COASTAL YORK COUNTY CULVERT & BRIDGE ANALYSIS

Culvert Prioritization Decision Support Tool Development

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GEOLOGICAL SURVEY

We would like to thank our Steering Committee members who contributed their time, perspective and energy to guiding this project.

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INTRODUCTION

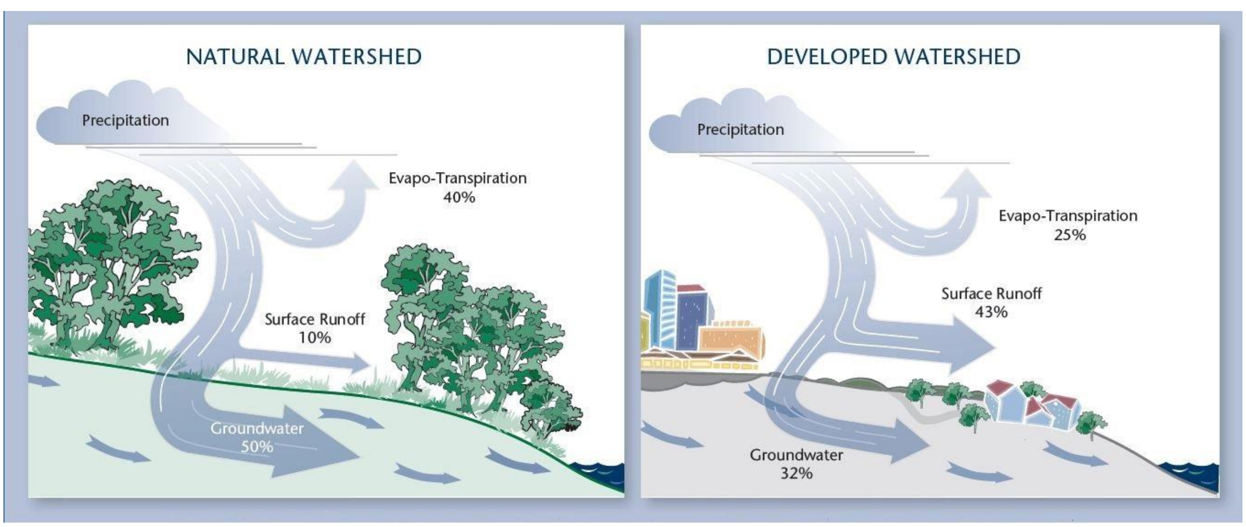
According to the United Nations International Strategy for Disaster Recovery as referenced by the World Bank

> Resilience is the ability of a system, community, or society exposed to hazards to resist, absorb, accommodate for, and recover from the effects of a hazard in a timely and efficient manner.[1]

This definition, as well as others, refers mostly to how a system, community, or entity is able to recuperate losses after a crisis or challenge to the system. Resiliency is reactive and responsive. Yet, resiliency does not always depend on innate abilities, but rather is just as likely to rely on planning and preparation for those potential challenges. In an age of increased occurrence and severity of storms, building resilient systems is a crucial aspect of present day planning. Local government resiliency planning impacts public safety and the economic and environmental viability of a municipality.

The ways in which communities have altered natural landscapes to suit the built environment has had vast impacts on the ways in which those landscapes are able to respond to and recover from storm impacts. For example, in an undeveloped watershed, only 10% of precipitation results in surface water runoff. A remaining 50% infiltrates the soil and becomes groundwater, while 40% evapo-transpires (is released into the air via plant respiration). In a developed watershed, 43% precipitation becomes stormwater runoff, 32% groundwater, and 25% is returned to the atmosphere via evapo-transpiration.

FIGURE 1 : TYPICAL PRE- AND POST-DEVELOPMENT HYDROLOGY PATTERNS[2]



[1] Jha, A. K.-G. (2013). *Building Urban Resilience: Principles, Tools, and Practice.* Directions in Development. Washington D.C.: World Bank. doi:10.1596/978-0-8213-8865-5.

[2] Roseen, R. M., Janeski, T. V., & Houle, J. J. (2011, January). *Forging the Link.* Retrieved from University of New Hampshire Storm Water Center: www.unh.edu/unhsc/forgingthelink

These percentages are linked to the amount of impervious surface that has been created through the development of roads, sidewalks, buildings and other hardscape surfaces that no longer allow for the natural infiltration of water into the ground. In general, the greater the development, the greater the percent of impervious cover and the higher the percent of surface water runoff.

The increase in percent of surface water signifies an increase in the quantity of water from any storm event that needs to be managed via the built and natural drainage network. Subsequently, increases in the volume and velocity of surface water runoff is a threat to the immediate capabilities and longevity of the current system of culverts and bridges. The majority of surface water transport systems via culverts and bridges have not been designed with these increases in mind. As a result, the more rain an area receives the greater the likelihood of culvert and road failures.

In coastal York County, bridge and culvert infrastructure is prone to damage from flooding. The most recent and extreme examples are the Mother's Day and Patriot's Day events in 2006 and 2007. These storms combined resulted in an estimated $40 million damages to public property in all of York County.[3],[4] Much of this damage resulted from failed culverts and resulting road washouts. According to the New England Environmental Finance Center as referenced by The University of Southern Maine, most of the 35,000 culverts in Maine are unable to handle the expected increase in precipitation.[5] During both storm events, flooding in York County at multiple sites peaked at 100 and 500 year storm re-occurrence intervals.[6] The 2006 storm hit the inland and Cumberland County harder than the 2007 storm, whereas the inverse was true for York County coastal communities.[7]

In order to deal with both the expected growth in population and increases in storm surge events in Maine, studies report that communities should

- develop in a way that reduces or limits the construction of new road-stream crossings

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[3] Lombard, P. J. (2009). *Flood of April 2007 in Southern Maine: Scientific Investigations Report 2009-5102.* USGS. Retrieved from http://pubs.usgs.gov/sir/2009/5102

[4] Stewart, G., & Kempf, J. (2008). *Flood of May 2006 in York County, Maine: U.S. Geological Survey Scientific Investigations Report 2008-5047.* USGS.

[5] USM, The University of Southern Maine. (2013, May 31). *Muskie report recommends investment in land conservation, low impact development, and improved culverts to preserve Maine's water resources.* Retrieved from https://usm.maine.edu/muskie/muskie-report-recommends-investment-land-conservation-low-impact-development-and-improved-cul

[6] Lombard, P. J. (2009). *Flood of April 2007 in Southern Maine: Scientific Investigations Report 2009-5102.* USGS. Retrieved from http://pubs.usgs.gov/sir/2009/5102

[7] Lombard, P. J. (2009). *Flood of April 2007 in Southern Maine: Scientific Investigations Report 2009-5102.* USGS. Retrieved from http://pubs.usgs.gov/sir/2009/5102

- institute or upgrade stormwater ordinances to include the most current probabilities for extreme rainfall events
- create a database of road-stream crossings and other stormwater assets to monitor their efficiency and condition over time
- develop a way to prioritize those assets as their condition, municipal development and extreme events change.[8]

SMPDC focused on the final recommendation of assisting municipalities in prioritizing their crucial infrastructure assets. In 2014, the Southern Maine Planning and Development Commission (SMPDC) received funding through the Maine Department of Agriculture, Conservation, and Forestry (DACF) to conduct a vulnerability analysis of culverts and bridges in the coastal portion of York County. The project was an extension of work conducted by the Sea Level Adaptation Working Group to identify public and private roads in the Saco Bay region that are susceptible to sea level rise. (See Appendix A)

This assessment of culverts and bridges in York County began in response to increased storm surge events in the coastal region. Utilizing the data and tools on hand, the project transformed to include the development of an Excel based decision support tool for municipalities. Across the country, planners recognize the necessity for adaptation strategies, such as what is outlined here, to prepare for future storm surge events and changes in precipitation. These adaptation strategies are part of an increasing network of tools to build economic and environmental resiliency.

PROJECT GOALS AND CHALLENGES

The Coastal York Culvert Analysis project began as an effort to provide municipalities and the Maine Department of Transportation (MaineDOT) with a priority list of culverts for upgrades and utilizing Stream Smart principles. Initial goals included

- Maps of MaineDOT bridges, scour bridges, and culverts
- Maps of essential services and locations (Fire/Rescue, hospitals, police etc.)
- Providing MaineDOT with a list of rated and prioritized culverts based on available data
- Draft and final reports in paper and electronic PDF format

The team began by creating a map of bridges utilizing data from MaineDOT on bridges. The essential fire/rescue, hospital and police data points were gathered from the Maine Office of GIS (MEGIS) online.[9] Initial information on fish habitat also came

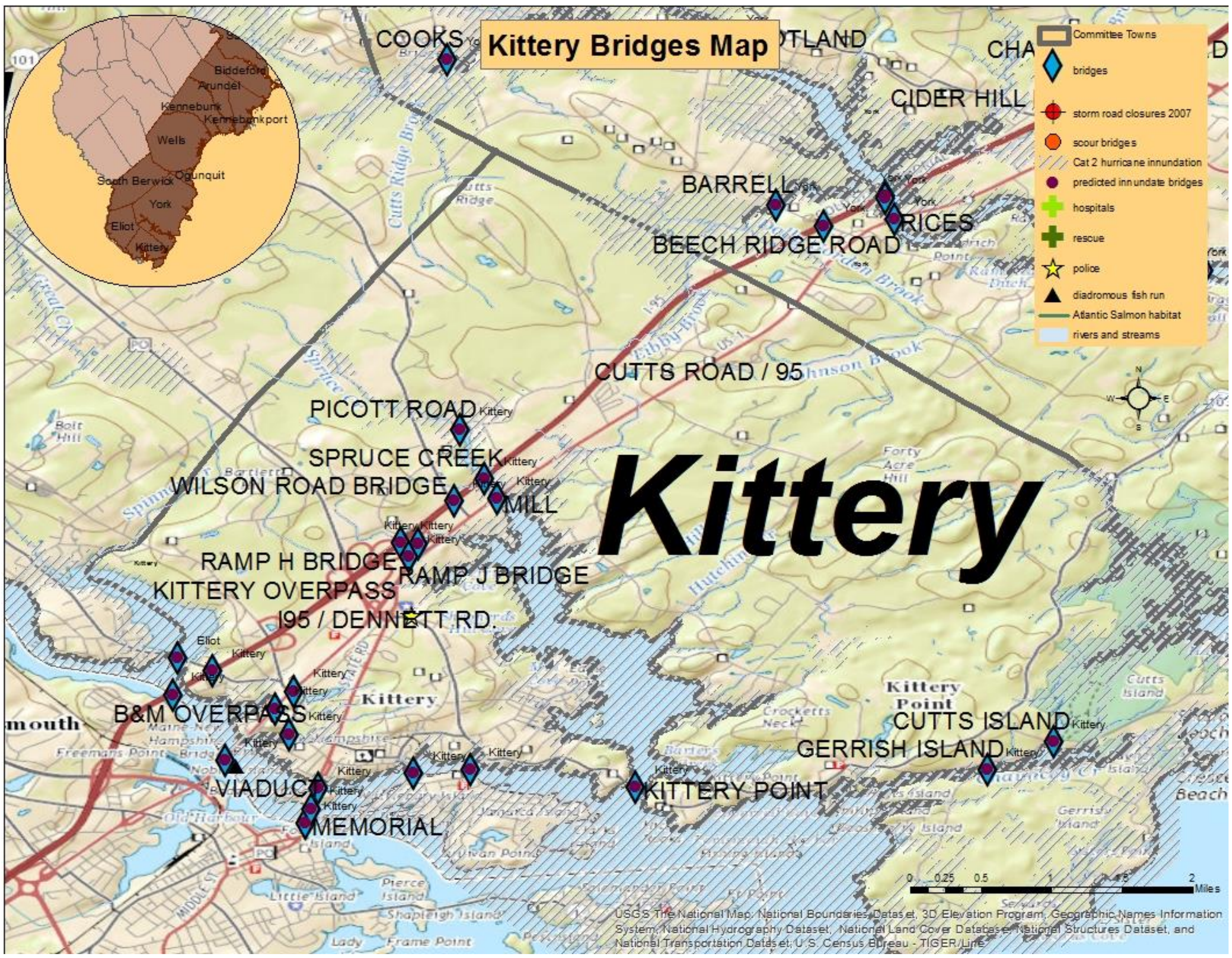
[8] Gray, A. (2014). *Fall 2014 - Comate Highlights: Extreme Precipitation and Population: Maine in the Context of the Northeast.* The University of Maine, Maine Climate News. Retrieved October 30, 2015, from http://umaine.edu/maineclimatenews/archives/fall-2014/climate-highlights

[9] These data layers can be found under the "facilities and structures" category at http://www.maine.gov/megis/catalog/

from MEGIS. The USGS storm road closures information originated from SMPDC. And the hurricane inundation and flooding data is sourced by the Maine Geological Survey mapping project of potential flooding scenarios.[10]

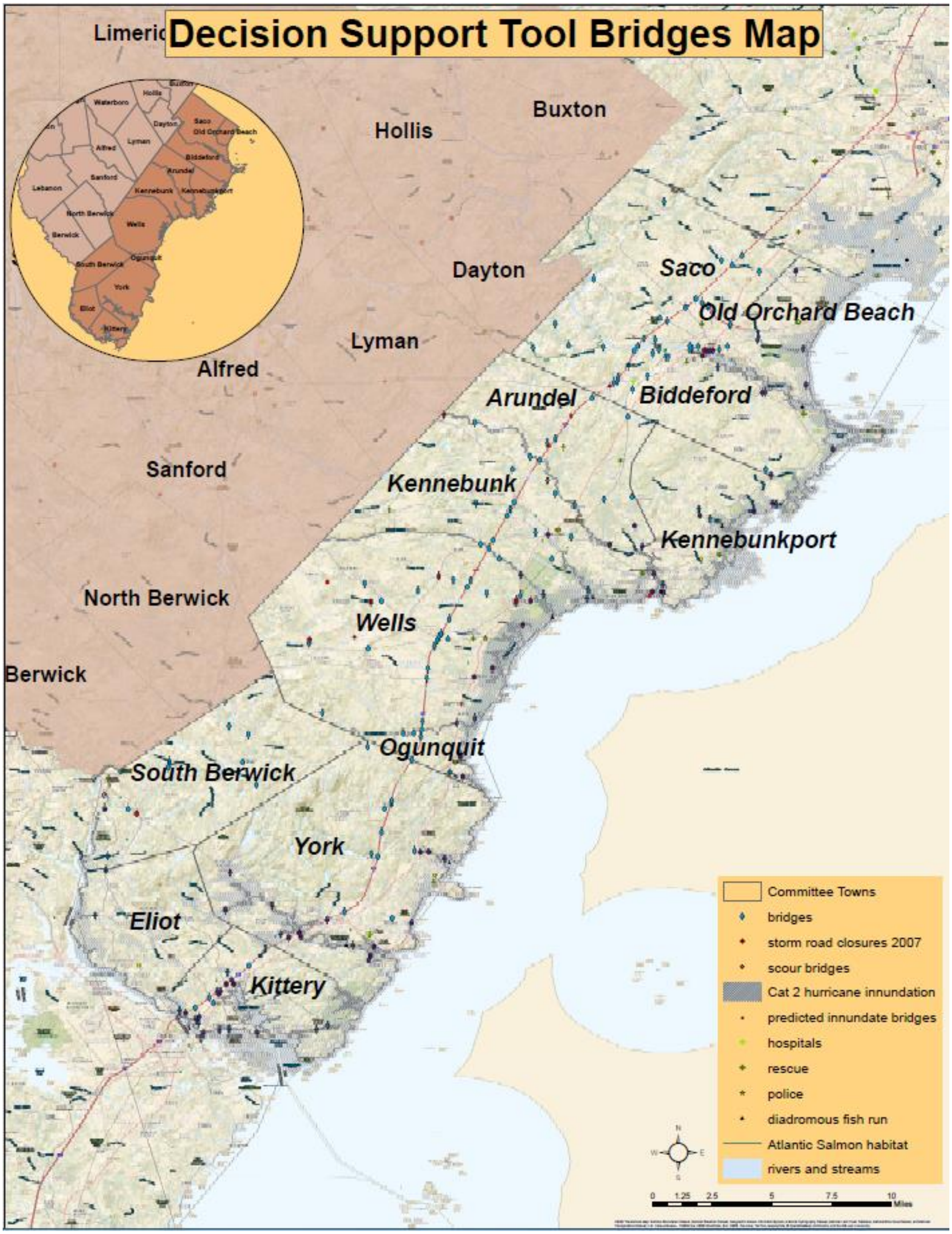
One of the first challenges was that the data gathered about MaineDOT culverts and bridges resulted in many points to review without much varied information to base a comprehensive evaluation on. There were a total of 86 bridges and 15 scour bridges in coastal York County maintained by MaineDOT. The majority of information was related to condition, location, and the party responsible for maintenance.

FIGURE 2: KITTERY BRIDGES MAP



[10] More information and the shapefile can be found at http://www.maine.gov/dacf/mgs/hazards/phim/index.shtml

FIGURE 3: MAP OF YORK COUNTY BRIDGES

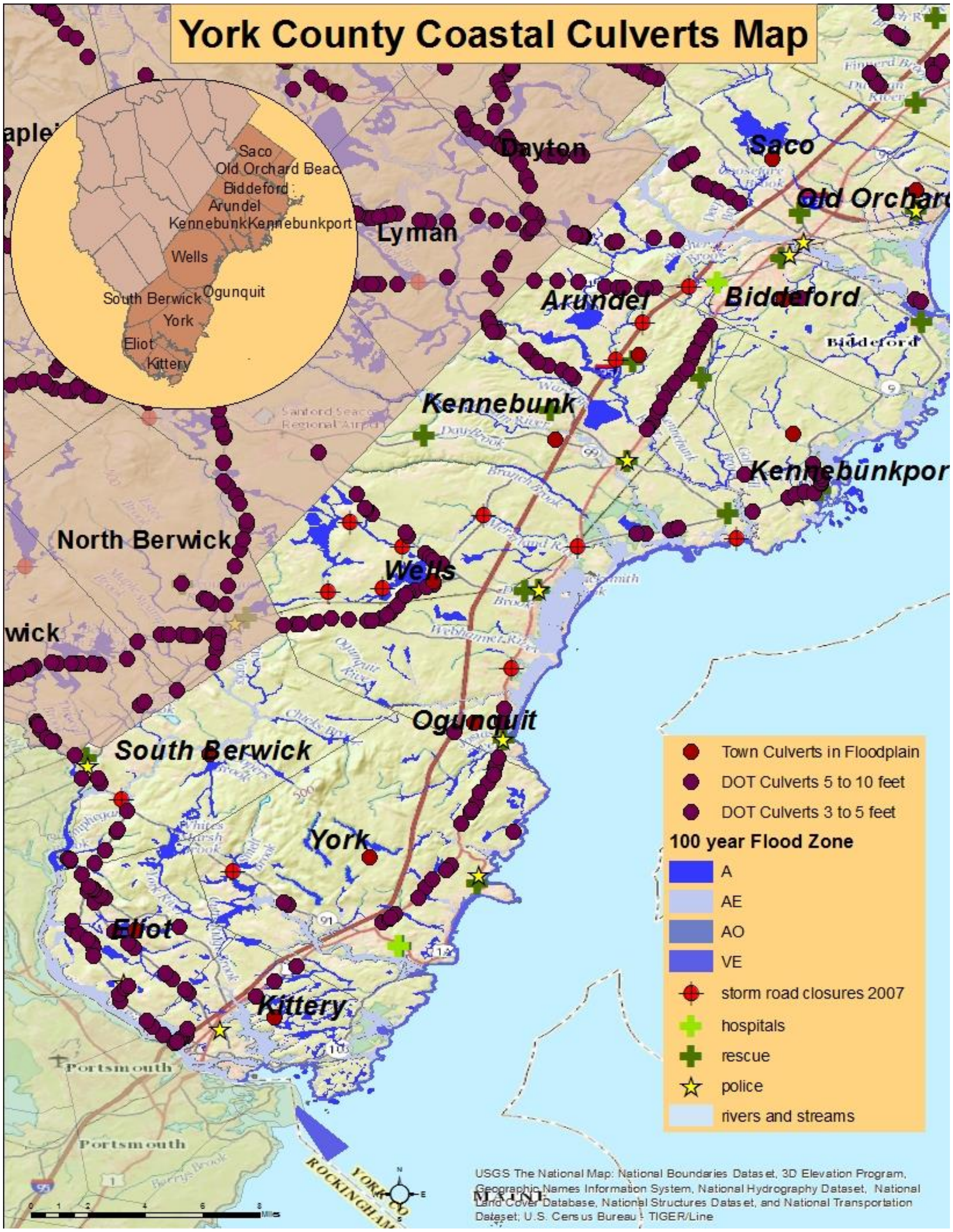


After a discussion about the type of information on hand, the potential information available, and what would be most useful for the committee members, the Steering Committee decided to focus the prioritization list. The committee members indicated that any culverts over ten feet in diameter would require engineering and therefor would fall into a more involved budgetary scheme. Culverts under three feet would be too numerous and too small to be conducting enough water during a storm event to warrant the budgetary expense of reconstructing a road. Therefore the Steering Committee made a plan to identify culverts between three and ten feet in diameter within the 100 year FEMA floodplain.

As it turned out, gathering information on culverts was even more challenging than the bridges. The number of MaineDOT culverts was overwhelming and the type of information was limited to conditions and locations. The narrowed range of three to ten foot culverts within the 100 year FEMA designated floodplain helped to limit the scope of the project, but did not solve the issue of how to evaluate the culverts.

Limited by time and budgets, the team was able to get data from only four out of 13 coastal York County municipalities. Furthermore, the data collected by municipalities varied greatly in both quantity and content. South Berwick collected 41 pieces of information on each of their culverts, of which only four pieces (composition/pipe type, condition, pipe size, and owner) overlapped with data collected by Kittery. The lack of data and consistent parameters set a barrier to the ability of our team to create a useful prioritization list.

FIGURE 4: YORK COUNTY MAINEDOT CULVERTS, 3-10 FEET



After meeting with municipal partners and members of the Stream Connectivity Work Group who developed Stream Smart,[11] it became evident that there was already a road-stream crossing survey effort at hand in the process of collecting data on culverts

[11]For more information on Stream Smart, see http://maineaudubon.org/streamsmart/

in Southern Maine. Once the data was gathered, there would still exist a local need for creating a method of prioritization that could be utilized now and in the future by multiple municipalities. As a result the following goals were added to the project:

- Develop Decision Support Tool (DST) for prioritizing culverts for capital improvements
- Utilize available town and MaineDOT data to test DST

METHODOLOGY

The municipal level DST was based on other model decision support tools and input by the Steering Committee. At the forefront of the DST development were planning principles of evaluating risks and formulating a comprehensive approach to infrastructure changes.[12] It was the comprehensiveness of our approach that encouraged us to expand on other model tools while making the tool accessible to municipalities with varying levels of technical staff. We strove to include the needs of municipal decision makers and match those needs to available scientific resources.

OTHER DECISION SUPPORT MODELS AND STUDIES

In 2014, the Minnesota Department of Transportation (MnDOT) in coordination with the private sector created a pilot study that utilized metrics to assess flood vulnerability of two places in Duluth, MN. These metrics included 19 questions dealing with a structure's (bridge, large culvert, pipe, or road) risk of failure, structural conditions, surrounding hydrologic landscape and the potential impact flooding or asset failure would have on the ability for the community to reroute traffic.[13] The metrics were scored and weighted according to the type of asset.

This tool is a high-level assessment tool that is directly linked to the local data provided within the study parameters. It was helpful in constructing an outline for our own DST, but could not be directly applied to the York County data on hand.

In partnership with Catalysis Adaptation Partners, MaineDOT had also been developing an infrastructure vulnerability assessment process, specific to state owned roads. The Steering Committee utilized their draft assessment tool as a model for a municipality-centered DST. The MaineDOT version included questions about habitat for

[12] (APA), American Planning Association. (2015, January 15). Planning Resilient Infrastructure. (The Planning for Post-Disaster Recovery: Next Generation Briefing Papers). Retrieved November 19, 2015, from https://www.planning.org/research/postdisaster/briefingpapers/infrastructure.htm

[13] Parsons Brinckerhoff and Catalysis Adaptation Partners, LLC. (2014). *MnDOT Flash Flood Vulnerability and Adaptation Assessment Pilot Project.* MnDOt and USDOT Federal Highway Administration.

critical species, the surrounding hydrological landscape, documented flooding, and condition ratings of the asset.

It is worthwhile to note that municipalities may have differing priorities than the MaineDOT, as well as limited access to the technical support needed to apply the type of assessment tool the MaineDOT had been developing.

In addition to the MnDOT and MaineDOT assessment tools, Stream Smart design standards and aquatic species habitat concerns were taken into consideration. Through collaboration with partners in the Stream Connectivity Work Group, the DST was designed to connect municipalities to relevant scientific data to prepare for climatic changes and increased storm surges. Also, since the data is collected by a single entity, connecting the DST to the Maine Stream Habitat Viewer allows for more consistent comparisons between municipalities.

STEERING COMMITTEE

The Steering Committee for the Culvert Prioritization Decision Support Tool (DST) consisted of range of scientists, planners, and municipal public workers. Committee members were sought from thirteen coastal communities in York County via the Public Works Departments and Town Managers. The following agencies and Public Works Directors/Managers and employees from the communities listed below participated in the decision making and discussion around the development of the DST. (See Appendix B for meeting notes and attendees).

- Maine Audubon
- U.S. Fish and Wildlife Service, Gulf of Maine Coastal Program
- The Maine Geological Survey
- Maine Department of Transportation
- The Nature Conservancy
- Southern Maine Planning and Development Commission

- Eliot
- Kittery
- York
- Wells
- Kennebunkport
- Saco

The entire committee met three times and a sub-committee met once over the course of nine months. The sub-committee focused on portions of the tool that draws on information being collected for the Maine Stream Habitat Viewer. This source of information connects the DST's sections on habitat potential, infrastructure condition and risk with regularly collected and updated data. These meetings allowed for feedback from all participating members of the Steering Committee. The views of committee members helped to give direction to the project as well as shape the final DST product. Drafts of the tool were sent to committee members for review and comment. One town volunteered to beta-test the DST, which is in the process now.

DECISION SUPPORT TOOL

Essential to building more resilient places is the "management of locational, structural, operational, and financial aspects of risk."[14] The resulting DST is an accessible and hopefully effective method for municipalities to prioritize culvert remediation projects with the goal of incorporating and balancing these multiple measures concern. Specifically, the DST focuses on:

- Infrastructure conditions and risk of failure
- Habitat barriers and improvement potential
- Road access importance in case of flooding
- Budgetary issues that impact the likelihood of project implementation

The DST is flexible to the concerns of the individual municipality. Also, the DST can be applied to any size culvert. It is up to the municipality or entity utilizing the tool to decide what parameters are necessary for creating a pool of culvert candidates for evaluation. (See Appendix C for a copy of the DST).

The DST takes form as a list of 23 questions that are individually scored. Each section of the DST can be weighted so that the sections are given equal priority or that certain sections can be given greater priority. Within the infrastructure sections higher priority is given to culverts that are at greater risk of failure or are more likely to degrade over time. This section includes questions about previous flooding, design standards, the condition and the material of the culvert. For the sake of consistency, most of these questions are best answered using the Maine Stream Habitat Viewer.[15] Some of these questions may be answered by the

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[14] Jha, A. K.-G. (2013). *Building Urban Resilience: Principles, Tools, and Practice.* Directions in Development. Washington D.C.: World Bank. doi:10.1596/978-0-8213-8865-5. p. 141.

[15] Find the Maine Stream Habitat Viewer at http://mapserver.maine.gov/streamviewer/streamdocHome.html and http://mapserver.maine.gov/streamviewer/index.html

entity/municipality that is taking inventory of their assets. There are special trainings provided on Stream Smart evaluation techniques that could help a municipality learn how to inventory their culverts in a manner consistent with the data collected for the Maine Stream Habitat Viewer.

The Stream Smart principles of making a culvert "invisible" to the aquatic species that utilize the culvert are taken into account. These questions deal with the substrate or lack of substrate and the span of the culvert at bankfull width. Those qualities that are negative are given a higher rating since the purpose is to give a higher score to those assets that need to be addressed.

Higher priority is also given to culverts that have a maximum impact on improving habitat. These questions can only be answered if there is data recorded in the Maine Stream Habitat Viewer. Again, the tool is flexible. If there are other habitat questions the municipality would like to consider, they can add them.

Culverts that have the potential to have greater negative impacts on community access to emergency services are given higher priority. This section looks at evacuation routes and the length of detour, access to hospitals, police, and fire departments, and highway corridor priority (which expands upon average daily traffic, but only applies to MaineDOT culverts).

Also, those culvert projects that have a greater likelihood of being implemented are given a higher priority. Here the tool evaluates budgetary impacts and whether there is already the potential for community support for the project via active watershed groups.

The instructions guide the user of the DST to sources of information needed to answer the questions. Also, the instructions provide the user a list of assumptions made throughout the questions. Detailed instructions on how to use the DST can be found in Appendix D.

WHAT ARE NEXT STEPS NEEDED?

- ***Beta test tool with 2-3 towns.*** Currently, we are in the process of testing the DST with the Town of Kittery. The Maine Stream Habitat Viewer data is being prepared for Kittery to utilize. That information should be available in the late winter or early spring. It would be ideal to test the DST with multiple towns that have varying priorities to see what issues they run into.
- ***Modify the DST utilizing feedback from beta testing period.*** Most useful tools go through a process of development. Right now the DST is in that phase and it is expected that modifications will be needed to improve its efficacy.
- ***Assess culvert data gaps***. Once there is access to all the Maine Stream Habitat Viewer data, the municipalities should be able to match their own data points to the online data. The Maine Stream Habitat Viewer data is based on

known perennial streams and intermittent streams with known issues. As well as non-stream crossing culvert data, it is possible that the municipalities will have data on unofficial stream crossing culverts that they could evaluate using the DST.

Furthermore, there could be culvert data that is simply unknown or not monitored regularly. It would be useful to know what these data gaps are.

- ***Engage municipalities to make a plan to address data gaps***. This could include education around the importance of preparing for emergencies, reducing the risk of major impacts from storm events, and figuring out how to best manage those risks beginning with an accurate inventory of culvert assets.
- ***Continue work with USFWS, TNC and Maine Audubon to collect data.*** This work is fundamental to providing municipalities with the consistent and reliable data. Knowledge of culverts at stream crossings provides a solid framework for making informed decisions about how to protect the state's economic and environmental resources.
- ***Continue to provide feedback to USFWS, TNC and Maine Audubon on Stream Viewer webpage for accessibility and appropriateness at municipal level.*** SMPDC is uniquely positioned to assist our scientific community in making connections with our regions urban and rural centers.
- ***Complete data collection.*** When needed, SMPDC could assist municipalities in data collection.
- ***Build into SMPDC website an obvious and clear space for DST and supporting information.*** This would allow our communities to easily access the DST and important watershed planning information.
- ***Continue to update and map culvert assets.*** As assets are improved, suffer damages, are added to or removed, an accurate map of culverts will help municipalities make informed decisions and track progress.
- ***Comprehensive watershed planning, including revolving funding sources and integrated information sharing.*** Funding will continue to be important and the need for culvert upgrades is proving more and more vital to the economic and environmental stability of our region. Finding continuous and stable funding sources for watershed planning and restoration is a crucial to reducing risks to our municipalities' vulnerable resources.

CONCLUSION

This project recognizes the economic value of creating sustainable systems for both our environmental resources and infrastructure investments. With over $40 million in damages from the storms in 2006 and 2007, comprehensive risk assessment and abatement are already acknowledged as a priority for the region's municipalities and MaineDOT.

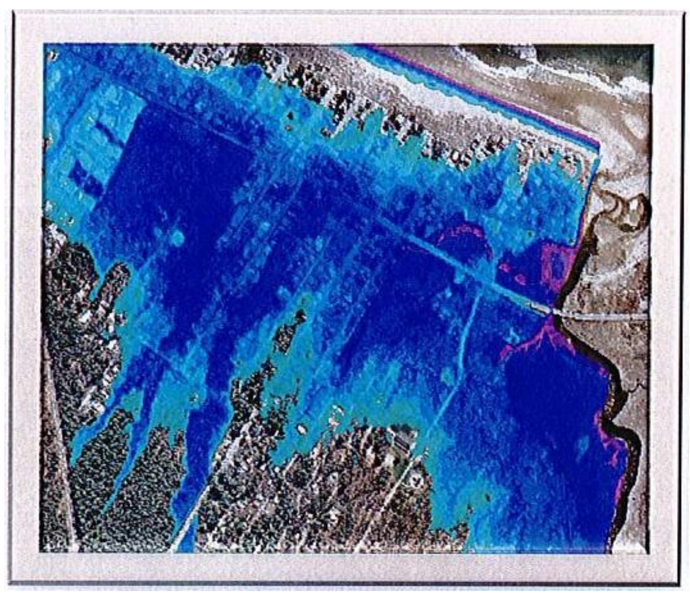
SMPDC sees an opportunity to advance regional watershed planning through the dissemination and organization of climate resiliency building tools and watershed data. There are multiple agencies working on different aspects of climate resiliency: coastal programming, habitat restoration, stream connectivity, soil erosion and stormwater pollution are a few examples. SMPDC is poised to bring to the forefront science and planning in the area of coastal and watershed resiliency at the local municipal level of planning. Beginning with the stormwater infrastructure in the coastal communities of southern Maine and connecting these communities with their upstream watershed partners, our long term goal is to assist in creating watershed wide awareness of the impacts of storm surge events and sea level rise, while providing our communities the best available tools and information to plan for climate change adaptation and mitigation.

Lastly, the DST is not intended to be an end all tool. It is one tool of several and can be used in conjunction with other data or tools. The idea behind the tool was to provide something that is accessible to municipalities and can balance multiple priorities that are financial, logistical/locational, structural, and operational realities. It is expected that the tool will evolve as needed from one municipality to another.

APPENDICES

APPENDIX A: SEA LEVEL ADAPTATION WORKING GROUP ROAD INFRASTRUCTURE ASSESSMENT

Sea Level Adaptation Working Group



Road Infrastructure Assessment

'Wouldst thou" - so the helmsman answered. -"Learn the secret of the sea?
Only those who brave its dangers comprehend its mystery!"

Henry Wadsworth Longfellow

GEOLOGICAL SURVEY Maine Coastal Program

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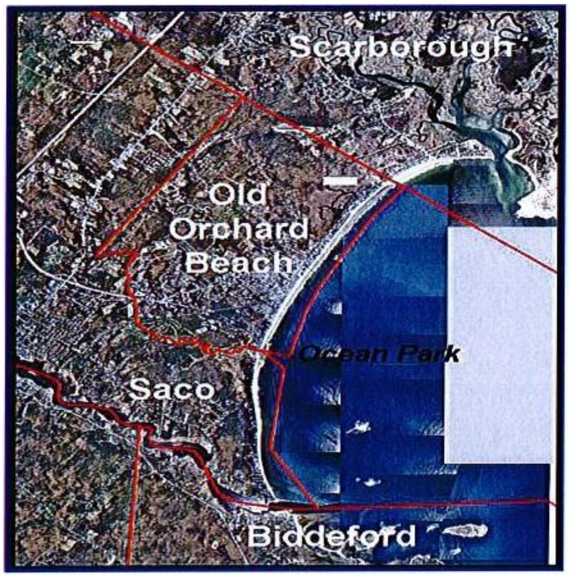
Purpose:
This report was generated by the Saco Bay Sea Level Adaptation Working Group (SLAWG) for the purpose of identifying and assessing the potential impacts of several different scenarios of sea level rise or storm surge on both public and private roads within the Saco Bay region.

The purpose of the Sea Level Adaptation Working Group (SLAWG) is: 1) to review information generated from the Coastal Hazard Resiliency Tools Project related to sea level rise; 2) to create a Vulnerability Assessment for Saco Bay, and 3) to develop and implement an Action Plan of strategies for regional solutions. Previously, the SLAWG completed a Vulnerability Assessment to assess the potential impacts to buildings, roads, and wetlands of two (2) feet of sea level rise on top of the Highest Annual Tide (HAT) and the 1% storm stillwater elevation.



The current report expands on this original analysis to include updated data, and takes a "scenario based approach" to the analysis, using potential sea level rise or storm surge scenarios of 1, 2, 3.3, and 6 feet at the time of HAT or during a 1% storm event. These scenarios are generally considered low, moderate, and high predictions of potential future sea level scenarios, and are consistent with predictions from the US National Climate Assessment (Figure 1). This assessment also provides insight to the potential impacts of landfalling Category 1and 2 hurricanes corresponding with mean high tide. This type of data is integral in developing and updating evacuation plans in the event of a landfalling storm.

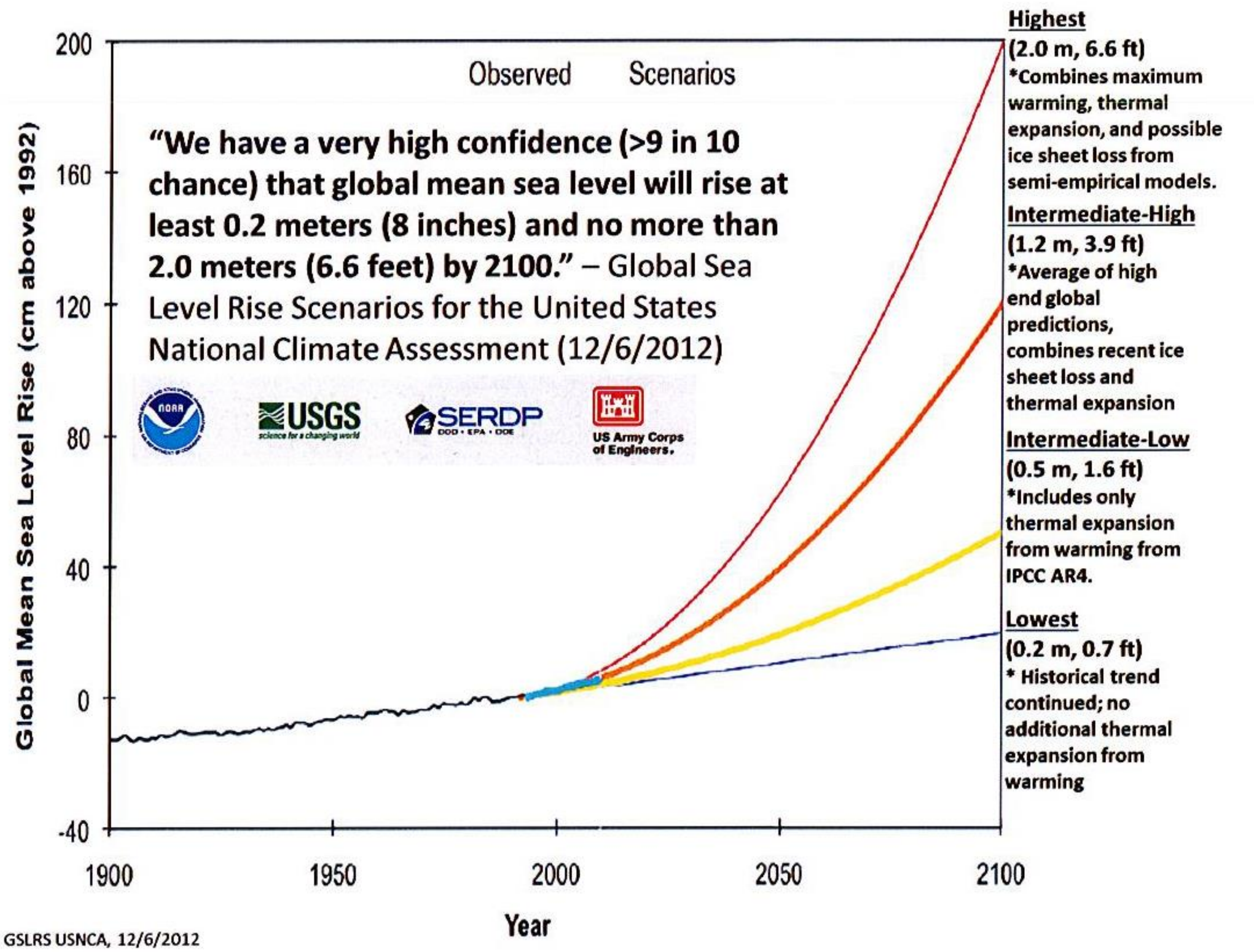
This report can be used to establish a baseline of information for the communities to use both in analyzing potential road impacts in both short and long-term timescales, and furthering the public conversation on the potential impacts of sea level rise and storms. SLAWG recommends that the communities use this data to help guide funding requests for future Capital Improvement Projects in order to be resilient to storms that may compromise road infrastructure in the near future, and the longer-term impacts of sea level rise.

Methods, Assumptions, and Limitations
The SLAWG's technical advisor with the Maine Geological Survey used Light Detection and Ranging (UDAR) topographic data in conjunction with the following datasets to perform this analysis:

- 2013 highest annual tide (HAT) tidal prediction values the closes tidal prediction stations in Saco Bay (available from the National Oceanic and Atmospheric Administration's National Ocean Service). These elevations may vary slightly within each community;
- Published 1% storm (also commonly known as the "100 year storm") stillwater coastal flood elevations from each community's effective FEMA Flood Insurance Study (available from the FEMA Map Service Center). These elevations vary within each community based on location; and

- Stillwater "storm tide" (i.e.,astronomical tides plus storm surge) elevations derived from the National Hurricane Center's Sea Lake and Overland Surges from Hurricanes (SLOSH) modeling program. These elevations vary within each community based on location.

Each of these datasets were imported into a Geographic Information System (GIS), and GIS models were developed and used to query the available LiDAR dataset to determine all land areas below the above



referenced water elevations. These layers were then overlain onto GIS road features available from the Maine Office of GIS to determ ine potentially impacted sections of roads. These were summed and tallied for each community. For each dataset, potential scenarios of 1, 2, 3.3, and 6 feet of sea level rise were then added and impacts to roads assessed.

This analysis is based on several important assumptions, which should be noted.

- The analysis uses what is known as "stillwater" elevations, which are simply static water elevations and do not account for impacts of waves; thus, some of the impacts along the open coast may be under- predicted.
- The analysis does not include the additional impacts of riverine flow or precipitation-driven flooding;
- The simulations of future sea level conditions use a "bathtub" method, which simply assumes that the topography stays static in the future (i.e., there is no erosion or accretion) and that the water level simply rises uniformly;
- To the maximum extent possible, tidally-unconnected low-lying areas were removed from the analysis;
- The topographic data used, LiDAR, represents a "snapshot" in time of the land surface, and ground conditions may have changed since data was collected (which was 2006);
- Results from the National Hurricane Center SLOSH modeling include a +20% error, which is the published inherent potential error of the model; and
- A road was considered "impacted" if any portion of the inundation scenario was shown to encroach onto the road when the scenario was overlain in GIS; a road may not actually be damaged in this case, but will likely be flooded.

Because of these assumptions and limitations, results from these simulations should be considered for **general planning purposes only.**

The Planning Scenarios: Data for Short and Long Term Planning Horizons

As mentioned previously, scenarios of 1, 2, 3.3, and 6 feet of sea level rise were analyzed as part of this study. SLAWG recommends that these scenarios on top of the HAT be considered for both short and long-term planning purposes. From a sea level rise standpoint, some recent scientific studies suggest that one foot of sea level rise by the year 2050 is possible based on current ice sheet melting rates coupled with warming and expansion of the oceans (Rignot and others, 2011). At the same time, these same scenarios correspond very well with storm surges that have statistically occurred at the Portland tidal station over the past 100 years.

Thus, these same scenarios could serve as proxies for storm surges that have occurred in the past and might coincide with higher tides today (Figure 2).

For short-term planning, this analysis also looks at the potential impacts to roads under the current 1% ("100 year storm" scenario), which is based off of the stillwater elevations from the February 7, 1978 Northeaster'. Additionally, the potential impacts from landfalling Category 1and 2 hurricanes, at the time of high tide, can be used to assess impacts from an emergency management preparedness standpoint for tropical events that could occur today.

For longer term planning, each of the sea level rise scenarios used as part of this analysis is considered to be plausible by the year 2100 in the US National Climate Assessment. These scenarios on top of the 1% existing storm can be used to assess the potential impacts should a similar event occur after 1, 2, 3.3, or 6 feet of sea level rise at some point in the future, and is applicable for long term planning efforts.

Thus, a total of 12 different scenarios were used for this analysis - existing conditions for HAT and the 1% event, existing conditions for a Category 1and 2 event at mean high tide, and then sea level rise scenarios of 1, 2, 3.3, and 6 feet on top of both the HAT and the 1% event.

Portland Storm Surges, any tide (1912-2012)

Time Interval (years)	Surge Height (feet)
1 (100 %)	1.8
2 (50%)	2.4
5 (20%)	3.3
10 (10 %)	4.0
20 (5%)	4.7
25 (4 %)	4.9
50 (2 %)	5.6
75 (1.3 %)	6.0
100 (1%)	6.3

These numbers correlate relatively well with overall longer term sea level rise planning!

P.A. Slovinsky, MGS

<u>Initial results: Analysis of Existing and Potential Future Conditions and Potential Impacts</u>

As mentioned previously, "impacted" sections of road were summed for each of the 12 potential inundation scenarios. It is important to note that impacts for each road, the summed distance is provided, but that there may be 3 or 4 different sections of road that are potentially impacted to create that summed distance.

Results of the lengths of potentially impacted roads, in miles, for the overall Saco Bay, including all four communities, are summarized in Table 1.

Community	Highest Annual Tide (+ SLR in feet)					1% Storm Event (+ SLR in feet)					Hurricane	
	HAT	HAT+1	HAT+2	HAT+3.3	HAT+6	1%	1%+1	1%+2	1%+3.3	1%+6	Cat1	Cat2
Scarborough	0.1	2.2	4.8	8.3	17.6	5.3	8.0	10.9	15.7	25.6	15.9	29.8
Old Orchard Beach	1.9	3.3	4.8	7.1	11.0	5.4	7.2	8.4	10.4	13.5	10.5	15.3
Saco	0.0	0.2	1.0	2.5	4.5	1.5	2.5	3.3	4.2	6.0	4.3	7.5
Biddeford	0.1	0.7	1.8	3.6	6.8	1.7	3.0	4.3	5.8	8.8	6.0	10.9
Baywide Totals	2.1	6.5	12.3	21.5	39.8	13.8	20.8	26.9	36.1	53.9	36.8	63.4

Distances of potential roads impacted in miles

Table 1. Potential distances, in miles, of roads impacted within the entire Saco bay region, under existing and potential future scenarios of sea level rise.

From a baywide perspective, the majority of potential impacts to roads under existing scenarios {HAT, 1% storm, and the hurricane events) are within the communities of Scarborough and Old Orchard Beach. For the existing HAT, impacts are mostly limited to within the Old Orchard Beach Ocean Park area. However, because a tide gate is used to restrict flow into these areas and can stop inundation up to about 12 – 12.5 feet MLLW, these impacts actually do not occur until the tide gate would be breached or if it were left open. This analysis assumes that the tide gate would be left open, so results here are a bit misleading, but are still useful from a planning perspective. Of the 4 communities, overall impacts for both existing and potential future scenarios are generally smallest within Saco, and highest within Scarborough.

Community based Analysis

The road impacts in each community were classified using a color-coded scheme as shown in Table 2. This data was reviewed with each Public Works department, and was determined to be a good way of summarizing the results of this roads impact analysis. Note again that distances are summed lengths of roads that may be impacted, and may include several sections. *The City of Saco decided that the 0-10ft and 11-50 ft classes be joined into one class of 0-50ft*

No to little impact	Some Impact	Moderate Impact	Major Impact	Severe Impact
0-10 ft	11-50 ft	50-100 ft	100-500 ft	500+ ft (or entire road)

Table 2. Classification scheme used to assess potential impacts to roads.

For each community, tables have been prepared that summarize the potential impacts to roads from each scenario. The tables include each potentially impacted road name, road classification (by Maine DOT), and the summed distance (in linear feet) of potential impacts under each scenario. The summed distances may include several sections of roads impacted. Each community's table also provides summed distances for the entire community, at the bottom of the table, for each scenario. These tables are provided in separate appendices for each community (north to south), as follows:

- Appendix A - Town of Scarborough
- Appendix B - Town of Old Orchard Beach
- Appendix C - City of Saco
- Appendix D - City of Biddeford

Impacts to each community's roads are discussed in the sections on the following few pages. Please refer to the tables in the appropriate appendices for each community.

Additionally, the SLAWG technical staff met with the Public Works Directors/Engineers from all 4 communities individually to review this preliminary data in order to help gather their thoughts on establishing priorities and basic cost data associated with reconstruction of streets in order to begin a Capital Improvements program on a regional level for the communities individually and collectively. Highlights of some of these discussions will be noted.

Scarborough (Appendix A)
Highest Annual Tide Scenarios
Under existing HAT, only 4 total roads (2 public) are impacted, including Sawyer Road and Winnocks Neck Road, accounting for only 0.1 miles of impacted roads. However, with 1foot of sea level rise (or storm surge), this increases to 31 roads, 20 of which are private, for a total of 2.2 miles. As the scenarios increase (for 2, 3.3, and 6 feet) on top of HAT, the overall number of roads increases significantly to 49, and 72 roads (and 4.8, 8.3, and 17.6 miles of impacts). The most important potential impacts to public roads are to Route 1, Pine Point Road, Payne Road, Black Point Road, Winnocks Neck Road, and the Eastern Trail Road.

1% storm scenarios
Under the existing 1% storm, 50 roads may be impacted to some extent. This number increases to 67, 81, 115, and 148 roads under scenarios of 1, 2, 3.3, and 6 feet of sea level rise. The mileage of roads potentially impacted is 5.3, 8.0, 10.9, 15.7, and 25.6, respectively. The most impacted public roads are similar to the HAT scenarios.

Category 1 and 2 hurricanes
For a Category 1event, up to 15.9 miles of road and 163 roads are impacted. Under the worst case scenario (a Category 2 storm making landfall at high tide), 166 roads and up to almost 30 miles of road are potentially impacted. Of these, 108 are publicly owned.

Highlights of Discussions with Public Works/Engineering
One of the most vulnerable roads in Scarborough appears to be Route 1, and Pine Point Road (Route 9), both state roads. The Town works with Maine DOT to maintain Route 1every few years, as the road appears to be sinking into the marsh. At Route 9, Maine DOT is working to replace the bridge over the train tracks. SLAWG and the Town have identified the culvert under Route 9 as an issue, but it will likely not be addressed by Maine DOT with the bridge reconstruction. Black Point road, identified as a road with severe vulnerability, is in the towns FY'15 budget to have a portion of that road reconstructed. As part of this exercise it has been determined by the Public Works Director that by potentially adding additional pavement in one segment of the road may help delay inundation due to HAT and HAT+l foot.

Old Orchard Beach (Appendix B)

Highest Annual Tide Scenarios

Old Orchard Beach's roads, notably in Ocean Park, appear to be the most heavily impacted under existing HAT conditions, though that is a bit misleading since the analysis assumes that the tide gate at New Salt Road in Ocean Park is removed. If the tide gate failed or was not closed correctly (as happened during the Patriots' Day Storm of 2007), inundation from the normal HAT would impact potentially 32 roads, for a total of 1.9 miles, the most of any community. With increased sea level rise (or storm surge scenarios of 1, 2, 3.3, or 6 feet), those numbers increase to 35 roads and 3.3 miles, 43 roads and 4.8 miles, 57 roads and 7.1miles, and 92 roads and 11miles. The most at-risk major roads include West Grand Ave., East Grand Ave., Temple Ave ., Milliken St., Seaside Ave., Walnut St., and Randall Ave .

1% Storm Scenarios

Under the existing 1% event, West Grand Ave. and Seaside Ave. are most at-risk, but there are a total of 47 roads impacted, or 5.4 miles vulnerable. With increased sea level rise (1, 2, 3.3, or 6 feet), those numbers increase to 57 roads and 7.2 miles,60 roads and 8.4 miles, 105 roads and 10.4 miles, and 106 roads and 13.5 miles. The same roads as under the HAT scenarios are most at-risk.

Category 1 and 2 hurricanes

Under these scenarios, anywhere between 10.5 and 15.3 miles of roads could potentially be inundated to some extent, with the worst impacts along East and West Grand Avenues.

Highlights of Discussions with Public Works/Engineering

Discussions with Public Work s identified that Walnut Street, from Milliken St to Portland St, is already on the list of near-term improvements, and consideration could be given to increasing the elevation of Walnut Street. Other priority roads currently noted for improvements were Temple Street and West Grand Ave.

Saco (Appendix C)

Highest Annual Tide Scenarios

Under the existing highest annual tide, Saco has no roads that appear to be impacted. This increases slightly to 7 roads and 0.2 miles under a scenario of 1foot of sea level rise or storm surge. The major road potentially impacted includes Seaside Avenue (Route 9). With additional increased sea level rise (or storm surge scenarios of 2, 3.3, or 6 feet), those numbers increase to 20 roads and 1miles, 29 roads and 2.5 miles, and 37 roads and 4.5 miles. The majority of impacts are in the northern end of Saco, nearest Goosefare Brook, and in the Camp Ellis neighborhood. Seaside Avenue remains the major road that is most vulnerable under these scenarios.

1% Storm Scenarios

The existing 1% storm potentially inundates 22 roads and 1.5 miles, the majority within ????. With additional scenarios (1, 2, 3.3, and 6 feet), these numbers increase to 29 roads and 2.5 miles, 34 roads and 3.3 miles, 37 road and 4.2 miles, and 43 roads and 6.0 miles, respectively. Under the higher 2 scenarios, almost all of Seaside Avenue is inundated, as are most of the side streets in Camp Ellis and Seaside.

Category 1 and 2 hurricanes

Under a Category 1 scenario, about 4.3 miles of roads may be impacted, while under a Category 2 storm, up to 7.5 miles of road may be inundated. This includes almost all roads in the south, almost all of Seaside Ave., and all roads near Goosefare Brook.

Highlights of Discussions with Public Works/Engineering
Saco has already taken the steps to abandon a section of Surf Street after the 2007 Patriots' Day Storm. Saco has immediately identified a need to consider Ferry Road and Lower Beach Road as near term projects relating to SLR other than the most immediate need of addressing the Camp Ellis project.

Biddeford (Appendix D)
Highest Annual Tide Scenarios
In Biddeford, approximately 0.1miles of road, most notably Fortunes Rocks Road and Granite Point Road, are potentially impacted under the existing HAT. With the addition of 1foot of either storm surge or sea level rise, this increases to 0.7 miles from 9 different roads, with the most extensive impacts along Mile Stretch Road and Granite Point Road. Under the additional scenarios (2, 3.3, and 6 feet), impacts increase to 14 roads and 1.8 miles, 25 roads and 3.6 miles, and 44 roads and 6.8 miles. Under these scenarios, Fortunes Rocks, Mile Stretch, Granite Point, and Hills Beach Road are most vulnerable.

1% Storm Scenarios
For the existing 1% storm event, simulations show that 15 roads and 1.7 miles may be inundated, with the majority of impacts along Granite Point Road, Mile Stretch Road, and Timber Point Road. As sea level rise is added (1, 2, 3.3, and 6 feet), these numbers climb to 21 roads and 3 miles, 27 roads and 4.3 miles, 42 roads and 5.8 miles, and 59 roads and 8.8 miles, respectively. Again, Fortunes Rocks, Mile Stretch, Granite Point, Hills Beach Road, and Timber Point Road are most impacted.

Category 1 and 2 hurricanes
For an existing Category 1event, approximately 6.0 miles of roads may be impacted. Under a Category 2 storm, this increases to almost 11miles of roads.

Highlights of Discussions with Public Works/Engineering
Based on discussions, much of Biddeford's concern is not having the committed dollars to address the improvements needed. They have identified several areas that could be considered in an incremental manner to start making progress toward SLR impacts. Those areas include: Mile Stretch Road, Hills Beach Road and Granit Point/Sea Spray, which currently sees over flows at the current HAT levels. A known problem location is at the eastern end of Mile Stretch Road, which is low-lying and undergoes inundation during highest tides today.

Status of Community Resiliency and Adaptation Efforts
Each community, though a member of SLAWG and is working regionally on sea level rise issues, has undertaken some of its own efforts to further resiliency and adaptation.

Scarborough: Of the four communities, Scarborough appears to be the farthest along in terms of developing information relevant to data collection and looking at various aspects of sea level rise and storm surge. Not only has the community been a member of the SLAWG group, but they have had additional data gathering and analysis occurring under a separate grant received as a "Project of Special Merit" from the National Oceanic and Atmospheric Administration, and administered through the Department of Agriculture, Conservation and Forestry to assess the potential impacts of sea level rise on marsh migration, since the Scarborough River is home to the largest expanse of coastal wetlands in the state. There was a previous effort in Scarborough to implement an increased freeboard standard (see Saco, below), but that was met with some opposition in the general public until the preliminary FEMA floodplain map process was resolved. Scarborough, to date, has not undertaken any municipal ordinance changes relevant to sea level rise or storm surge.

Old Orchard Beach: In Old Orchard Beach, there has been a focus on resiliency efforts in the Ocean Park neighborhood, at the southern end of town, adjacent to Goosefare Brook. This community was heavily impacted by ocean flooding during the Patriots' Day Storm of 2007. This helped spearhead the Town's efforts, including involvement in SLAWG. Since then, the town has been an active SLAWG participant, and was one of two SLAWG communities (with Saco) to remap its regulatory Shoreland Zone using HAT data and LiDAR. It has also undertaken efforts for flood control Walnut Street through the dredging of the freshwater channel leading to Jones Creek, and has investigated flood control berms around New Salt Road. Also, Old Orchard Beach is currently updating its Comprehensive Plan and is considering the subject of SLR within the context of the document.

Saco: Saco has been extensively involved in coastal hazard and resiliency issues for many years, mostly through the Camp Ellis neighborhood and the federal US Army Corps of Engineers project associated with the Saco River jetties. These efforts have touched mostly on shoreline protection and jetty modification to mitigate for the erosion caused by the federal jetty at Camp Ellis. In 2009, the City decided to remove a section of Surf Street, after it was extensively damaged by the Patriots' Day storm of 2007. This section of Surf Street was being damaged each year. Saco was the first community in the State, and in the northeast, to implement a floodplain management ordinance that included three feet of freeboard (this effort was attempted in Scarborough as well). In addition, Saco, like Old Orchard Beach, used the LiDAR-derived Highest Annual Tide to remap its regulatory Shoreland Zone.

Biddeford: Biddeford has been a member of SLAWG since its inception, and has held some public discussions on sea level rise impacts within the community. The community has not undertaken any modifications to existing ordinances to account for sea level rise or storms, and has not created any new ones to date.

Suggestions for Moving Forward

The SLAWG makes some of the following suggestions for moving forward with this assessment.

Start small but think big. Originally, SLAWG hoped to investigate not only potential road impacts, but impacts to associated utilities such as stormwater, sewer, culverts, etc. SLAWG decided, at this point, to focus solely on road impacts. However, communities should consider the impacts to larger associated public infrastructure systems, and the different players (local, regional, and state) that may need to be involved. Considering infrastructure improvements to at-risk roads only will automatically bring many of these other systems into consideration.

Act locally but think regionally. This assessment was prepared for each community individually, and each community has its own set of issues to deal with, and in most cases, will choose to undertake adaptation on its own. However, storm surge and sea level rise related impacts do not know geopolitical boundaries, and there are many streets that are interconnected between communities, creating a networked, regional issue. It will make sense for neighboring communities that share roads to coordinate and plan improvements together to the extent practicable. Specifically, abutting communities should work together to evaluate evacuation routes to determine if the current routing system makes sense or should other alternative be considered. Impacts of Category 1and 2 Hurricane events need to be considered closely by Emergency Management Agencies. The EMA's should coordinate Table top exercises on a yearly basis to determine the sufficiency of the evacuation methods and routes in order to move people out of harm's way in an early and orderly fashion since the storm events will critically impact those designated evacuation routes.

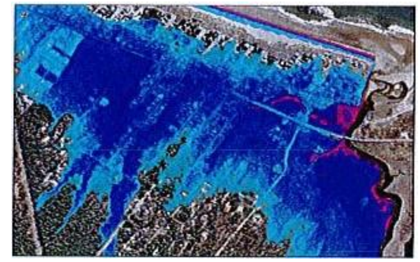
Consider different timeframes in planning and planning goals. The datasets used to assess road vulnerability to sea level rise and storms considers several different planning horizons - both short and long-term. In a short- term sense, existing condition scenarios such as Highest Annual Tide, the 1% event, and land/ailing hurricane events illustrate currently vulnerable infrastructure. That said, it is unlikely that communities would try to engineer structures to withstand a landfalling Category 2 storm; instead, that data should be used more for evacuation planning purposes. The "sea level rise" scenarios of 1, 2, 3.3, and 6 feet on top of the Highest Annual Tide can be used for both short and long term planning. Short-term in the sense that each of these scenarios could statistically occur as storm surge on top of the existing highest annual tide today. This would result in inundation of a road surface, but not for long periods of time. From a sea level rise planning standpoint, consideration of one foot of sea level rise by the year 2050, and the potential for 2-3 feet, and maybe more, are good short and long-term planning horizons. Communities need to continue to be diligent in designating CIP projects to the list that will address Sea level rise and storm events in the future.

Consider regulatory environmental factors. Consider regulatory environmental factors. SLAWG examined (as an example the Highest Annual Tide plus 3.3 foot scenario) some of the potential constraining environmental factors to engineering or adaptation efforts of municipal roads. These included whether or not the road is located within a regulated coastal sand dune (either frontal dune, D1, or back dune D2, or in an Erosion Hazard Area, or EHA); or the existing mapped 100-year floodplain, per the preliminary FEMA maps (either a VE-zone, AO-zone, AE zone, 0.2 percent chance or 500-year zone, or an X-zone, outside of the 500- year floodplain). This will help guide how a road may be adapted under existing regulatory language.

The results of this analysis are provided behind each table in the appendix designated by community. Any improvements should be sure to meet other environmental or regulatory constraints such as habitat, shoreland zoning, and other Land use related regulatory requirement s.

Continued Education is required. Continued education of citizenry is required in order to educate the public on impacts to the infrastructure and the financial implications of doing nothing.

On going infrastructure analysis. Additional study is required in order to look at the other infrastructure pieces such as sewer treatment plants, pump stations, etc...



Appendix A

No to little impact	Some Impact	Moderate Impact	Major Impact	Severe Impact
0-10 ft	11-50 ft	50-100 ft	100-500 ft	500+ ft*

** or entire road*

Appendix A: Assessment of Potential Impacts to Roads: Town of Scarborough

Road Name	Road Class	Highest Annual Tide (+ SLR in feet)					1% Storm Event (+ SLR in feet)					Hurricane	
		HAT	HAT+1	HAT+2	HAT+3.3	HAT+6	1%	1%+1	1%+2	1%+3.3	1%+6	Cat1	Cat2
Alden Ln	Private										226		463
Arrowhead Ln	Private		11	270	355	355	289	355	355	355	355	355	355
Ashton St	Local					71				68	213	44	352
Autumn Ln	Private					91				47	254	59	254
Avenue 1	Local		147	175	235	535	189	279	323	485	669	472	669
Avenue 2	Local		135	178	228	411	192	228	365	399	440	404	440
Avenue 3	Local			92	255	417	129	251	384	417	417	417	417
Avenue 4	Local		57	138	371	371	164	371	371	371	371	371	371
Avenue 5	Local			161	448	763	253	445	551	707	818	714	818
Avenue 6	Local			28	233	233	28	233	233	233	233	233	233
Avenue 7	Local			132	155	155	139	155	155	155	155	155	155
Avenue B	Private				29	53		23	35	48	68	52	84
Bay St	Local										321		321
Bayberry Ln	Local					809				415	1090	758	1090
Bayview Ave	Local			244	474	846	294	478	639	829	953	773	1293
Baywoods Dr	Local				27	919			288	775	959	738	959
Beach St	Local					65				44	313	47	313
Beech Ridge Rd	Minor Collector					397			74	335	611	328	791
Birch Ln	Private				97	212			85	203	319	169	438
Black Point Rd	Major/urban collector		1558	1994	2998	7483	1955	2849	4958	6552	9377	6348	11828
Black Rock Rd	Private	30	518	853	1524	2097	949	1541	1700	2033	2423	2022	2423
Blaine Ave	Private				85	127		77	86	98	162	106	162
Bliss St	Local					186				105	309	128	309
Bornheimer Pl	Local										201		550
Campus Dr	Private												121
Canterbury Ln	Private					112				80	638	52	775
Catherine Dr	Local					6					968	6	968

Road Name	Road Class	Highest Annual Tide (+ SLR in feet)					1% Storm Event (+ SLR in feet)					Hurricane	
		HAT	HAT+1	HAT+2	HAT+3.3	HAT+6	1%	1%+1	1%+2	1%+3.3	1%+6	Cat1	Cat2
Cattail Ln	Private					198				185	198	192	198
Cedar Cir	Local				70	517		63	242	463	585	476	585
Champion St	Local		132	327	387	387	338	387	387	387	387	387	387
Chase Deer Ln	Private				66	365		69	282	325	365	333	365
Claudia Way	Private					464				428	464	352	464
Clay Pits Rd	Local			320	1101	2517	483	1071	1673	2361	2668	2398	2748
Clearwater Dr	Local					215			95		1551	188	2569
Cloutier Ln	Private										294		459
Coachlantern Ln E	Local					499				339	793	400	793
Coachlantern Ln W	Local					123				114	820	133	820
Cottage Ln	Private												259
Coulthard Farms Rd	Local					483			112	446	896	383	996
Country Club Rd	Private												540
Dover St	Local					206				120	279	108	279
Driftwood Ln	Local				312	610		312	527	586	770	587	1087
Dunefield Ln	Local					297				228	430	192	430
Dunstan Landing Rd	Local				33	153		37	82	145	257	142	280
E Grand Ave	Major/urban collector					2447				2047	3331	2119	3331
Eastern Rd Marsh	Private/Local		2009	3511	4235	7078	3616	4503	5686	7302	9027	7233	10701
Eleventh St	Local					86					181		181
Emily Way	Private					216				207	216	211	216
Farmhouse Rd	Local												112
Fern Cir	Local				25	609		30	427	609	609	609	609
Ferry Rd	Private				262	421		261	310	404	1336	388	1800
Fogg Rd	Local				41	851		0	48	512	1966	540	2471
Garrison Ln	Private			252	683	902	393	717	808	887	903	871	903
Gorham Rd	Minor arterial												374
Grandview Dr	Local					165				134	413	114	436
Granite St	Local					242				148	275	149	275

No to little impact	Some Impact	Moderate Impact	Major Impact	Severe Impact
0-10 ft	11-50 ft	50-100 ft	100-500 ft	500+ ft*

* or entire road

Road Name	Road Class	Highest Annual Tide (+ SLR in feet)					1% Storm Event (+ SLR in feet)					Hurricane	
		HAT	HAT+1	HAT+2	HAT+3.3	HAT+6	1%	1%+1	1%+2	1%+3.3	1%+6	Cat1	Cat2
Greenwood Ave	Local										215		321
Hackmatack Dr	Local					166				61	450	101	825
Hampton Cir	Local					224				36	1010	35	1010
Harmon St	Private										267		553
Harmons Is	Private		452	650	705	865	644	706	761	838	1080	814	1322
Hawthorn Cir	Local				357	607		157	561	607	607	607	607
Hemlock Cir	Local				291	596		70	538	596	596	596	596
Higgins Creek Rd	Private					266			69	250	347	265	420
Horseshoe Dr	Local										1139		1543
Hummingbird Ln	Private					244				224	244	244	244
Hunnewell Ave	Private		58	135	215	344	167	207	260	313	426	321	479
Hurdle Fence Rd	Private					33					296		305
Indian Woods Rd	Private										89		287
Iris Dr	Local										213		301
Jones Creek Dr	Local		64	480	1191	2244	783	1170	1875	2244	2244	2244	2244
Kent St	Local		2	28	83	83	37	83	83	83	83	83	83
Kimball Dr	Local					7					268		268
King St	Local		290	586	1586	2518	711	1616	1706	2233	3006	2411	3006
Kingfisher Dr	Local												69
Lane By The Sea	Private		2	36	72	319	38	67	154	319	319	319	319
Lincoln Ave	Local										174		337
Longwave Pl	Private					144				128	219	137	219
Manson Libby Rd	Private					464			84	391	1404	422	2577
Marginal Way	Private		15	65	259	867	63	261	508	908	1692	671	2017
Massacre Ln	Private		54	236	973	1118	383	979	1036	1089	1136	1071	1136
Melbourne Dr	Local				52	654		59	370	595	654	580	654
Milliken Rd	Local			141	234	399	179	242	345	391	494	383	527
Moonlight Dr	Private					267				253	267	267	267
Moors Point Rd	Private					412				79	498	280	498

No to little impact	Some Impact	Moderate Impact	Major Impact	Severe Impact
0-10 ft	11-50 ft	50-100 ft	100-500 ft	500+ ft*

* or entire road

Road Name	Road Class	Highest Annual Tide (+ SLR in feet)					1% Storm Event (+ SLR in feet)					Hurricane	
		HAT	HAT+1	HAT+2	HAT+3.3	HAT+6	1%	1%+1	1%+2	1%+3.3	1%+6	Cat1	Cat2
Morning St	Local				344	579	32	371	494	578	627	560	757
Ninth St	Local					74					231	50	231
Nonesuch Cove Rd	Local					768			427	722	942	732	1062
Oak St	Local					262			110	246	379	247	379
Ocean Ave	Local				93	366		105	243	342	508	325	1314
Oceanwood Dr	Private												72
Old Blue Point Rd	Local												128
Old Colony Ln	Private										288		352
Old County Rd	Local					1219			168	886	2669	935	2669
Old Neck Rd	Local			389	804	3000	433	751	1232	2637	3804	2625	3804
Olde Mill Rd	Local					199				90	966	201	966
Orchard St	Local										46		76
Oriole Way	Private												249
Osprey Ln	Private		127	369	442	550	403	449	550	550	550	550	550
Partridge Ln	Local				698	1368	35	718	1026	1343	1368	1368	1368
Payne Rd	Major/urban collector		725	1250	1516	2037	1297	1520	1735	1950	2448	1947	2536
Pearl St	Local												38
Phinneas Ln	Local					121					652	99	763
Pillsbury Dr	Local										891		1117
Pine Point Rd	Major/urban collector		292	2996	4766	5390	3187	4764	5091	5329	5749	5316	5943
Pine St	Local					129				82	297	81	297
Pinewood Cir	Private					66				17	740		924
Pintail Point Dr	Local					52				38	1140	129	1239
Pleasant Hill Rd	Major/urban collector					49					332		424
Plover Ln	Local												11
Primrose Ln	Local												33
Prospector Ln	Local												173
Reef Ln	Private					439			117	439	439	439	439
Rhonda Dr	Local					123					786	3	786

No to little impact	Some Impact	Moderate Impact	Major Impact	Severe Impact
0-10 ft	11-50 ft	50-100 ft	100-500 ft	500+ ft*

* or entire road

Road Name	Road Class	Highest Annual Tide (+ SLR in feet)					1% Storm Event (+ SLR in feet)					Hurricane	
		HAT	HAT+1	HAT+2	HAT+3.3	HAT+6	1%	1%+1	1%+2	1%+3.3	1%+6	Cat1	Cat2
River Bend Ln	Private				250	407		294	407	407	407	407	407
River Sands Dr	Local					136					1348	25	1351
Rose Hill Way	Local										133		149
Ross Rd	Local				56	199				107	337	132	477
Roundabout Dr	Private			208	469	664	285	447	541	634	776	645	840
Route 1	Minor arterial		2179	3158	3625	4117	3101	3506	3802	3948	4247	4060	4867
Running Tide Dr	Private					471				220	788	259	788
Saccarappa Ln	Local		246	500	655	851	533	663	779	849	920	819	920
Sandpiper Cove Rd	Private												121
Sandy Point Rd	Local										321		491
Sargent Rd	Local			70	137	384	92	146	212	351	568	326	603
Sawyer St	Local	206	715	875	973	1070	851	951	984	1041	1138	1062	1235
Scottow Hill Rd	Local		48	62	235	361	144	239	282	353	478	339	504
Sea Meadows Ln	Private			25	72	173	28	66	107	158	219	164	219
Sea Rose Ln	Local					16					332		332
Seavey Landing Rd	Local			36	96	404	49	115	289	319	504	363	587
Shipwreck Ln	Local			5	449	549	143	444	549	549	549	549	549
Smithers Way	Private					48				16	188		408
Snow Canning Rd	Local		980	1144	1280	1369	1168	1288	1321	1357	1426	1351	1426
Southgate Rd	Local				143	759		144	361	669	1354	627	1622
Sprague Way	Private										15		73
Spruce Cir	Local					587				587	587	587	587
Spurwink Rd	Major/urban collector		16	20	72	365	26	61	205	340	948	316	2242
Starbird Rd	Local		117	367	634	854	546	637	714	812	957	786	1011
Stone Rd	Private												420
Strawberry Fields Ln	Private												51
Summerfield Ln	Private												62
Tall Pines Rd	Local				142	2677			63	1964	3152	2112	3200
Tasker Ave	Local			67	147	333	98	144	266	333	333	333	333

No to little impact	Some Impact	Moderate Impact	Major Impact	Severe Impact
0-10 ft	11-50 ft	50-100 ft	100-500 ft	500+ ft*

* or entire road

Road Name	Road Class	Highest Annual Tide (+ SLR in feet)					1% Storm Event (+ SLR in feet)					Hurricane	
		HAT	HAT+1	HAT+2	HAT+3.3	HAT+6	1%	1%+1	1%+2	1%+3.3	1%+6	Cat1	Cat2
Tenney Ln	Local												98
Tenth St	Private					58					162		162
Thomas Dr	Local					551				199	1880	161	1880
Tide Mill Ln	Private		59	176	257	412	175	236	305	354	484	379	484
Trostle Ln	Private					225				207	225	190	225
Val Ter	Local										165		569
Verrier Ln	Private										127		311
Vesper St	Local			326	628	738	506	628	705	737	854	719	939
Virdap St	Private	98	233	348	352	352	352	352	352	352	352	352	352
Washington Ave	Local					113				59	230	73	774
Whispering Surf Ln	Private				82	240		67	156	240	240	240	240
Whistler Lndg	Local										153		300
White Sands Ln	Private			84	302	302	110	302	302	302	302	302	302
Wildrose Ln	Private					35				30	106	21	143
Wiley Way	Private		261	510	722	826	616	723	765	825	893	809	893
Willowdale Rd	Local			72	69	300		70	120	259	389	253	418
Winnocks Neck Rd	Local	21	366	1232	2436	4524	1253	1783	2949	3746	6072	4086	6257
Winnocks Neck Sq	Private					138			86	130	225	117	225
Wood Ln	Local					97					319		364
Woodrock Dr	Local					342		44	86	263	705	222	815
Woodside Dr	Local		3	35	121	318	45	117	196	282	509	286	609
Woodview Dr	Local										121		187
Wynmoor Dr	Local					362				28	1376		1750
TOTALS (in feet)		**355**	**11871**	**25357**	**43809**	**93122**	**27922**	**42501**	**57729**	**83043**	**135081**	**84185**	**157524**
TOTALS (in miles)		**0.1**	**2.2**	**4.8**	**8.3**	**17.6**	**5.3**	**8.0**	**10.9**	**15.7**	**25.6**	**15.9**	**29.8**

NOTES: Highest Annual Tide based on the 2013 predicted value from NOAA for tidal stations in the community
All distances referenced are in linear feet of road, unless otherwise specified
A combination of Maine E911 Roads NextGen and Maine DOT Roads layers were used for the analysis

No to little impact	Some Impact	Moderate Impact	Major Impact	Severe Impact
0-10 ft	11-50 ft	50-100 ft	100-500 ft	500+ ft*

** or entire road*

Example of Regulatory Restriction Analysis for HAT + 3.3 ft Scenario – Scarborough, ME

Road Name	Road Class	Length of Road (ft)	Existing* Flood Zone	Dune Bounds**
Arrowhead Ln	Private	355	AE	D2
Avenue 1	Local	235	AE	D2
Avenue 2	Local	228	AE	D2
Avenue 3	Local	255	AE	D2
Avenue 4	Local	371	AE	D2
Avenue 5	Local	448	AE	D2
Avenue 6	Local	233	AE	D2
Avenue 7	Local	155	AE	D2
Avenue B	Private	29	AE	
Bayview Ave	Local	474	AO, AE	D2, EHA
Baywoods Dr	Local	27		
Birch Ln	Private	97		
Black Point Rd	Major/urban collector	2998	AE, 0.2 PCT, X	
Black Rock Rd	Private	1524	VE, AE	D1, D2
Blaine Ave	Private	85	0.2 PCT, X	D2
Cedar Cir	Local	70		
Champion St	Local	387	AO, AE	D1, D2, EHA
Chase Deer Ln	Private	66	AE, X	
Clay Pits Rd	Local	1101	AE	
Driftwood Ln	Local	312	AE	D2
Dunstan Landing Rd	Local	33	AE, X	
Eastern Road Marsh	Private/Local	4235	AE	
Fern Cir	Local	25	0.2 PCT, X	
Ferry Rd	Private	262	AE	D2
Fogg Rd	Local	41		
Garrison Ln	Private	683	AO, AE	D2, EHA
Harmons Is	Private	705	AE, X	
Hawthorn Cir	Local	357	0.2 PCT	
Hemlock Cir	Local	291	0.2 PCT	
Hunnewell Ave	Private	215	AE	
Jones Creek Dr	Local	1191	AE	D2
Kent St	Local	83	AO, AE	D2, EHA
King St	Local	1586	AE	D2
Lane By The Sea	Private	72	AE, 0.2 PCT	D2
Marginal Way	Private	259	VE	
Massacre Ln	Private	973	AE	D2
Melbourne Dr	Local	52	X	
Milliken Rd	Local	234	AE	

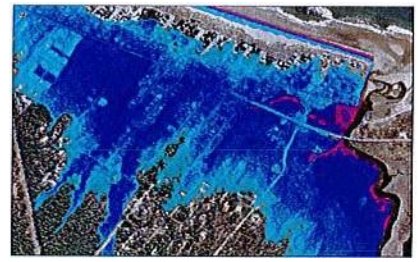
Morning St	Local	344	A0,0.2 PCT	D2, EHA
Ocean Ave	Local	93	AE	

Old Neck Rd	Local	804	AE, X	
Osprey Ln	Private	442	AE	
Partridge Ln	Local	698	AE, 0.2 PCT, X	
Payne Rd	Major/urban collector	1516	AE,X	
Pine Point Rd	Major/urban collector	4766	AE, 0.2 PCT, X	D2
River Bend Ln	Private	250	AE	
Ross Rd	Local	56		
Roundabout Dr	Private	469	AE	
Route 1	Minor arterial	3625	AE, 0.2 PCT	
Saccarappa Ln	Local	655	AE,X	D2
Sargent Rd	Local	137	AE, X	
Sawyer St	Local	973	AE	
Scottow Hill Rd	Local	235	AE, X	
Sea Meadows Ln	Private	72	0.2 PCT	D2
Seavey Landing Rd	Local	96	AE, 0.2 PCT	
Shipwreck Ln	Local	449	AO	D1, D2, EHA
Snow Canning Rd	Local	1280	AE, X	
Southgate Rd	Local	143	AE, 0.2 PCT	
Spurwink Rd	Major/urban collector	72	AE, 0.2 PCT	
Starbird Rd	Local	634	AE, X	
Tall Pines Rd	Local	142		
Tasker Ave	Local	147	AE, 0.2 PCT	D2
Tide Mill Ln	Private	257	AE,X	
Vesper St	Local	628	AO, AE, X	D1, D2, EHA
Virdap St	Private	352	AO,AE	D2, EHA
Whispering Surf Ln	Private	82	AE	
White Sands Ln	Private	302	AO, AE	D2
Wiley Way	Private	722	AE, X	
Willowdale Rd	Local	69	AE, X	
Winnocks Neck Rd	Local	2436	AE, 0.2 PCT, X	
Woodside Dr	Local	121	AE	

**analysis based on preliminary FEMA Flood Mapping products from 2013*

***analysis based on the effective coastal sand dune boundaries, as delineated by MGS*

Symbol	Explanation
D1	Frontal Dune
D2	Back Dune
EHA	Erosion Hazard Area (all D1 in EHA)
VE	V-zone, known elevation
AO	AO zone
AE	A-zone, known elevation
A	A-zone, known elevation
0.2 PCT	Between 100 and 500 yr flood zone
X	Above 500-yr flood zone



Appendix B

Appendix B: Assessment of Potential Impacts to Roads, Town of Old Orchard Beach

No to little impact	Some Impact	Moderate Impact	Major Impact	Severe Impact
0-10 ft	11-50 ft	50-100 ft	100-500 ft	500+ ft*

** or entire road*

Road Name	Road Class	Highest Annual Tide (+ SLR in feet)					1% Storm Event (+ SLR in feet)					Hurricane	
		HAT	HAT+1	HAT+2	HAT+3.3	HAT+6	1%	1%+1	1%+2	1%+3.3	1%+6	Cat1	Cat2
ALDINE TERR	Local					37				33	124	39	237
ANCONA AV	Local	174	225	346	468	567	387	472	567	567	567	567	567
ATLANTIC AV	Local					102				87	255	86	393
AZALEA ST	Local					15					106		252
BAKAM ST	Local			125	172	172	164	172	172	172	172	172	172
BAY AV	Local					18					165		226
BEACH ST	Local					188				113	316	119	316
BEATRICE WY	Local				67	123	33	74	123	123	123	123	123
BOISVERT ST	Local					49				33	150	43	286
BRADBURY ST	Local			192	192	192	192	192	192	192	192	192	192
BRIDGE ST	Local					25				20	384	59	761
BRISSON ST	Local					33				28	151	35	296
BROWN ST	Local					51				42	205	49	322
CAMP COMFORT AV	Local										139		320
CARL SMITH RD	Local					29				23	107	28	258
CARLL AV	Local			34	223	401	116	234	323	387	467	385	537
CASCO AV	Local	53	139	269	439	481	337	439	461	477	519	487	544
CASCO AV EXT	Local	74	147	241	497	873	306	503	534	873	873	865	873
CLEAVES ST	Local					36				30	125	36	304
COLBY AV	Local	487	875	1211	1741	1987	1401	1747	1878	1987	1987	1987	1987
CONN AV	Local										144		882
CONN AV EXT	Local				342	387	15	345	387	387	387	387	387
CONNECTICUT EXT	Local												37
CORTLAND ST	Local					23					173	9	316
DUBE AV	Local					44				31	206	43	300
DUNE ST	Local					38					360		524
DUROCHER ST	Local					361			243	361	361	361	361

Road Name	Road Class	Highest Annual Tide (+ SLR in feet)					1% Storm Event (+ SLR in feet)					Hurricane	
		HAT	HAT+1	HAT+2	HAT+3.3	HAT+6	1%	1%+1	1%+2	1%+3.3	1%+6	Cat1	Cat2
E GRAND AV	Major/urb collector			687	4085	8824	1343	4154	4847	7839	9107	8034	9107
ELEVENTH AV	Local												304
FERNALD ST	Local					111				24	280	25	280
FIRST ST	Local					424				363	1657	372	2224
FOOTE ST	Local			356	537	695	417	538	615	678	776	673	834
FOURTH AV	Local					23					185		282
FOURTH ST	Local	600	879	879	879	879	879	879	879	879	879	879	879
FRANCIS ST	Local			259	398	638	276	413	526	625	656	625	656
FREE ST	Local	49	282	671	930	1837	720	926	1442	1794	2273	1774	2305
GRAHAM ST	Local				70	235		90	176	235	235	235	235
GRANDVIEW AV	Local				91	115		99	115	115	115	115	115
HAMPTON AV	Local	187	232	263	360	391	323	367	384	391	391	391	391
HARRISBURG ST	Local					28					152	27	315
HEATH ST	Local					240				216	393	202	490
HOFFMAN AV	Local				192	307		193	241	298	387	297	453
IMPERIAL ST	Local				31	195		35	101	187	281	182	368
ISLANDVIEW AV	Local				136	140		140	140	140	140	140	140
KING ST	Local										177		281
KINNEY AV	Local					23				18	119	27	322
LADD AV	Local				127	264		195	264	264	264	264	264
LITTLE RIVER RD	Local	619	660	703	730	761	719	732	761	761	761	761	761
MAINE AV	Local			62	387	739	180	403	577	689	1259	727	1421
MARSHVIEW RD	Local	17	278	299	299	299	299	299	299	299	299	299	299
MASS AV	Local				136	441		165	327	421	745	411	1460
MCNALLY WY	Local										13		170
MILLIKEN RD	Local	296	369	410	485	485	447	485	485	485	485	485	485
MILLIKEN ST	Local	740	1144	1694	1988	2177	1774	1994	2080	2170	2190	2175	2190
MORRISON ST	Local					332				301	332	267	332
MULLEN ST	Local					60					307		307

No to little impact	Some Impact	Moderate Impact	Major Impact	Severe Impact
0-10 ft	11-50 ft	50-100 ft	100-500 ft	500+ ft*

* or entire road

Road Name	Road Class	Highest Annual Tide (+ SLR in feet)					1% Storm Event (+ SLR in feet)					Hurricane	
		HAT	HAT+1	HAT+2	HAT+3.3	HAT+6	1%	1%+1	1%+2	1%+3.3	1%+6	Cat1	Cat2
NEW SALT RD	Local	182	612	825	886	886	878	886	886	886	886	886	886
OCEAN AV	Local					52				35	462		621
OCEANA AV	Local	474	657	785	1011	1119	852	1012	1047	1106	1155	1117	1155
ODENA AV	Local				21	241		30	106	234	328	222	353
ODENA AV EXT	Local										48		318
ODESSA AV	Local		292	522	619	666	558	630	646	659	958	669	985
OLD ORCHARD RD	Major/urb collector												183
OLD ORCHARD ST	Local					167				92	285	81	285
OLD ORCHARD ST	Major/urb collector										458		528
PARCHER AV	Local				92	220		93	124	192	339	161	339
PAVIA AV	Local	104	193	291	426	500	310	426	445	480	556	493	556
PEARL AV	Local					21					167		219
PIERCE ST	Local										187		268
PORTER RD	Local	223	333	383	458	458	438	458	458	458	458	458	458
PORTLAND AV	Local										379		662
RANDALL AV	Local	613	1164	1517	1682	2368	1558	1689	2072	2343	3013	2352	3018
REGGIO AV	Local	204	518	648	803	1060	697	814	968	1052	1181	1064	1189
ROANOAKE ST	Local	86	196	235	256	256	248	256	256	256	256	256	256
ROSEWOOD ST	Local				103	247	26	104	201	245	272	246	272
ROSS RD	Local	301	382	438	486	581	455	493	522	568	646	552	728
ROUSSIN ST	Local					65				39	259	44	296
SAUNDERS AV	Local					261			28	261	261	261	261
SCOLLARD RD	Local					194				194	194	194	194
SEABREEZE AV	Local				192	231	53	192	213	231	231	231	231
SEACLIFF AV	Local					218				208	454	210	719
SEASIDE AV	Local	79	875	1559	2785	3323	2173	2803	2980	3299	3782	3325	3809
SEAVEY ST	Local												87
SEVENTH AV	Local	214	279	321	357	357	335	357	357	357	357	357	357
SIXTH AV	Local		32	250	605	726	309	617	726	726	726	726	726

No to little impact	Some Impact	Moderate Impact	Major Impact	Severe Impact
0-10 ft	11-50 ft	50-100 ft	100-500 ft	500+ ft*

** or entire road*

Road Name	Road Class	Highest Annual Tide (+ SLR in feet)					1% Storm Event (+ SLR in feet)					Hurricane	
		HAT	HAT+1	HAT+2	HAT+3.3	HAT+6	1%	1%+1	1%+2	1%+3.3	1%+6	Cat1	Cat2
STAPLES ST	Local												99
STAPLES ST EXT	Local					297			141	269	325	271	325
SURFSIDE AV	Local	63	86	101	487	670	110	538	608	661	735	680	735
TEMPLE AV	Local	91	238	304	458	610	362	457	608	610	610	610	610
TEMPLE AV	Major/urb collector	229	548	733	1131	2327	808	1149	1396	2107	2472	2250	2656
TIOGA AV	Local	138	196	232	409	580	366	415	448	496	580	511	580
TIOGA AV EXT	Local		113	216	375	476	271	392	476	476	476	476	476
TRAYNOR ST	Local					71				15	271	14	271
TRIPOLI AV	Local	143	220	241	259	517	248	259	274	481	564	496	564
TUNIS AV	Local	133	187	220	244	301	228	252	268	289	385	301	573
UNION AV	Local					70				58	143		209
UNNAMED B	Local					49					287	129	517
W GRAND AV	Major/urb collector	1805	2616	3291	3553	5380	3399	3568	3691	4840	6475	5003	6708
WALNUT ST	Local	914	989	1046	1099	1230	1074	1104	1138	1210	1558	1217	1648
WALNUT ST	Major/urb collector	62	84	100	154	291	105	165	219	291	291	291	291
WAVELET ST	Local				219	1064		279	1033	1064	1064	1064	1064
WEYMOUTH AV	Local	102	281	340	400	584	354	407	507	584	584	584	584
WILLOW CREEK LN	Local												348
WINONA AV	Local	818	1361	1609	1663	1968	1625	1676	1855	1960	1968	1967	1968
WINTERGREEN ST	Local			231	272	352	250	280	319	346	433	349	683
YORK ST	Local					22					264		264
TOTALS (in feet)		**10274**	**17682**	**25139**	**37507**	**57971**	**28418**	**38086**	**44155**	**54836**	**71399**	**55577**	**80575**
TOTALS (in miles)		**1.9**	**3.3**	**4.8**	**7.1**	**11.0**	**5.4**	**7.2**	**8.4**	**10.4**	**13.5**	**10.5**	**15.3**

NOTES: Highest Annual Tide based on the 2013 predicted value from NOAA for tidal stations in the community

All distances referenced are in linear feet of road, unless otherwise specified

No to little impact	Some Impact	Moderate Impact	Major Impact	Severe Impact
0-10 ft	11-50 ft	50-100 ft	100-500 ft	500+ ft*

** or entire road*

Road Name	Road Type	Length of Road (ft)	Existing* Flood Zone	Dune Bounds**
ANCONA AV	Local	468	AE	D2
BAKAM ST	Local	172	AE	D2
BEATRICE WY	Local	67	AE	D2
BRADBURY ST	Local	192	AE	
CARLL AV	Local	223	AE	
CASCO AV l	ocal	439	AE	D2
CASCO AV EXT	Local	497	AE	D2
COLBY AV	Local	1741	AE	D2
CONN AV EXT	Local	342	AE	
E GRAND AV	Major/urb collector	4085	AE	D2
FOOTE ST	Local	537	AE	
FOURTH ST	Local	879	AE	
FRANCIS ST	Local	398	AE	
FREE ST	Local	930	AE	
GRAHAM ST	Local	70	AE	D2
GRANDVIEW AV	Local	91	AE	D2
HAMPTON AV	Local	360	AE	D2
HOFFMAN AV	Local	192	AE	
IMPERIAL ST	Local	31	AE	
ISLANDVIEW AV	Local	136	AE	D2
LADD AV	Local	127	AE	D2
LITTLE RIVER RD	Local	730	AE	D2
MAINE AV	Local	387	AE	
MARSHVIEW RD	Local	299	AE	
MASS AV	Local	136	AE	
MILLIKEN RD	Local	485	VE, AE	D1, D2
MILLIKEN ST	Local	1988	AE	
NEW SALT RD	Local	886	VE,AE	D1, D2
OCEANA AV	Local	1011	AE	D2
ODENA AV	Local	21	AE	D2
ODESSA AV	Local	619	AE	D2
PARCHER AV	Local	92	AE	D2
PAVIA AV	Local	426	AE	D2
PORTER RD	Local	458	VE, AE	D1, D2
RANDALL AV	Local	1682	AE	D2
REGGIO AV	Local	803	AE	D2
ROANOAKE ST	Local	256	AE	D2
ROSEWOOD ST	Local	103	AE	D2

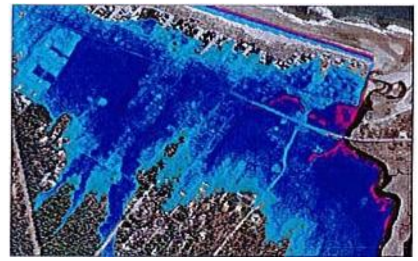
ROSS RD	Local	486	AE, X	

SEABREEZE AV	Local	192	AE	D2
SEASIDE AV	Local	2785	AE	D2
SEVENTH AV	Local	357	AE	
SIXTH AV	Local	605	AE	
SURFSIDE AV	Local	487	VE, AE	D1, D2
TEMPLE AV	Major/urb collector	1131	AE	D2
TEMPLE AV	Local	458	AE	D2
TIOGA AV	Local	409	AE	D2
TIOGA AV EXT	Local	375	AE	
TRIPOLI AV	Local	259	AE	D2
TUNIS AV	Local	244	AE	D2
W GRAND AV	Major/urb collector	3553	VE, AE	D2
WALNUT ST	Local	1099	AE	D2
WALNUT ST	Major/urb collector	154	AE	
WAVELET ST	Local	219	AE	D2
WEYMOUTH AV	Local	400	AE	D2
WINONA AV	Local	1663	AE	D2
WINTERGREEN ST	Local	272	AE	

**analysis based on preliminary FEMA Flood Mapping products from 2013*

***analysis based on the effective coastal sand dune boundaries, as delineated by MGS*

Symbol	**Explanation**
D1	Frontal Dune
D2	Back Dune
EHA	Erosion Hazard Area (all D1 in EHA)
VE	V-zone, known evaluation
AO	AO zone
AE	A-zone, known elevation
A	A-zone, unknown elevation
0.2 PCT	Between 100 and 500 year flood zone
X	Above 500- year flood zone



Appendix C

Appendix C: Assessment of Potential Impacts to Roads, City of Saco

No to some impact	Moderate Impact	Major Impact	Severe Impact
0-50 ft	50-100 ft	100-500 ft	500+ ft

* or entire road

Road Name	Road Class	Highest Annual Tide (+ SLR in feet)					1% Storm Event (+ SLR in feet)					Hurricane	
		HAT	HAT+1	HAT+2	HAT+3.3	HAT+6	1%	1%+1	1%+2	1%+3.3	1%+6	Cat1	Cat2
ABBY LN	Local												238
ATLANTIC WY	Local												79
BAY AV	Local			95	378	430	323	380	405	430	430	430	430
BAY VIEW RD	Local					160			91	145	205	157	380
BAYVIEW RD	Major/urb collector					646			372	594	776	602	1277
BEACH AV	Local				86	364	7	87	216	347	364	351	364
BEACON AV	Local			32	66	102	39	66	77	96	419	97	504
CAMP ELLIS AV	Local			183	754	917	222	807	916	916	916	916	916
COTTAGE AV	Local				49	165		52	93	165	165	165	165
COURTLYNN CIR	Local												436
COVE AV	Local				273	594		271	422	559	709	549	709
CURTIS AV	Local				56	187		63	98	167	303	179	335
DUNE AV	Local		43	217	298	347	246	303	328	342	459	347	459
EAGLE AV	Local				26	53		26	38	51	148	54	465
EASTERN AV	Local			54	110	475	63	110	407	458	631	461	631
FAIRHAVEN AV	Local			12	47	177	21	42	65	104	515	87	628
FERRY LN	Local										16		425
FERRY PARK AV	Local					33				25	404	12	595
FERRY RD	Major/urb collector		53	311	313	496	313	311	327	472	823	453	1729
FRONT ST	Local				247	445		211	308	396	490	482	599
HARRIMAN FARM	Local												149
ISLAND VIEW AV	Local					90			69	84	276	84	331
ISLAND VIEW ST	Local					111				37	350	40	455
KING AV	Local										174		365
LANDING RD	Local												1103
LIGHTHOUSE LN	Local										46		221
LOWER BEACH RD	Local			79	135	365	98	140	186	355	632	346	877

Road Name	Road Class	Highest Annual Tide (+ SLR in feet)					1% Storm Event (+ SLR in feet)					Hurricane	
		HAT	HAT+1	HAT+2	HAT+3.3	HAT+6	1%	1%+1	1%+2	1%+3.3	1%+6	Cat1	Cat2
MAIN AV	Local				195	932		276	559	873	1077	856	1077
MARSHWOOD CIR	Local										53		196
MEADOW AV	Local		23	108	108	108	108	108	108	108	108	108	108
MORRIS AV	Local					103			47	93	139	102	301
NORTH AV	Local			39	755	755	540	755	755	755	755	755	755
OCEANSIDE DR	Local					1100				846	1676	934	1676
OLD ORCHARD RD	Major/urb collector										13		45
OUTLOOK AV	Local			105	141	205	118	143	167	200	504	201	590
PALMER AV	Local		211	597	635	774	620	635	662	774	774	774	774
PEARL AV	Local					144			56	103	144	100	144
PINE RIDGE RD	Local												518
PINE TREE AV	Local			178	493	892	232	496	627	892	892	892	892
PINEY WOODS RD	Local		204	442	503	650	472	503	573	650	650	650	650
POND AV	Local												82
RIVERSIDE AV	Local			92	301	563	213	312	429	521	694	518	694
SALTAIRE AV	Local			23	248	294	52	256	294	294	294	294	294
SEASIDE AV	Major/urb collector		276	1961	5562	8427	3132	5590	7072	8173	10225	8574	10804
SHORE AV	Local		332	387	447	549	409	450	495	549	549	549	549
SUNRISE AV	Local				65	120	33	59	90	115	325	112	448
SUNSET AV	Local			121	155	294	124	156	170	194	544	211	712
SURF ST	Local				10	450		9	62	361	1887	206	2027
SYLVAN AV	Local										67		212
WEST AV	Local			14	712	1027	333	718	868	1028	1028	1028	1028
WILDWOOD DR	Local												38
TOTALS (in feet)		**0**	**1142**	**5050**	**13168**	**23544**	**7719**	**13339**	**17452**	**22272**	**31648**	**22677**	**39478**
TOTALS (in miles)		**0.0**	**0.2**	**1.0**	**2.5**	**4.5**	**1.5**	**2.5**	**3.3**	**4.2**	**6.0**	**4.3**	**7.5**

NOTES: Highest Annual Tide based on the 2013 predicted value from NOAA for tidal stations in the community

All distances referenced are in linear feet of road, unless otherwise specified

The City of Saco requested that the classification scheme to include 0-50 feet as no to little impact instead of 0-10 ft

No to some impact	Moderate Impact	Major Impact	Severe Impact
0-50 ft	50-100 ft	100-500 ft	500+ ft

** or entire road*

Example of Regulatory Restriction Analysis for HAT + 3.3 ft Scenario - Saco, ME

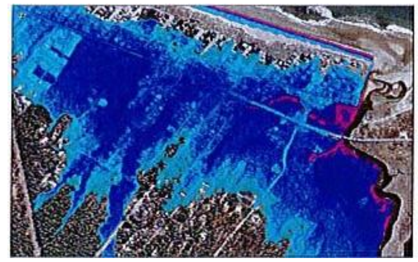
Road Name	Road Class	Length of Road (ft)	Existing* Flood Zone	Dune Bounds**
BAY AV	Local	378	VE, AE	D1, D2
BEACH AV	Local	86	AE	D2
BEACON AV	Local	66	AE	D2
CAMP ELLIS AV	Local	754	AE	D2
COTTAGE AV	Local	49	AE	D2
COVE AV	Local	273	AE	D2
CURTIS AV	Local	56	AE	D2
DUNE AV	Local	298	AE	D2
EAGLE AV	Local	26	AE	D2
EASTERN AV	Local	110	VE, AE	D2
FAIRHAVEN AV	Local	47	AE	D2
FERRY RD	Major/urb collector	313	AE	D2
FRONT ST	Local	247	0.2 PCT, X	D2
LOWER BEACH RD	Local	135	AE	D2
MAIN AV	Local	195	AE	D2
MEADOW AV	Local	108	AE	D2
NORTH AV	Local	755	VE, AE	D1, D2
OUTLOOK AV	Local	141	AE	D2
PALMER AV	Local	635	AE	D2
PINE TREE AV	Local	493	AE	D2
PINEY WOODS RD	Local	503	AE	D2
RIVERSIDE AV	Local	301	AE	D1, D2
SALTAIRE AV	Local	248	AE	D2
SEASIDE AV	Major/urb collector	5562	VE, AE, X	D2
SHORE AV	Local	447	AE	D2
SUNRISE AV	Local	65	AE	D2
SUNSET AV	Local	155	AE	D2
SURF ST	Local	10	VE	D1
WEST AV	Local	712	AE	D2

*analysis based on preliminary FEMA Flood Mapping products from 2013

*'" analysis based on the effective coastal sand dune boundaries, as delineated by MGS

Symbol	Explanation
D1	Frontal Dune
D2	Back Dune
EHA	Erosion Hazard Area (all D1 in EHA)
VE	V0zone, known elevation
AO	AO zone

AE	A-zone, known elevation
A	A-zone, unknown elevation
0.2 PCT	Between 100 and 500 yr flood zone
X	Above 500 year flood zone



Appendix D

Appendix D: Assessment of Potential Impacts to Roads: City of Biddeford

Road Name	Road Type	Highest Annual Tide (+ SLR in feet)					1% Storm Event (+ SLR in feet)					Hurricane	
		HAT	HAT+1	HAT+2	HAT+3.3	HAT+6	1%	1%+1	1%+2	1%+3.3	1%+6	Cat1	Cat2
Bay St	Local												21
Bayberry Rd	Local										175		674
Beach Ave	Local			87	210	217	42	160	217	217	217	217	217
Beach House Ln	Local			343	777	1124	181	635	1014	1124	1124	1124	1124
Beach Rose Way	Local			130	208	222	96	185	222	222	222	222	222
Brackett Point Rd	Local					33				7	74	6	112
Breakwater Ave	Local					370				56	643	167	681
Bridge Rd	Secondary		59	72	420	887	100	151	491	760	936	811	1402
Channel Cove Ln	Local				44	191		14	82	161	253	174	323
Cleaves St	Local										221	98	494
Clifford St	Local												141
Crane Ave	Private			76	217	229	58	174	229	229	229	229	229
Crestwood Dr	Local												21
Deerwander Rdg	Local										33		155
E Crescent Cove Ln	Local					310				153	499	151	625
Edgewater Pl	Local				56	156			127	156	156	156	156
Elizabeth Rd	Local					235				80	693	102	963
Elphis St	Local					40				7	231	30	264
Fifth St	Local												134
First St	Local										196		334
Fortunes Rocks Rd	Local	156	271	627	3531	6466	636	2714	4093	5520	7686	5488	8235
Fourth St	Local										103		309
Gilbert Pl	Local		93	414	414	414	414	414	414	414	414	414	414
Golden Ave	Local			10	41	247	3	26	54	77	414	89	414
Goldthwaite Ln	Local										313		388

No to little impact	Some Impact	Moderate Impact	Major Impact	Severe Impact
0-10 ft	11-50 ft	50-100 ft	100-500 ft	500+ ft*

** or entire road*

Road Name	Road Type	Highest Annual Tide (+ SLR in feet)					1% Storm Event (+ SLR in feet)					Hurricane	
		HAT	HAT+1	HAT+2	HAT+3.3	HAT+6	1%	1%+1	1%+2	1%+3.3	1%+6	Cat1	Cat2
Granite Point Rd	Local	344	1676	2800	3399	5620	2717	3174	3786	4995	6782	5023	7055
Heather Ln	Local					126			7	91	184	86	224
Heron Cv	Local					153				111	153	153	153
Hills Beach Rd	Local		52	518	2220	5308	380	1530	2986	4421	6405	4945	7295
Ice House Rd	Local										62		80
Island View Dr	Local					83				76	139	76	204
Juniper Ln	Local					117				96	155	100	199
Landing Way	Local				4	54			15	36	91	43	328
Leighton Point Ln	Local					165			20	70	318	130	318
Lester B Orcutt Blvd	Local					40				21	109	30	183
Lily Pond Ave	Local				75	218		44	131	184	464	182	531
Lindsay Ln	Local												81
Long Ave	Local				17	290			27	64	488	124	566
Maddox Pond Rd	Local				113	798		56	303	772	845	784	878
Main St	Secondary												4
Marblehead Ln	Local												74
Marsh View Dr	Local												104
Meetinghouse Rd	Local												166
Mile Stretch Rd	Secondary	36	795	2215	3998	4966	2037	3484	4731	4947	5004	4954	5333
Moore Ln	Local												125
Ocean Ave	Local					504				211	1212	176	2277
Ocean Edge Ln	Local				27	270			166	270	270	270	270
Ocean Spray Ave	Local										85		258
Ocean View Dr	Local												90
Old Kings Hwy	Local					257				131	409	124	510
Old Pool Rd	Local										20		139
Peter Pond Ln	Local					138				99	182	106	229
Pike St	Local												88
Pleasant Ave	Local					60					236	18	288

No to little impact	Some Impact	Moderate Impact	Major Impact	Severe Impact
0-10 ft	11-50 ft	50-100 ft	100-500 ft	500+ ft*

* as entire road

Road Name	Road Type	Highest Annual Tide (+ SLR in feet)					1% Storm Event (+ SLR in feet)					Hurricane	
		HAT	HAT+1	HAT+2	HAT+3.3	HAT+6	1%	1%+1	1%+2	1%+3.3	1%+6	Cat1	Cat2
Pool St	Secondary					40				28	61	31	89
Private Way Ln	Local				85	152		49	142	152	152	152	152
Red Oak Ln	Local										28		79
Reserved Ln	Local										250		358
Salt Marsh Ln	Local					73					546	22	837
Sand Dollar Hvn	Local					29				5	179	19	210
Sea Spray Dr	Local	22	273	361	454	821	346	424	485	616	950	617	996
Seabreeze Ave	Local					377				253	667	309	667
Seal Ln	Local				89	301		76	160	216	378	213	492
Second St	Local												44
Seventh St	Local										394		865
Shore Rd	Local												84
Sixth St	Local												211
Sky Harbor Dr	Local				50	224	2	6	78	175	552	199	962
Slyes Hl	Local												87
Surf Ave	Local										13		64
Theresa Ln	Private												27
Third St	Local										110		325
Thorndike Ave	Local				77	111		67	82	100	183	102	274
Timber Point Rd	Local		407	1320	2110	2527	1527	2089	2207	2447	2884	2476	3048
Town Landing	Private										7		34
Water St	Local												224
Winter Harbor Ln	Local												225
Yates St	Local		108	476	581	712	440	527	600	695	755	703	842
TOTALS (in feet)		**558**	**3734**	**9450**	**19217**	**35678**	**8979**	**15999**	**22869**	**30465**	**46555**	**31645**	**57298**
TOTALS (in miles)		**0.1**	**0.7**	**1.8**	**3.6**	**6.8**	**1.7**	**3.0**	**4.3**	**5.8**	**8.8**	**6.0**	**10.9**

NOTES: Highest Annual Tide based on the 2013 predicted value from NOAA for tidal stations in the community
All distances referenced are in linear feet of road, unless otherwise specified

No to little impact	Some Impact	Moderate Impact	Major Impact	Severe Impact
0-10 ft	11-50 ft	50-100 ft	100-500 ft	500+ ft*

** or entire road*

Example of Regulatory Restriction Analysis for HAT + 3.3 ft Scenario - Biddeford, ME

Road Name	Road Type	Length of Road (ft)	Existing* Flood Zone	Dune Bounds**
Beach Ave	Local	210	AE	D2
Beach House Ln	Local	777	VE, AE	D1, D2, EHA
Beach Rose Way	Local	208	AE	D1, D2, EHA
Bridge Rd	Secondary	420	AE	D2
Channel Cove Ln	Local	44	AE	
Crane Ave	Private	217	AE	D2
Edgewater Pl	Local	56	AE	D2
Fortunes Rocks Rd	Local	3531	AE	D1, D2, EHA
Gilbert Pl	Local	414	AE	D2
Golden Ave	Local	41	AE	D2
Granite Point Rd	Local	3399	AE	D1, D2, EHA
Hills Beach Rd	Local	2220	VE, AE	D1, D2, EHA
Landing Way	Local	4	AE	
Lily Pond Ave	Local	75	AE	
Long Ave	Local	17	AE	D2
Maddox Pond Rd	Local	113	AE	
Mile Stretch Rd	Secondary	3998	AE	D1, D2, EHA
Ocean Edge Ln	Local	27	AE	D2
Private Way Ln	Local	85	AE	D2
Sea Spray Dr	Local	454	VE, AE, X	D1, D2, EHA
Seal Ln	Local	89	AE	
Sky Harbor Dr	Local	50	VE	
Thorndike Ave	Local	77	AE	D1, D2
Timber Point Rd	Local	2110	VE, AE	D1
Yates St	Local	581	AE, X	

**analysis based on preliminary FEMA Flood Mapping products from 2013*

***analysis based on the effective coastal sand dune boundaries, as delineated by MGS*

Symbol	Explanation
D1	Frontal Dune
D2	Back Dune
EHA	Erosion Hazard Area (all D1 in EHA)
VE	V-zone, known elevation
AO	AO zone
AE	A-zone, known Elevation
A	A-zone, unknown elevation
0.2 PCT	Between 100 and 500 year flood zone
X	Above 500 year flood zone

FEBRUARY 3, 2015

Steering Committee Meeting
York County bridges and culverts DST
Tuesday, February 3rd
1:00 p.m.-3pm
Wells Town Hall

Attendance: Patrick Fox – Saco, Jessa Kellogg - Kittery, Mike Livingston - Wells, Werner Gilliam - Kennebunkport, Leslie Hinz - York, Judy Gates - MaineDOT, Peter Slovinsky – Maine Geological Survey, Laura Crossley – Southern Maine Planning and Development Commission (SMPDC), Tom Reinauer - SMPDC

Agenda

1. **Introductions:** Everyone share name, work/position, why interested
2. **Project Summary:**-Tom
   - *Goals of project:* To provide a list of priority sites to towns and Maine DOT who can then do a cost/benefit analysis
   - *Purpose of steering committee:* Serve as a sounding board for tool proposal and report. Also help with providing data.
   - *End product:* Useful tool for DOT and/or municipalities and a report.
3. **Assessment tool ideas: -**
   - *Where did tool come from/How was it developed?* DOT and Catalysis Adaptive Partners developed questions (DST). JT Lockman and MnDOT developed a different and more detailed set of criteria. Judy found that an obstacle that they encountered was the lack of data available for utilizing tool.
   - *Look at questions and see if members have ideas to add:* Need to refine list of assets that are going to be reviewed using tool. Committee agreed that culverts from 3' to 10' in diameter that are influenced by tidal action within the 100 year flood zone would be a good place to start.

Also discussed the benefit of Permit By Rule (PBR) standards for upsizing culverts. In its current process, the DOT is not looking at sea level rise and storm surge to add to DST, so this would be a good use of the committee to fill in this gap. Additionally, any culvert over 10 feet requires engineering and under one foot would be impossible to find accurate data on.

4. **Data Gathering/Inputs:**-Laura
   - *Review data already gathered*
   - *What is missing?-Culvert data, other?* Need more culvert data at town and state level. Also need more habitat data for aquatic passage. (Ask Peter about this).
   - *Where can we find data?*

     Committee members will search for town level data on culverts size 3'-10'. Need information on who is responsible for the culvert maintenance and replacement, location, type of culvert, diameter, condition, when last worked on, when it would be scheduled for work, when it was installed, and when last inspected.

     We should create a standardized form that all communities could use to evaluate their culverts that includes the above listed criteria.

     Use preliminary FEMA 100 yr flood maps or CAT2 maps.

5. **Next Steps:**
   - Pete will send out Silver Jackets info.
   - Patrick will look for report on wetlands to share with committee.
   - Laura and Tom will do more data sleuthing and send questions to committee for review.
   - Jessa, Werner, Judy and Pete volunteered for providing feedback.
   - Laura will send out a Doodle for the next meeting and type up notes

6. **Next Meeting**

   Doodle is in the works, as soon as we have a better sense of data.

JUNE 22, 2015

Culvert Prioritization Steering Committee Meeting
to analyze decision support tool (DST)
June 22, 2015
10am-noon
SMPDC office, 21 Bradeen St, Suite 304, Springvale

Attendance: Joel Moulton, Alex Abbot, Tom Reinauer, Dana Lee, Pete Slovinsky, Leslie Hinz, Laura Crossley. Phone participation-Jessa Kellogg, Barbara Charry, Judy Gates.

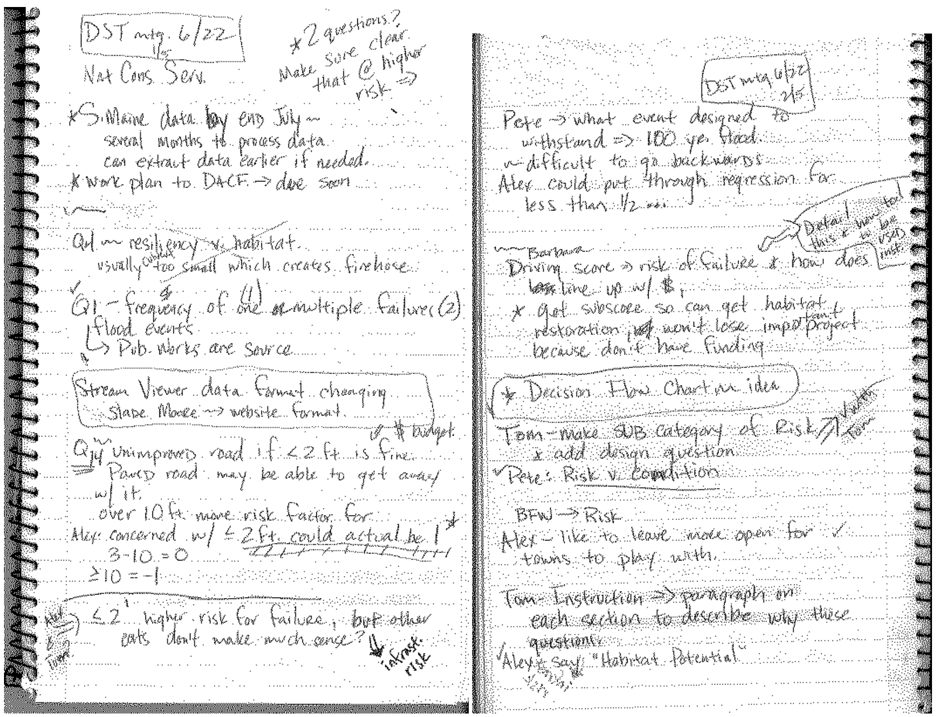
The purpose of this meeting is to finalize the decision support tool (DST) and the instructions that accompany the tool. You DO NOT need to have culvert data in order to participate in this meeting. For those of you, who have data on your culverts, please prepare for the meeting by attempting to run data that you have on culverts through the DST. You might try up to five culvert sites in order to gather a range of issues. We will quickly review one or two sites at the meeting as a demonstration of how the DST works.

Some things to keep in mind:

- Do instructions make sense?
- How should we weight the categories? Should each category be evenly weighted or are there particular questions that should be more highly prioritized?
- Q1-can municipalities tell us this information?
- For information that The Nature Conservancy and US Fish and Wildlife are collecting (Stream Viewer and Habitat table), do the municipalities find access to that information easy? If not, where are some areas that we can simplify?

1. Review test culvert site(s)

2. Questions and Committee Comments:


DST mtg. 6/22
1/5
Nat Cons Serv.
* 2 questions?
Make sure clear that @ higher risk ⇒
*S. Maine data by end July ~
several months to process data
can extract data earlier if needed.
* work plan to DACF → due soon
Q4 ~ resiliency v. habitat.
usually culvert too small which creates firehose
Q1 – frequency of one (1) multiple failures (2)
flood events
↳ Pub. Works are source
Stream Viewer data format changing
Slade Moore → website format
$ budget
Q14 Unimproved road if < 2 ft is fine.
Paved road may be able to get away w/ it.
over 10 ft more risk factor for
Alex concerned w/ ≤ 2 ft. could actual be 1 *
3-10 = 0
≥ 10 = -1
≤ 2' higher risk for failure, but other cats don't make much sense?
infrast. risk
DST mtg 6/22
2/5
Pete → what event designed to withstand ⇒ 100 yr. flood.
~ difficult to go backwards
Alex could put through regression for less than 1/2 ...
Detail this & how tool to be used inst.
~ Barbara
Driving score ⇒ risk of failure & how does line up w/ $,
* got subscore so can get habitat restoration & won't lose important project because don't have funding
* Decision Flow Chart ~ idea
Tom – make SUB category of Risk
& add design question
with Tom
Pete: Risk v. Condition
BFW → Risk
Alex – like to leave more open for towns to play with.
Tom – Instruction ⇒ paragraph on each section to describe why these questions.
Alex: say "Habitat Potential"

DST mtg 6/22 3/5

* Dead end roads could rate as well

"Probability of Implementation" ✓

Q1: Info more in notes format
SMPDC has 2007 inundations

✓ Alex Failed 2, damaged/flooding (1),
→ Barbara Clear about assumptions: Is damage or flooding related to size

~ look for erosion info in Stream Viewer comments.
~ Towns may have erosion info

Tom → being able to export would be great ⇒ ultimate goal

Ctrl F for # w/in table ⇒ Instructions

BFW ~ has variability in data collection
→ look up in table ⇒ Total Span in Viewer v. BFW
Stream Viewer 2 yrs out of date
Notes → use formula in Excel ✓

DST mtg 4/5

for The Vaughan Conserv.

* Use Crossing Substrate

use "substrate" for habitat connectivity to make culvert invisible to creatures.

✓ Primary Habs → more emphasis on than secondary

* Direct to Map Viewer DOT

Useful to towns
Will help w/ local Selectmen, need rational system can get funding.

Need local Evac Routes Data

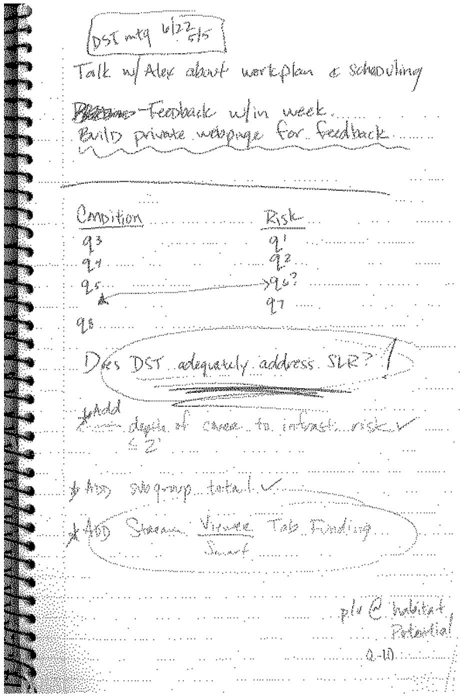
* Q13 ADD: are there alternate routes? or the only route to facility
✓ If culvert not operable, what is length of bypass ⇒ look @ MN report

Q15 Could be Conserv. Commission or Land Trust, Fishery associated w/ it?

Pete - Is culvert avail for funding

* Barbara → sent funding list

~~Separate [illegible]~~



DST mtg 6/22/15

Talk w/ Alex about workplan & scheduling

~~Bl~~ Feedback w/in week
Build private webpage for feedback

Condition	Risk
q3	q1
q4	q2
q5	q6?
	q7
q8	

Does DST adequately address SLR?

*Add depth of cover to infrast. risk ✓
≤ 2'

*Add subgroup total ✓

*Add Stream Viewer Tab Finding
Smart

plu @ habitat Potential

(2-11)

Culvert Analysis and DST Steering Committee Meeting

November 12, 10:00-11:30

Wells Town Hall

Littlefield Meeting Room

208 Sanford Road, Wells

Agenda

1. **Introductions/Announcements**
   - *Update on MaineDEP Stream Crossing Public Infrastructure Improvement Project Grants-Laura*
     Bill LaFlamme of MDEP presented at the "Watershed Roundtable" last week. He emphasized public safety, flood protection, and fish passage for the projects chosen. An applicant should show how their proposal would benefit water quality, improve habitat, increase public safety, and add provisions for climate resiliency.

     Also, the proposal should provide documentation on the history of culvert failure with the years and dates, the impacts of the culvert, and link safety to the length of detour.

     The applications have been delayed until January. There will be a couple of years' worth of funding. Prioritizing town maintained roads!

     There is another ballot in the process to get voters to approve a bond measure to continue funding after this round of funding has ended.

     In the last round municipal roads received most of the funding, but one land trust off the Crooked River did get money.

They gave multiple grants to Hancock County.

Grant amount were less than $100,000 each.

Match probably helps.

2. **Culvert analysis and DST report:** *Would anyone be willing to review our draft?*
Send out and ask for comments. Dec 1.

3. **Kittery beta testing information share:** *Jessa Kellogg, Kittery Shoreland Resource Officer to talk about using the DST*
Jessa-Kellogg DST process:

- Spreadsheet (how did it work going from column to column?)
- 3-10 ft., Towns data
- Edit data sources.
- Utilizing USGS Stream Stats-close window and now it is working (Alex)
- Able to answer about ½ questions without Habitat Viewer.
- Instructions were thorough.
- Add Google Earth as data source for q6.
- Q17- need to add info on how to use ruler tool to calculate miles. Is that the total distance around or distance to services.
- Some of it involves going out to see culverts personally.
- How many culverts in town total, which includes non-stream crossing? 100s. Info gathered from going in and out for each culvert.
- Without the Habitat Viewer info the ranking is difficult if not impossible
- If this tool was used by a Road Commissioner who is not doing the level of inspections that she/Jessa is doing, the Habitat Viewer info would be really helpful.
- Alex update-waiting for final agreement (to be signed in next 2 weeks) w/ TNC to pay programmer to build new Stream Viewer websight-60 days. Late January, early Feb. will have data ready to view. Alex could help beforehand for application with your data.
- How will towns be notified? SMPDC, Maine Audubon, and old viewer will redirect.
- The review went over perennial streams or intermittent w/ brook trout and road crossings. Not focused on size.

4. **Municipality watershed planning needs**

How can SMPDC best serve your town/city planning needs? How can SMPDC best serve the region as a whole?

- Towns need money and people resources for on the ground projects. Kittery did their watershed plan update.
- Large data set available. Town Admin not supporting longer water sampling work. The research brings to forefront hot spots and problem sources.
- Werner: looking for flood maps. Other projects pending on maps. Kennebunkport and coastal communities looking at CRS program. Community Rating System-voluntary rating system FEMA operates. Higher ratings lead to discounts of flood insurance discounts for communities. FEMA flood maps won't finish until 2017. Part is tracking damages. SMPDC could help deal with applications and how to make plans to maintain CRS rating.
- Wetland restoration also part of water bond. $400,000 sitting there. They didn't get a single application.
- Comp plan update for watershed planning. Wanting to do smaller updates for K-port over time. Volunteer committee and townspeople to deal with small bit.
- Beginning w/Habitat program should incorporate data from maps to add to Comp Plans. Stream Smart materials w/ data provided to towns who are writing comp plans.
- There is a disconnect between towns and Beginning w/ Habitat data. K-port missed getting data because they were not on list since updating comp plan. Towns could use notification that there is updated info.
- Updated Shoreland mapping needed and maps that are better utilized. Each layer being independent of each other. Lidar needed for better delineations. It is embarrassing when standing w/ resident and showing map property lines running through middle of house.
- K-port spent $30,000 to get maps updated. Tom Burns-in house GIS person.
- Making sure communities and road owners have habitat info and the training to implement data for use. Following up and what kind of support do communities need to use info available. We did training w/ Soil and Water Conservation District, are there other trainings needed at town level to access and utilize tools.
- Any training that are Freeport and south for Stream Smart would be great. Key audience is Public Works directors.
- Stream Simulation is US Forest Service approach. Scoring System:
- Maine DEP has scoring available for all applications.
- Bond 6 put emphasis on budget that clearly lays out cost elements and adding in info about match.
- Alex sending info on Restoration Plan summary draft of back up data. USFWS focused on salmon waters. Not looking at variety of areas. Looking to help with habitat issues and first come first serve.
- Share DST on Stream Smart website once it is refined.

5. **Next steps and future meetings-none scheduled**

			Data Source		Scoring	Maximum Score	Sub-group Score	*Enter Culvert ID, then score below*	Multiplier
Infrastructure-Risk	q1	Are there documented instances of culvert failure, flooding at the culvert, and/or damage to the culvert?	Town or MDOT	no	0				
				damage and/or flooding	1				
				failure	2	2			
	q2	How often has the culvert experienced flooding or damage?	Town or MDOT	never	0				
				single instance	1				
				multiple instances	2	2			
	q-3	Does the culvert meet design standards for a 100 year flood event	call USFWS or use the USGS	yes	0				
				no	1	1			
	q4	What material is the culvert made from?	Maine Stream Habitat Viewer	concrete	0				
				metal or plastic	1				
				composit, fiberglassor other	1	1			
	q5	Does the culvert span the width of the stream at bank full? ***(Enter bankfull width in cell below to find 1.2 times BFW in column E)***	Maine Stream Habitat Viewer	≥1.2x calculated bankfull width	0				
				1.0x ≤ calculated bankfull width <1.2x calculated bankfull width	1				
	Bankful width =	2	2.4	<1.0x calculated bankfull width	2	2			
	q6	What is the "Road Fill Height" or the distance between the top of the culvert to the road surface?	Maine Stream Habitat Viewer	≤ 2 feet	1				
				> 2 feet	0	1			1
							9	0	0

Infrastructure-Condition	q7	Is there erosion surrounding the culvert inlet or outlet?	Town, MDOT, or USFWS	no yes	0 1	1			
	q8	What is the condition of the culvert	Maine Stream Habitat Viewer or Town	Unknown/Needs Inspection New/Excellent OK/Good/Fair Poor	0 0 1 2	2			
	q9	What is the outlet condition?	Maine Stream Habitat Viewer	At Stream Grade Free Fall Cascade Free Fall Onto Cascade	0 1 1 1	1			
	q10	What is the inlet condition?	Maine Stream Habitat Viewer	At Stream Grade Inlet Drop Perched Clogged/Collapsed/Submerged	0 1 1 1	1			
	q11	Does the structure substrate match the stream?	Maine Stream Habitat Viewer	comparable contrasting not appropriate or none	0 0 1	1			1
							6	0	0

Habitat Potential	q12	How many miles would be reconnected if this culvert was improved, removing the barrier to connectivity?	Maine Stream Habitat Viewer or Stream Barrier Habitat	0 miles 0.1 ≤ 0.5 miles 0.5-5 miles ≥5 miles	0 1 2 3	3			
	q13	How many primary barrier classes/categories does the culvert impact? (Give the presence of any "Blocked Alewife Pond Acres" and "Blocked Salmon Habitat Units" a count of one each.)	Stream Barrier Habitat Table	0 1-3 4-6	0 2 4	4			
	q14	How many secondary barrier classes/categories does the culvert impact? (Exclude IWWH and Non-Native Fish).	Stream Barrier Habitat Table	0 1-3 4-5	0 1 2	2			1.555556
							9	0	0

Access Importance	q15	What is the Highway Corridor Priority (HCP) of the roadway? (For DOT roads only)	MDOT	Priority 4 or 5	0				
				Priority 2 or 3	1				
				Priority 1	2	2			
	q16	Is the culvert located on a road that is identified by the County Emergency Management Agency (EMA) or the municipality as an evacuation route?	SMPDC	no	0				
				yes	1	1			
	q17	If the culvert becomes inoperable and the road becomes inundated, what is the additional travel distance required to bypass the affected culvert using approved detour routes	Google Maps and SMPDC	<20 miles	0				
				21-35 miles	1				
				36-50 miles	2				
				>50 miles	3	3			
	q18	Is the culvert located on a road where EMA services (hospital, or ambulance/police/fire/emergency facilty) are located?	SMPDC or MEGIS (layer for hospitals, rescue, and	no	0				
				yes	1	1			
	q19	In the case that the culvert fails and the road becomes innundated, are there alternate routes available to drivers of this road to access critical services, such as the hospital, emergency response vehicles, police, or fire response?	Google Maps	yes	0				
				no	1	1			1.75
							8	0	0
Probability of Implementation	q20	What is the "Road Fill Height" or the distance between the top of the culvert to the road surface?	Maine Stream Habitat Viewer	≥ 10 feet	-1				
				3 - 10 feet	0				
				≤ 2 feet	1	1			
	q21	Is there an interested watershed group to help steward and monitor the culvert upgrades?	MaineDEP	no	0				
				yes	1	1			
	q22	Is there money available to fix the culvert?	Town, MDOT, Maine DEP	no	0				
				yes	1	1			
	q23	Is the culvert included in a Capital Improvement Plan?	Town or MDOT	no	0				
				yes	1	1			3.5
							4	0	0
						Total Score	36	0	0

Introduction

The purpose of this Decision Support Tool (DST) is to aid in the decision making process of selecting which culverts the municipality should focus efforts on for improvements. It is expected that each municipality will have varying needs and interests to focus on. The DST is a guide, but should only be seen as a guide and not as an all-encompassing ranking tool that precludes local knowledge and priorities. Other considerations that are not taken into account with the tool, may play a primary driving force as to which culverts should be addressed.

This was a collaborative effort led by the Steering Committee over six months. Collaborators included:

- SMPDC
- Maine Audubon
- Maine Department of Transportation
- Maine Geological Survey
- U.S. Fish and Wildlife Service
- The Nature Conservancy
- The towns of Biddeford, Eliot, Kennebunkport, Kittery, Ogunquit, Saco, South Berwick, Wells and York.

The DST attempts to bring to the forefront concerns regarding budgetary constraints, habitat concerns, community access to emergency resources and both the current infrastructure status and risks to infrastructure degradation or failure during storm events or over the long term sea level rise. These concerns have been broken out into the following categories: Infrastructure-Risk, Infrastructure-Condition, Habitat Potential, Access Importance, and Probability of Implementation.

- **Infrastructure-Risk:** This category considers the risk of failure or damage the culvert presents during storm events and sea level rise. Higher risks are given a higher priority in the ranking.
- **Infrastructure-Condition:** This category evaluates the current condition of the culvert, which relates to the risk that the culvert poses to failure or damage during storm surge events and/or sea level rise. Worse conditions are given a higher priority in the ranking.
- **Habitat Potential:** This category gauges the potential for improvement of local habitat concerns. It is assumed that greater distances that can be accessed by removing barriers to connectivity and higher numbers of primary and secondary habitat concerns that can be improved by addressing the culvert lead to greater improvements in overall habitat potential.
- **Access Importance:** This category incorporates the surrounding community's connection to emergency services, by comparing evacuation routes and distances to services. Higher priority is given to greater access importance.

- **Probability of Implementation:** This category assesses budgetary risks and the likelihood of local community support for restoration efforts. Higher priority is given to projects that are most likely to successfully be implemented.

When using the DST, take note that the scoring works differently for different categories. For Infrastructure-Risk, Infrastructure-Condition and Habitat Potential, the DST is designed to give higher priority to culverts that are at a higher risk for failure during storm surge flooding, more likely to degrade over time and that are negatively impacting habitat concerns. All of these issues lead to the need for restoration and reconnection to the natural hydrologic landscape. The rating of Access Importance gives higher priority to those culverts that are located in areas where the failure of that culvert will have a greater negative impact on accessing emergency services and that tend to see higher volumes of traffic. The Probability of Implementation gives higher priority to culverts that have a better chance of being addressed, based on budgetary concerns and community support to steward culvert repair projects. In this category, the assumption follows that the greater risk the project has to fail because of budgetary constraints, the lower priority the culvert gets.

Each culvert in each category receives an overall sub-score. As the DST currently reads, the categories are unevenly weighted. Infrastructure Risk and Condition combined lends to the highest priority and the Probability of Implementation receives the lowest priority between categories. The multiplier is intended to balance the inequities between the overall categories of Infrastructure (risk and condition combined), Habitat Potential, Access Importance and the Probability of Implementation. It is assumed that the municipality will decide if there are certain categories that need to take higher precedence in the overall rating of each culvert and will weight them according to the local political climate and project goals.

Copy and paste *(maintain the format)* the last two columns into the adjacent blank column as needed for adding more culverts. The formulas for calculating each group sub-score, the multiplier for each group sub-score, and the final scoring for each culvert should automatically update to the corresponding columns. A word of caution: If you change any of the weighting, make sure that it remains consistent throughout your calculations. For example, if you decide in cell J51 that Habitat Potential needs to be given more or less weighting, first change the weight multiplier in cell J50. Then make sure that the same weight is reflected in the appropriate cells in row 50, as the formula is linked to that row. If you decide to not use a particular question, it is best to leave that question in the row and leave it blank. Deleting or moving rows has the potential to impact your formulas, rendering them inoperable.

The Data Source column indicates the places where users of the DST may find information. The list is not comprehensive, but should point users in a direction to start. Review and collect the data sources at the start of the culvert review for ease and to create consistency of rating between culverts. The list of sources is as follows:

- The online Maine Stream Habitat Viewer - *http://mapserver.maine.gov/streamviewer/index.html*
- The Maine Audubon Barrier Habitat Table (an Excel table) found online - *http://maineaudubon.org/streamsmart/plan-goals/*

- The online Maine DOT Map Viewer of the Highway Corridor Priorities for the state - *http://www.maine.gov/MaineDOT/mapviewer/?show=Workplan%2016-17,Workplan%202015,HCP&hide=FFC,MEDOT%20Regions,Wetlands*
- Google Maps online – maps.google.com
- Emergency service maps found at *(SMPDC weblink)*

Other sources that may be useful:

- Listing of Maine Lake Associations - http://mainelakessociety.org/maine-lake-associations/
- Maine Volunteer Lake Monitoring Program – *http://www.mainevlmp.org/contact/*
- Local Land Trusts
- Local fisheries
- Stream Smart funding sources list - *http://maineaudubon.org/streamsmart/funding/*

Infrastructure-Risk

1. **Are there documented instances of culvert failure, flooding at the culvert, and/or damage to the culvert?**
   Municiplities or MaineDOT should have this information.

2. **How often has the culvert experienced flooding or damage?**
   Municipalities or MaineDOT should have this information.

3. **Does the culvert meet design standards for a 100 year flood event?**
   Contact USFWS to assist with regression calculation. If needed, come back to this question after an initial narrowing of choices.

4. **What material is the culvert made from?**
   Using the Maine Stream Habitat Viewer, http://mapserver.maine.gov/streamviewer/index.html "Build a Query" and select your municipality or "Zoom to Town." Select "Stream Crossings" to view barriers and potential barriers. You can then use the map to match your culvert location or you can build another query by road name and check the boxes of road barriers and potential barriers. Make sure to click the "calculate" box. Use the "Identify" key to find answers to questions ***4-6 and 8-12***.

   Although this question is listed under the "Infrastructure-Risk" category, there is an attempt to include an element of the impact on habitat here. Plastic does not pose a higher risk of failure or degradation than concrete, but it is less favorable for aquatic species passage. Therefore, plastic is given a rating of 1 point and concrete was given a rating of 0 points.

5. **Does the culvert span the width of the stream at bankfull**?
This requires a calculation of 1.2 multiplied by the bankfull width (BFW), which is then compared to the "total span ft." of the stream crossing as found in the Maine Stream Habitat Viewer. If you are unable to find the information in the Maine Stream Habitat Viewer, then look at the Stream Barrier Habitat Table found at http://maineaudubon.org/streamsmart/plan-goals/. Use the identification code of the culvert from the Maine Stream Habitat Viewer to find the culvert in the table. Click anywhere in the table, then click the Ctrl button and "F" key to search for the culvert site id.

Type in cell C-16 the BFW. The total of 1.2 times the BFW will appear in cell D16, which is the number to compare to the total span of the stream.

6. **What is the "Road Fill Height" or the distance between the top of the culvert and the road surface?**
This is the same as Q20 except that in this instance we are focused on how the road fill height impacts the risk of the culvert to infrastructure failure. Assuming that the culvert is undersized, any culvert within two feet of the road surface is more likely to wash out in the case of a severe storm. We realize that this is an assumption, which is why it is important to also look at the bankfull width measurement at the same time as answering this question. As long as these questions are answered in the same consistent way, the overall rank comparisons between culverts will not be impacted by this assumption.

*Find "Fill Height" using the Maine Stream Habitat Viewer, http://mapserver.maine.gov/streamviewer/index.html "Build a Query" and select your municipality or "Zoom to Town." Select "Stream Crossings" to view barriers and potential barriers. You can then use the map to match your culvert location or you can build another query by road name and check the boxes of road barriers and potential barriers. Make sure to click the "calculate" box. Use the "Identify" key to find answers to questions **4-6 and 8-12**.*

Infrastructure-Condition

7. **Is there erosion surrounding the culvert inlet or outlet?**
At this time there is no known database to refer to. This may be something that the town or MaineDOT will have to go out and collect. If so, then it may be worthwhile to come back to this question after an initial narrowing of choices.

8. **What is the condition of the culvert?**
*Using the Maine Stream Habitat Viewer, http://mapserver.maine.gov/streamviewer/index.html "Build a Query" and select your municipality or "Zoom to Town." Select "Stream Crossings" to view barriers and potential barriers. You can then use the map to match your culvert location or you can build another query by road name and check the boxes of road barriers and potential barriers. Make sure to click the "calculate" box. Use the "Identify" key to find answers to questions **4-6 and 8-12**.*
9. **What is the outlet condition?**

*Using the Maine Stream Habitat Viewer, http://mapserver.maine.gov/streamviewer/index.html "Build a Query" and select your municipality or "Zoom to Town." Select "Stream Crossings" to view barriers and potential barriers. You can then use the map to match your culvert location or you can build another query by road name and check the boxes of road barriers and potential barriers. Make sure to click the "calculate" box. Use the "Identify" key to find answers to questions **4-6 and 8-12**.*

10. What is the inlet condition?

*Using the Maine Stream Habitat Viewer, http://mapserver.maine.gov/streamviewer/index.html "Build a Query" and select your municipality or "Zoom to Town." Select "Stream Crossings" to view barriers and potential barriers. You can then use the map to match your culvert location or you can build another query by road name and check the boxes of road barriers and potential barriers. Make sure to click the "calculate" box. Use the "Identify" key to find answers to questions **4-6 and 8-12**.*

11. Does the structure's substrate match the stream?

Comparable and contrasting substrate is a preferable condition compared to none or not appropriate substrate.

*Search for "Crossing Substrate" using the Maine Stream Habitat Viewer, http://mapserver.maine.gov/streamviewer/index.html "Build a Query" and select your municipality or "Zoom to Town." Select "Stream Crossings" to view barriers and potential barriers. You can then use the map to match your culvert location or you can build another query by road name and check the boxes of road barriers and potential barriers. Make sure to click the "calculate" box. Use the "Identify" key to find answers to questions **4-6 and 8-12**.*

Habitat Potential

12. How many miles would be reconnected if this culvert was improved, removing the barrier to connectivity?

*Find "Upstream Miles Blocked" using the Maine Stream Habitat Viewer, http://mapserver.maine.gov/streamviewer/index.html "Build a Query" and select your municipality or "Zoom to Town." Select "Stream Crossings" to view barriers and potential barriers. You can then use the map to match your culvert location or you can build another query by road name and check the boxes of road barriers and potential barriers. Make sure to click the "calculate" box. Use the "Identify" key to find answers to questions **4-6 and 8-12**.*

*Or find "Blocked US Miles" in the Stream Barrier Habitat Table. Visit http://maineaudubon.org/streamsmart/plan-goals/ to find the latest updates for the **Stream Barrier Habitat Table**. Blocked US Miles refers to the number of miles upstream from the barrier, in this case, the culvert that would be reconnected to the downstream if the barrier was removed.*

13. How many primary barrier classes/categories does the culvert impact? (Give the presence of any "Blocked Alewife Pond Acres" and "Blocked Salmon Habitat Units" a count of one each.)

*Visit http://maineaudubon.org/streamsmart/plan-goals/ to find the latest updates for the **Stream Barrier Habitat Table**. (A link directly to the current table can be found here http://maineaudubon.org/streamsmart/files/2015/01/StreamBarrierHabitatTable-3-26-14.xlsm.*
Primary barrier categories to count here include: Blocked Alewife Pond Acres, Blocked Salmon Habitat Units, Salmon Critical Habitat, Sea Run Smelt Habitat, Brook Trout Habitat, and Tidal Marsh

14. **How many secondary barrier classes/categories does the culvert impact? (Exclude IWWH and Non-Native Fish).**
    *Visit http://maineaudubon.org/streamsmart/plan-goals/ to find the latest updates for the **Stream Barrier Habitat Table**. (A link directly to the current table can be found here http://maineaudubon.org/streamsmart/files/2015/01/StreamBarrierHabitatTable-3-26-14.xlsm. Secondary Barrier categories to count here include: Rare Aquatic Habitats, BwH Focus Area, BwH Connectors, Aquifer, and Acid Buffer Capacity.*

Access Importance

15. **What is the Highway Corridor Priority (HCP) of the roadway? (For DOT roads only).**
    Visit http://www.maine.gov/MaineDOT/about/assets/glossary/index.shtml for definitions. Utilize the MaineDOT Map Viewer at http://www.maine.gov/MaineDOT/mapviewer/?show=Workplan%2016-17,Workplan%202015,HCP&hide=FFC,MEDOT%20Regions,Wetlands and use the identify tool to see how roads are classified. Or, visit
    http://www.maine.gov/MaineDOT/about/assets/hwy/, and "Search Map by Town". Enter the municipality name and click on any of the customer service level types or project status to bring up a map of the area. Once you have a map, look under the "Data" tab to find "Roads". Click to turn on the "Highway Corridor Priorities" road categories. You can zoom in and out using the toolbar on the left or grab the map and re-center to find a road of your choice. There is an identification tool as well. Just click on the road segment to bring up more details about the road, if desired.

16. **Is the culvert located on a road that is identified by the County Emergency Management Agency (EMA) or the municipality as an evacuation route?**
    *Please see http://smpdc.org/for a map of roads and EMA evacuation routes. **(Note: this map is not yet on website, but will be added soon).***

17. **If the culvert becomes inoperable and the road becomes inundated, what is the additional travel distance required to bypass the affected culvert using approved detour routes.**[16]

[16] MnDOT. Report prepared by Parsons Brinckerhoff with contributions from Catalysis Adaptation Partners for the Minnesota Department of Transportaiton and the USDOT Federal Highway Administration. November 5, 2014.

Use Google Maps to find alternate routes by clicking on the route and moving the travel path to bypass and to calculate distances between points.

18. Is the culvert located on a road where EMA services (hospital, ambulance, police, fire, or emergency facility) are located?
Please see http://smpdc.org/for a map of roads and essential services ***(Note: this map is not yet on website, but will be added soon).***

*If you have GIS capabilities, you can use the MEGIS layers for police, rescue, and hospitals found at www.**maine**.gov/me**gis**/catalog. If you do not have this capability, contact SMPDC for assistance.*

Also, you can use "search nearby" function in Google Maps to find where "hospitals, police stations, fire departments, and ambulance or emergency rescue" are located.

19. In the case that the culvert fails and the road becomes inundated, are there alternate routes available for access to critical services (hospital, ambulance, police, fire, or emergency facilities)?
Use Google Maps to find alternate routes to services or check with SMPDC for maps of services.

Probability of Implementation

20. What is the "Road Fill Height" (the distance between the top of the culvert to the road surface)?
This is the same as Q6, except that here the purpose is to evaluate how road fill height impacts the probability of the project moving forward as a budgetary constraint. Culverts that are within two feet of the road surface may result in the need to alter the road's elevation, which is a greater budgetary cost. Culverts that are ten feet or more from the road surface become considerably more expensive to excavate. Between these measures is the "sweet spot" for budgetary interests. Round to the nearest whole number.

Find "Fill Height" using the Maine Stream Habitat Viewer, http://mapserver.maine.gov/streamviewer/index.html "Build a Query" and select your municipality or "Zoom to Town." Select "Stream Crossings" to view barriers and potential barriers. You can then use the map to match your culvert location or you can build another query by road name and check the boxes of road barriers and potential barriers. Make sure to click the "calculate" box. Use the "Identify" key to find answers to questions ***4-6 and 8-12****.*

21. Is there an interested watershed group to help steward and monitor the culvert upgrades?
To find engaged local watershed groups, which often change in activity level, begin by identifying the closest waterbody that connects with the culvert in question or watershed that encompasses the culvert.

One way is to visit the Maine Stream Habitat Viewer at http://mapserver.maine.gov/streamviewer/streamdocHome.html and build a query by town and then the road where the culvert is located. Once you have identified the water body you can Google search for local Lake Associations or watershed associations. Searching the internet by "[your water body name] watershed association" or by "[your water body name] advocacy" may yield the name and contact info of a local organization.

Also, contact the Volunteer Lake Monitoring Program (VLMP) http://www.mainevlmp.org/contact/ and/or the Maine Lakes Association http://mainelakes.org/.

Contact SMPDC for more help.

22. Is there money available to fix the culvert?

For municipal roads, please visit http://www.maine.gov/dep/land/water_bond_rfp.html for more information. For state roads that the municipality has interest in cost sharing, please find MaineDOT's Municipal Partnership Initiative http://www.maine.gov/MaineDOT/csd/mlrc/mpi.htm.

Also visit http://maineaudubon.org/streamsmart/funding/ for more ideas on where to find funding for Stream Smart road crossing projects.

23. Is the culvert included in a Capital Improvement Plan?

Visit http://maine.gov/MaineDOT/projects/workplan/search/ and search for your town to find information about CIP roadwork within the next three years.