Future Climate 24-hr Rainfall



serc.carleton.edu





Model Output



Punch Brook and Shekomeko Creek















<u>Next</u>



Northeast Regional Climate Center

New York StatepresenterWater Resources Institute







Watershed Delineation

The GPS location of culverts is one of our largest uncertainties

To compensate we "snap" to the nearest NHD stream or point of greatest flow accumulation





Peak Runoff Discharges

- USDA-NRCS model
- Peak discharge calculated for 1, 2, 5, 10, 25, 50, 100, 200 and 500 yr events
- Current storm events and 2050 projections
- Ignore upstream hydraulics, e.g., each culvert independently evaluated





Analyses more-or-less automater and the second seco

- Fulcrum uploads field data to my lab
- Calculations:
 - Watershed delineation
 - Area, CN, Time of Concentration
 - Peak stormflow
 - Culvert capacity
 - Compare capacity to peak stormflog

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	Start Time: Wed Aug 12 08:42:43 2015
	Succeeded at Wed Aug 12 08:42:44 2015 (Elapsed
	Time: 1.00 seconds)



Research – Next Steps

- New 2050 extreme rain estimates
- Compare our results to those using StreamStats for current conditions
- Improve peak discharge return periods, e.g., Shaw and Walter. 2009. WRR. 45: W03404.
- Evaluate impacts of upstream hydraulics (e.g., SWMM)
- Include economics



Evolving Project Objectives

Estimate culvert capacity and risk of capacity exceedance

- Current climate conditions
- Future climate conditions +
- Urban build-out scenarios
- Mitigation scenarios

Not sure how to adopt StreamStats

for these

Hydrologic analysis based on USDA-NRCS TR-55 model







Watershed Delineation

Inputs:

- Mosaiced Lidar DEM
 - Flow direction raster
 - Flow accumulation raster

Outputs:

 Culvert Watershed Shapefiles





REPORT america's NFRASTRUCTURE







Why Model Culverts?











- Capacity Calculation
 - Inlet control:

$$q = A_c \sqrt{D} \sqrt{\frac{\frac{H_{III}}{D} - y - k_s s_a}{c}}$$

- q =culvert peak flow capacity (m³ s⁻¹)
- A_c =culvert cross-sectional area (m²)
- D=culvert diameter (m)
- *H*_{III}=headwater depth, from culvert invert to top of road (m)
- Y,c =tabulated constants (table A.3)
- K_s=slope adjustment constant; -0.5 (mitered inlets +0.7)



Future Climate 24-hr Rainfall

Statistical relationships between GCM output and Gener Coupled Model Intercomparison Project Mod CMIP 3 (part of 2007 IPCC analysis)

Mid-21st Century would be ~10% greater than current 24-hr extreme rain events

Regional variations from this are smaller than variations among models



Stocical relationships between GCM output and Gener Coupled Model Intercomparison Project Mod CMIP 5 (part of 2011 IPCC analysis)

Mid-21st Century would be ~15-20% greater than current 24-hr extreme rain events

Future Climate

24-b Rainfall

Will use this going forward with project

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Data Collection: Fulcrum Cellphone App



Cancel Stormwater Culvert Data Coll... Save

1 0 86%

3. Inlet Measurements			
Inlet Clogged or Collapsed	* ()		
Yes	No		
Ditch intersect Skewed	* 0		
Inlet Shape Round			
Inlet Dimensions			
Inlet A 24	* 0		
Inlet B 24	* 0		
Head above culvert bottom 48	* ()		
Average Culvert Slope 3.2	* ()		
Length of stream through culvert 58			
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Culvert Capacity

- Inlet shape, dimensions, & type
- Pipe material, length, slope
- Bottom material
- Assume: inlet is submerged but road is not over-topped
- Inlet control

(we also calculate hydraulically long conditions)



Embedded Round Culver

Embedded Elliptical Culvert