RATIONALE FOR THE COLLECTION OF REGIONAL LiDAR DATA IN NEW HAMPSHIRE AND MAINE

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February 2009

Accurate high resolution surface elevation data support a variety of public and private sector needs. Elevation data for many states, including New Hampshire and Maine, are available at mixed resolutions that are often inadequate to support certain key uses and analyses. LiDAR (Light Detection and Ranging) is a proven technology that is available to acquire seamless high resolution (1- to 3-m spacing) elevation data over large spatial areas. This position paper outlines the rationale and need to acquire LiDAR data to improve topographic products for the New Hampshire and southern Maine coastal region to support several important community needs. A pilot acquisition and demonstration project in this area will 1) help to better define requirements and costs associated with the acquisition, processing, management, and distribution of LiDAR data; 2) enable a thorough analysis of diverse user needs to ensure the data products are useful for multiple purposes; and 3) demonstrate one way the data can be used as the basis of advancing community resilience to the impacts of climate change.

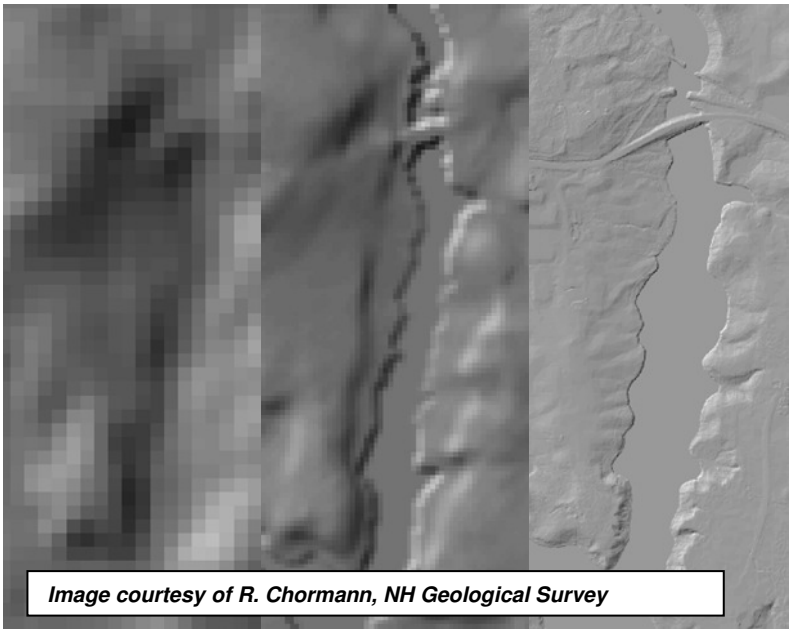
A number of studies have called attention to the inadequacies of existing elevation data. At the state level, the New Hampshire Geographic Information System (GIS) Strategic Plan (New Hampshire GIS Advisory Committee, 2007) identifies developing statewide high-quality topographic data as a high priority. The State of Maine Strategic Plan Update (Maine GeoLibrary Board 2008) also cites the development of high-resolution elevation data as a priority recommendation. In both states, the data available at a statewide level can at best support generation of a statewide 10' contour data set, and thus are not suitable for several important analyses, such as floodplain delineation, land use planning, and transportation infrastructure development. For example, FEMA's floodplain delineation standards require 4' contours in rolling and hilly terrain and 2' contours in flat areas (FEMA, 2003). A recent report by the National Research Council, *Elevation Data for Floodplain Mapping* (2007), identifies similar deficiencies in available land surface elevation data nationally. The report finds that for most of the nation, "FEMA needs land surface elevation data that are about ten times more accurate than data currently available" to support modernization of floodplain maps under the National Flood Insurance Program (NRC 2007). This report recommends that FEMA adopt 1' contour accuracy as the standard basis for floodplain mapping in flat coastal and inland areas.

The benefits of high resolution elevation data become apparent when comparing the elevation models that can be generated from different resolutions of baseline data. The figure below shows digital elevation models constructed from data available at 30-meter, 10-meter, and 1-

meter resolutions. Landscape details become much more apparent and clear as the resolution of the elevation data increases, yielding distinct advantages for regulatory decision-making and other management applications.

Airborne LiDAR uses laser pulses to measure elevations of the earth's surface, vegetation, and the built environment. The technology offers a way of obtaining very precise, accurate, and high resolution elevations (equivalent to the 1-meter resolution shown below) in a consistent manner across large spatial areas. Despite its value, large-area LiDAR acquisitions are rare, but a number of states are developing statewide LiDAR programs.

Comparison of terrain models for Fresh Creek, Strafford County, NH: NED 30-meter and 10-meter DEMs versus 1-meter LiDAR



High resolution elevation data are particularly important in shallow sloping coastal areas, but LiDAR is currently available only along the edge of the coastline, and coverage does not extend into low relief portions of coastal watersheds. These data limitations pose challenges as coastal communities attempt to make decisions in the context of climate change. Communities are struggling to identify areas that may be inundated due to sea level rise and/or flooded during intense storms. Flood risk assessment products can be developed using existing models to guide planning, zoning, and infrastructure decisions in these communities; however, high resolution elevation data are necessary for these products to be specific and credible within decision-making arenas.

High resolution elevation data obtained from LiDAR can be applied for a variety of additional purposes to address both public and private sector needs, including:

- Hydrologic modeling
- Floodplain evaluation and mitigation
- Land protection prioritization
- Restoration planning
- Community planning
- Design of roads and stormwater drainage systems
- Public facility siting
- Disaster planning and emergency response
- Land cover and environmental classification
- Forestry production and monitoring
- Siting of cell phone towers
- Monitoring of utility lines

Coupling the LiDAR topographic data with other remotely sensed data, such as digital orthophotography, enables additional applications for LiDAR data—surface feature extraction (e.g., buildings and other human infrastructure), habitat mapping, and forestry and agricultural management. In addition, once the LiDAR topographic data have been collected, it is likely that other valuable analyses can be conducted.

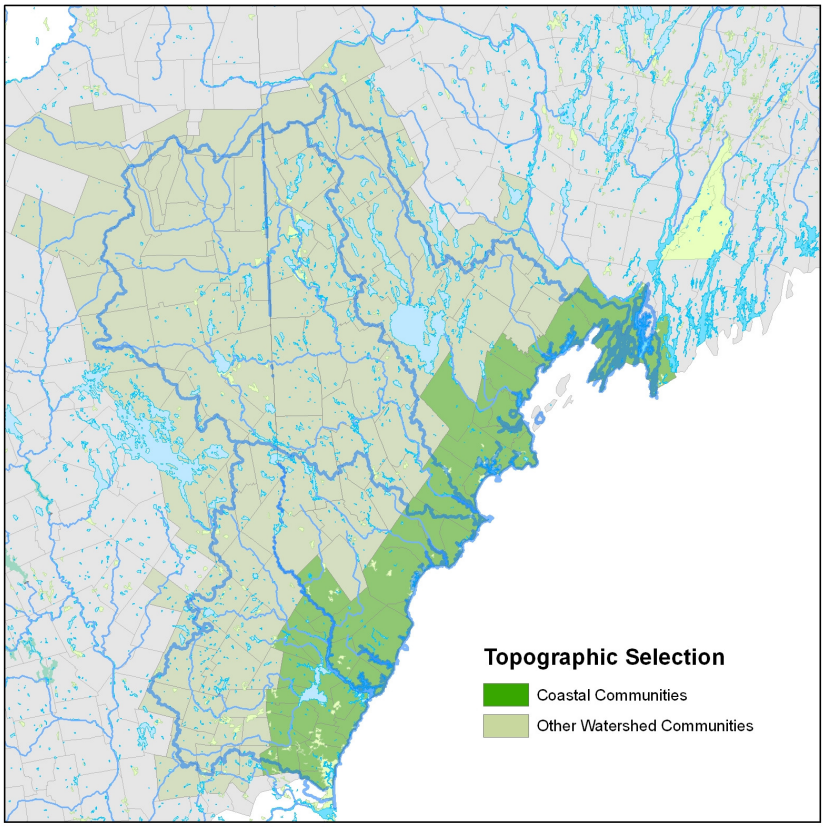
The cost associated with LiDAR and the recognition that a variety of users will benefit significantly from the availability of an enhanced topographic data set requires a coordinated effort that will take advantage of economies of scale in its acquisition and ensure that products suit the needs of multiple user groups. Such an approach offers many benefits, including the seamless collection of large swaths of data and uniform application of expert quality assurance and quality control. Coordination ensures standardization across the entire data set and reduces the cost per unit area associated with the data collection, processing, management, and distribution.

Pilot LiDAR acquisition in coastal New Hampshire and southern Maine

We propose a near-term acquisition of high resolution LiDAR data for the New Hampshire and southern Maine coastal areas. This collection will encompass three coastal watersheds—Piscataqua-Salmon Falls, Saco, and Presumpscot—as delineated in the figure below. For coastal communities (i.e., towns with elevations below 10 meters), LiDAR data with 1-meter point spacing and 9 cm RMSE vertical resolution would support 1-foot contours within the gradual topography of the coastal zone. For upper portions of the watershed with more topographic relief, LiDAR data with 2-meter point spacing and 18 cm RMSE vertical resolution would support 2-foot contours. Approximate costs associated with such an acquisition, based on estimates provided by Kirk Waters at NOAA's Coastal Services Center, are shown in the table below. These costs accommodate the basic data collection and associated processing, as well as the production of commonly utilized derivative products (e.g. cartographic contours based on incorporating topographic breaklines). (Subsequent discussions with Lester Neifert, USGS Geospatial Liaison for Vermont and New Hampshire, suggest that the estimates presented are somewhat high. We retain the original figures to provide flexibility in requesting additional

products, including bare earth Digital Elevation Models and/or intensity images.) Note that data storage, maintenance, and distribution costs are not included in the cost estimates.

Area of proposed LiDAR acquisition



Costs associated with proposed LiDAR acquisition and processing

	Acquisition Area			Estimated Costs			
	NH mi^2	ME mi^2	Total mi^2	Point Data[1]	Breaklines[2]	Contours[3]	**Total Costs**
Coastal Communities	269.9	788.4	1058.3	$687,895	$370,405	$158,745	$1,217,045
Balance of Watershed	2318.8	2080.7	4399.5	$1,759,800	$1,539,825	$659,925	$3,959,550
Total	2588.7	2869.1	5457.8	**$2,447,695**	**$1,910,230**	**$818,670**	**$5,176,595**

[1] $650/$mi^2$ for 1-m point spacing and 9 cm RMSE vertical resolution in coastal communities
$400/$mi^2$ for 2-m point spacing and 18 cm RMSE vertical resolution in upper watershed
[2] $350/$mi^2$
[3] $150/$mi^2$

Broad demand for high-resolution elevation data

Many groups, agencies, and entities need high resolution elevation data to complete targeted analyses to address existing information needs. The following groups will be asked to contribute supporting paragraphs explaining their need for and expected utilization of LiDAR data:

New Hampshire State Agencies

New Hampshire Department of Environmental Services:
- New Hampshire Coastal Program
- New Hampshire Geological Survey

New Hampshire Fish and Game Department:
- Great Bay National Estuarine Research Reserve

New Hampshire Office of Energy and Planning

New Hampshire Department of Safety:
- Division of Homeland Security and Emergency Management

New Hampshire Department of Transportation

New Hampshire Department of Resources and Economic Development

Maine State Agencies

Maine Department of Conservation:
- Maine Geological Survey

Maine State Planning Office:
- Floodplain Management Office
- Maine Coastal Program

Maine Department of Marine Resources

Wells National Estuarine Research Reserve

Maine Department of Transportation

Regional and Municipal Groups

Rockingham (NH) Regional Planning Commission

Strafford (NH) Regional Planning Commission

Southern Maine Regional Planning Commission

The Nature Conservancy

New England Interstate Water Pollution Control Commission

New Hampshire Estuaries Project

Casco Bay Estuaries Project

Friends of Casco Bay

Cities of Exeter, Portsmouth, Newmarket, Durham, and Dover, NH

Cities of Wells, Saco, and Portland, ME

Federal Agencies

U. S. Geological Survey

EPA Region 1

NOAA River Forecast Office, Taunton, MA

NOAA Restoration Center

Natural Resources Conservation Service

Rachel Carson National Wildlife Refuge

Great Bay National Wildlife Refuge

Application of LiDAR data for flood risk assessment in context of climate change

One immediate use of the data will be for the development of flood risk information that will provide insights into the future implications of climate change at a local scale within coastal communities. As climate change occurs, flooding in coastal communities will be affected by both sea level rise and changing precipitation patterns. Many of these communities are already seeking information to guide planning and decision-making within the context of climate change. Methodologies exist for developing flood risk information that accounts for the implications of climate change. We have assembled a team of scientists to conduct flood risk analyses that account for implications of sea level rise and precipitation, but the quality and resolution of products will be determined by the quality and resolution of the underlying elevation data. Hence, LiDAR will be critical to support this effort and similar initiatives that will enable coastal communities to plan for and adapt to climate change.

Kirshen *et al*. (2008) developed a method for estimating coastal flood elevations using future sea level rise projections. This method was used to create maps of the projected 100-year coastal flood for Boston, as shown in Figure 1. Inundated areas (shown in blue) were identified by overlaying the projected coastal flood elevation onto a high resolution DEM developed from LiDAR data by MassGIS. The LiDAR DEM was available as a collection of raster images with 1 meter X 1 meter resolution, a horizontal accuracy of 0.5 meters and a vertical accuracy of 0.15 meters. We envision performing the same type of analysis along the coastal zones of Maine and New Hampshire, but are hampered by the lack of a high resolution DEM. Given that the change in coastal flooding elevations can be on the order of tenths of a meter in some cases, the accuracy of the currently available 30-meter DEM is not adequate for identifying inundated areas. Hence, for this project to proceed, we need a DEM of the same high resolution and accuracy as is available in coastal Massachusetts.

Projected changes in climate and land use can be coupled to evaluate potential changes in the spatial extent of 100 year floodplains (Figure 2). Analyses will be consistent with guidance for floodplain analysis (FEMA 2002). Four land use scenarios will be examined spanning a range of impervious cover: 1) land use conditions at the time of the existing FEMA studies (1981-2001); 2) current land use conditions; 3) a maximum build-out condition based on current zoning; and 4) a Low Impact Development (LID) build-out scenario with a maximum of 10% effective impervious cover (EIC). Climate change will be considered both for the recent historical period (1981-2001) and for three future scenarios over two time frames (2041-2070 and 2071-2100). We will use output from a suite of atmosphere-ocean general circulation models (AOGCMs) forced using the IPCC scenarios (Nakicenovic *et al*. 2000); higher (A1FI), mid-high (A2), and lower (B1) emissions. Monthly AOGCM temperature and precipitation fields have already been statistically downscaled to daily values with a resolution of 1/8 of a degree for the northeast United States (e.g., Hayhoe *et al*. 2007) after Wood *et al*. (2002). This downscaling used an empirical statistical technique that maps the probability density functions for modeled monthly and daily precipitation and temperature for the climatological period (1961–1990) onto those of gridded historical observed data. In this way, the mean and variability of both monthly and daily observations are reproduced by the climate model output. Downscaled temperature and precipitation were then used as input to the Variable Infiltration Capacity (VIC) model (Liang *et al*. 1994, 1996; Cherkauer *et al*. 2002). This hydrological model simulates the full water and

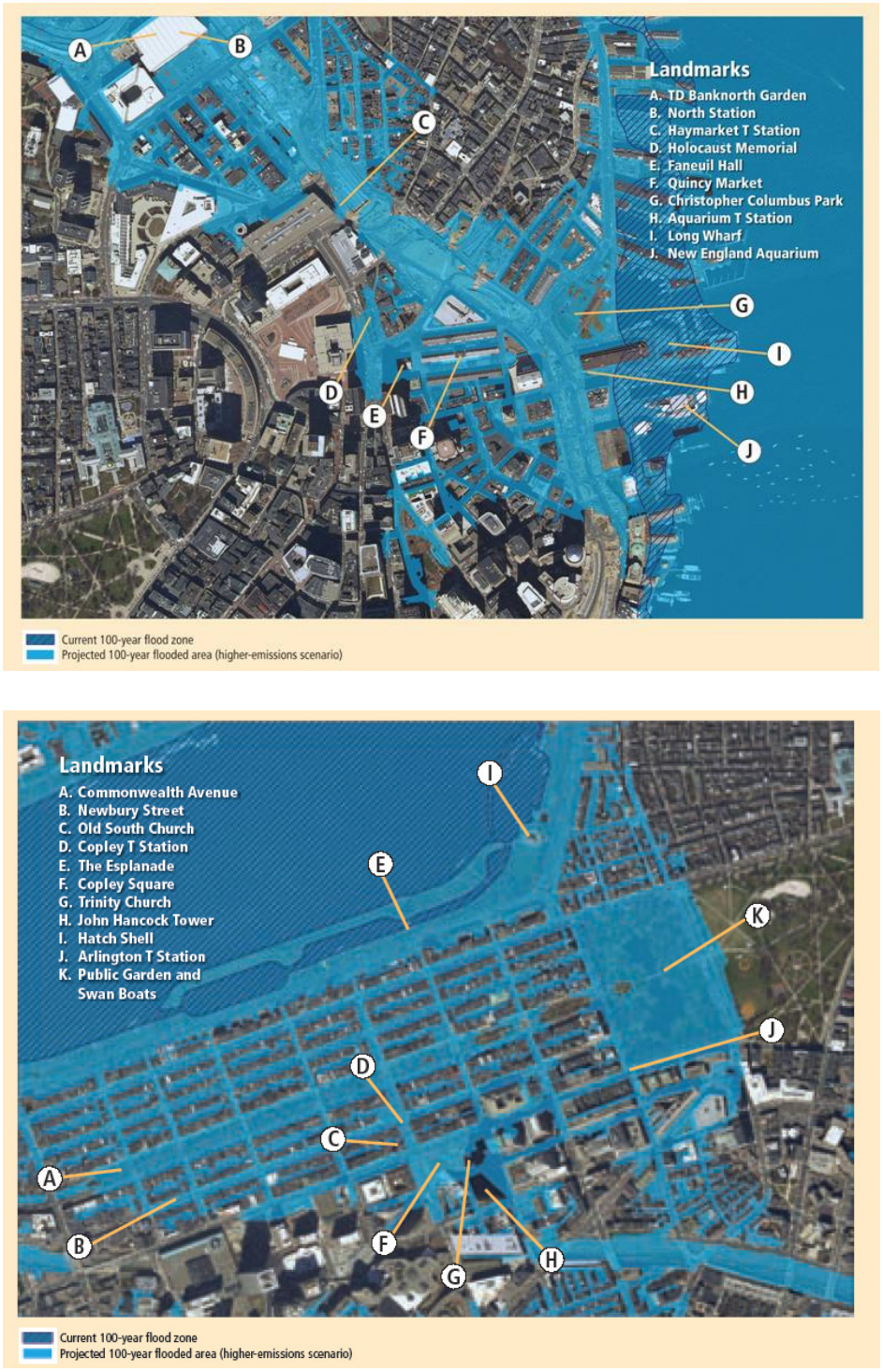


Figure 1. Projected 100-year coastal flooding of downtown Boston (top) and Back Bay area of Boston (bottom) under a sea level rise of 16 inches (after IPCC, 2007) (Source: Frumhoff *et al.*, 2007)

energy balance at the earth's surface by modeling processes such as canopy interception, evapotranspiration, runoff generation, infiltration, soil water drainage, and snow pack accumulation and melt. The VIC output will then be used as input for the watershed model described below. Each land use condition (four in total) will be assessed with the seven climate scenarios (one historical, six future [three scenarios for two different time periods]). In all, 28 conditions will be evaluated.

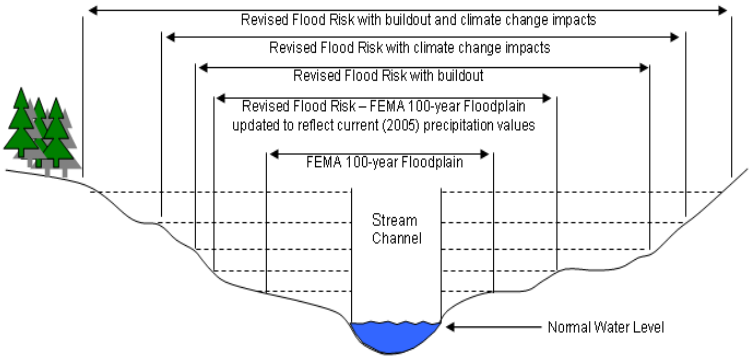


Figure 2: Concept floodplain with land use and climate scenarios.

For the watershed modeling, the discharge frequency relationship will be defined within a watershed from records at USGS gauging stations. Updates of the rainfall runoff, peak discharge, and land use changes will be modeled using either Hydrologic Engineering Centers Hydrologic Modeling System (HEC-HMS) or published regression equations for the study area watershed. Precipitation estimates for either approach will be derived from the VIC model. Land use and land cover (LULC) characteristics (ie., soil type, vegetation, development patterns) from land use data (GRANIT, 2008) and an impervious cover assessment (GRANIT, 2005) will be used to develop curve numbers. Terrain analysis based on 10-meter digital elevation models (DEMs) will be performed to assess watershed characteristics including slope and distance traveled. Floodplain analyses will be performed using the Hydrologic Engineering Centers River Analysis System (HEC- RAS). For each scenario, flood vulnerability areas will be mapped by applying base flood elevation estimates to available topographic data. The resolution of outputs using currently available 10-meter DEMs could be greatly enhanced using high resolution LiDAR data.

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Statements of support for regional LiDAR acquisition

I. New Hampshire State Agencies

1. New Hampshire Geological Survey

The New Hampshire Geological Survey (NHGS) collects data and conducts applied research related to the land and water resources of the state of New Hampshire. Several of our key programs are critically dependant upon high-resolution digital elevation models needed to accurately depict the natural and man-influenced landscape in order to produce accurate results. NHGS personnel have served on several commissions and advisory committees that have formally recognized the need for airborne Light Detection and Ranging (LiDAR) data acquisition in order to empower the abilities of state agencies, public safety and emergency management officials, academic researchers, planners, and local governments to accurately evaluate the landscape for a variety of purposes. In acknowledgement of these needs, the New Hampshire Geographic Information System (GIS) Strategic Plan identifies the need to develop statewide high-quality topographic and elevation data to replace the existing mixed resolution data for NH (currently 30-meter and partial 10-meter digital elevation models) available as part of the USGS National Elevation Dataset.

In New Hampshire, climate change scenarios paint a disturbing outlook for an increased occurrence of flooding events, reduced snowfall, and coastal flooding. The Seacoast Region of New Hampshire represents the area that is likely to suffer the most losses to property, and estuarine and ecological resources from a combination of sea-level rise and backwater flooding effects of coastal rivers. Therefore, there is a critical need for high-resolution elevation data to create an elevation model that can be used to predict potential coastal flooding, and accounts for the effects of projected sea-level rise, tidal surges, and peak discharge from rivers. The subtleties of the landscape in the coastal region also require that any digital elevation models be derived from data with a nominal accuracy of plus or minus 15 centimeters in the vertical dimension.

Three major (100-year or greater recurrence interval) flood events in NH during the last the last 3 years have highlighted the vulnerability of the New Hampshire landscape to major flooding. As a result, New Hampshire House Bill 648, Chapter 179.1, Laws of 2007, established a commission to develop a comprehensive flood-management plan for the state of New Hampshire. One of the Commission's key recommendations was to enhance the statewide topographic model with LiDAR data and imagery. This effort would not only enhance the state's abilities in flood-plain management, but would also constitute a database that would have ancillary uses such as land-use and transportation planning, hazard mitigation, and airshed and terrain modeling for communication systems and alternative energy (e.g., wind farm) applications.

The NHGS manages the state's Geological Mapping Program, and LiDAR data would strongly enhance our ability to identify and characterize glacial landforms, geologic faults, fractures, and other structurally-controlled land forms that have implications for public safety and water resource development. NHGS is currently developing a Fluvial Erosion and Geologic Hazards program, and LiDAR imagery is a critical component for evaluating and analyzing the geomorphic network and landscape, which can be used to support, or substitute for field surveys for channel analysis, volumetric calculations, and other uses. Moreover, the identification of bank erosion, as well as earthen slumps and landslides, is an important application for geologic hazard evaluation. NHGS, through a Memorandum of Agreement (MOA) with the U.S. Geological Survey, also serves as the data steward of the state's Hydrography Dataset, and LiDAR imagery would enhance significantly our efforts to delineate accurate stream traces, channel networks, and characterize and determine accurate flow directions.

In closing, I fully support all efforts for the acquisition of regional and statewide LiDAR data. This may be one of the most important and fundamental data-collection investments that the state of New Hampshire can undertake in the 21st century.

Sincerely,
David R. Wunsch, State Geologist and Director
New Hampshire Geological Survey

2. *New Hampshire Coastal Program*

The State of New Hampshire
DEPARTMENT OF ENVIRONMENTAL SERVICES

Thomas S. Burack, Commissioner

January 6, 2009

Dear Ms. Mills,

I am writing this in support of current efforts between the Great Bay National Estuarine Research Reserve (GBNERR), Complex Systems Research Center and the UNH Institute for the Study of Earth, Oceans, and Space to acquire LiDAR for coastal New Hampshire and Maine.

As manager of the NH Coastal Program, I am often invited to sit on commissions, committees and task forces looking at coastal issues. I am not engaging in hyperbole when I say that I have heard the "acquisition of LiDAR" as a significant recommendation from nearly every committee in the last few years. Recent Legislative Commissions on flooding, sediment pollution to Great Bay, and stormwater have all made the point that improving the resolution of our DEMs is a necessity for better resource management. In particular, the need for wide scale watershed modeling at fine resolution is driving this need. The Governor's Climate Change Task Force also identified LiDAR as a need for better adaptation policies.

In addition to these major policy initiatives, my program is involved in on the ground restoration. It is appropriate that your proposal shows Fresh Creek in Dover. That is a high priority target for restoration of anadromous fish. We need very good topography and bathymetry to better understand what the site would look like after a restoration project. Similarly, many of our salt marsh restoration projects would benefit from LiDAR both for project planning and for better understanding of future sea level rise on salt marshes.

Clearly, sea level rise is a huge concern. In 2002, we funded the Jackson Estuarine Laboratory to model sea level rise in our seacoast communities. The best DEM that they could produce was with 2 foot contours. While that could show gross sea level rise impacts, the more subtle impacts on natural systems and specific households was impossible to garner without better elevation information.

I encourage state, Federal, foundation and local funding for LiDAR. I believe that this is an investment that will yield great returns in better land use planning and coastal resources decisions.

Sincerely,

Ted Diers, Manager
New Hamsphire Coastal Program

3. *New Hampshire Fish and Game Department*

New Hampshire
Fish and Game Department
Region 3

225 Main Street, Durham, NH 03824-4732
(603) 868-1095
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FAX (603) 868-3305
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Web site: www.WildNH.com

Glenn Normandeau
Executive Director

January 20, 2009

354 Morse Hall
Institute for the Study of Earth, Oceans, and Space
University of New Hampshire
Durham, NH 03824

Dear Dr. Wake, Ms. Mills, and Ms. Rubin:

The New Hampshire Fish and Game Department (NHFGD) acts as the steward for the State's fish, game, and wildlife by managing resident and migratory species and protecting their life sustaining habitats. The availability of LIDAR data for the Piscataqua-Great Bay watershed and for New Hampshire's coastal estuaries would support the Department's existing management and protection responsibilities while also advancing its efforts to anticipate ecosystem impacts of climate change.

A major responsibility of the Marine Division of the NHFGD involves evaluating and enhancing the accessibility of estuaries and interconnected coastal rivers and streams to diadromous, resident estuarine, and migratory marine fishes, some of which are currently considered both state and federal species of concern. LIDAR data would advance the State's ability to accurately assess and mitigate anthropogenic or natural impacts that restrict habitat access for these species. Dam removal is one way in which we address barriers to diadromous fish migration, and LIDAR data would substantially improve current restoration planning processes. High resolution topography and bathymetry for restoration sites would enable an accurate assessment of the physical appearance and ecological outcomes of different restoration scenarios, thereby ensuring the selection of ecologically beneficial and publically acceptable restoration options.

Another responsibility of the NHFGD is to manage habitats to sustain populations of fish and wildlife in the state. Coastal marshes provide important habitats for many juvenile fish and birds, and their internal features such as creeks, pools, pannes, ditches, and berms affect their habitat support functions. In addition, intertidal and subtidal areas provide critical habitat for fish and shellfish. In New Hampshire's estuaries, these critical habitats are difficult to map based on the resolution of existing aerial imagery. Detailed topographic and bathymetric data would help the NHFGD (and other supporting state and federal agencies) better characterize these habitats, structure monitoring programs to understand their ecological importance, determine the extent of invasive encroachment into sensitive habitats, and provide a baseline for future assessments of habitat change.

LIDAR data would also help the NHFGD better manage wildlife in upland portions of coastal watersheds. Critical habitats for some species of concern, such as the silver-haired bat, are defined by slope and aspect of the terrain. Accurate detection of these features using existing topographic maps is limited, but they could be readily identified with high resolution LIDAR data. In addition, LIDAR data would enable us to better assess the impacts of wildlife management decisions. For example, beaver activity in certain areas may flood human infrastructure or affect other sensitive habitats. Detailed elevation data would enable the NHFGD to target activities that encourage beaver activity, such as timber harvests, in areas that will not threaten sensitive fish and wildlife habitats or induce flooding in nearby human communities.

Finally, the NHFGD must consider potential ways in which climate change will impact the State's natural resources, management responsibilities, and stewardship goals. Sea level rise may alter coastal and estuarine marshes as well as upland transitional habitats. Understanding how these habitats will be affected by sea level rise requires knowing their existing elevations as well as the location and elevation of barriers that may impede their gradual migration in response to rising waters. LIDAR data would provide these necessary pieces of information, which could be paired with sediment accretion and plant colonization data to more fully understand habitat changes that may result from sea level rise.

The NHFGD supports this initiative to acquire LIDAR for the Piscataqua-Great Bay watershed and New Hampshire's coastal areas. Although beyond the scope of the current proposal, we would also benefit from the acquisition and interpretation of bathymetric LIDAR for nearshore subtidal and intertidal areas of New Hampshire's coast, bays, and estuaries. The availability of high resolution elevation data will provide the NHFGD with state-of-the-art technical information to use for protecting, restoring, and mitigating habitats that support fish and wildlife in coastal New Hampshire.

Sincerely,

Douglas Grout

Douglas Grout
Chief, Marine Division

4. *Office of Energy and Planning*

JOHN H. LYNCH
GOVERNOR

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OEP
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January 15, 2009

Ms. Fay Rubin
GRANIT Project Director
Morse Hall
University of New Hampshire
Durham, NH 03824

Dear Ms. Rubin:

On behalf of the New Hampshire Office of Energy and Planning, I am writing in support of the efforts to acquire LiDAR data for coastal New Hampshire by the Great Bay National Estuarine Research Reserve and the University of New Hampshire's Complex Systems Research Center at the Institute for the Study of Earth, Oceans, and Space. While LiDAR data would enhance many of OEP's existing initiatives, it would significantly benefit our Geographic Information System (GIS) Program and the Floodplain Management Program.

OEP's GIS Program works closely with the Complex Systems Research Center and numerous state agencies to coordinate the activities of New Hampshire's statewide GIS, known as GRANIT. This multi-agency coordination includes reviewing the broad array of application areas in which geospatial technologies are applied at the state and local levels, and planning for the acquisition and maintenance of data sets required to support those applications. As called for by the state's 2007 Strategic GIS Plan, this proposed project would significantly advance the development of a high priority data set - high-resolution elevation data for the state.

Further, OEP is the lead agency for the state's Floodplain Management Program, which is supported primarily by funds from FEMA's National Flood Insurance Program (NFIP). Local floodplain maps are the foundation of the NFIP and are used by many communities to make floodplain management and land use decisions. However, in New Hampshire, many of these floodplain maps are based on outdated and "coarse" topographic data models. More accurate floodplain maps will greatly enhance land use decisions by community officials as they will have better tools to inform their efforts to protect their communities and residents from future flood damage.

Finally, several new studies that were completed after the state's recent three major flood disasters (2005, 2006, 2007) have reported that LiDAR data are urgently needed to improve the accuracy of the state's mapped floodplain areas. In addition, acquisition of statewide LiDAR was a key recommendation put forth in the 2008 final report of the Comprehensive Flood Management Study Commission, authorized by House Bill 648 in the 2007 legislative session.

Thank you for the opportunity to comment on this important initiative.

Sincerely,

Amy Ignatius, Director
NH Office of Energy and Planning

5. *New Hampshire Department of Resources and Economic Development*

STATE OF NEW HAMPSHIRE
DEPARTMENT of RESOURCES and ECONOMIC DEVELOPMENT
OFFICE of the COMMISSIONER
172 Pembroke Road P.O. Box 1856 Concord, New Hampshire 03302-1856

GEORGE M. BALD
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January 14, 2009

Fay Rubin
GRANIT Project Director
Complex Systems Research Center
Morse Hall
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Durham, NH 03824

SUBJECT: LiDAR Project

Dear Ms. Rubin:

I am writing on behalf of the State of New Hampshire, Department of Resources and Economic Development to show our whole hearted support for the proposed project involving the collection of Regional LIDAR data (Light Detection and Ranging).

Our Agency currently manages over 166,000 acres of forests and parks throughout the State of New Hampshire. We would find it tremendously beneficial to have high accuracy topographic detail readily available when making decisions regarding land acquisition projects, managing communication tower sites and the development of park infrastructure such as building sites, campground development and road development.

I feel the funding of this project is extremely important to assist those of us charged with ever expanding responsibility to best manage our land resources.

Sincerely,

George M. Bald, Commissioner
NH Department of Resources and Economic Development

Cc: Brad Simpkins, Interim Director – Div. of Forests and Lands
Bill Carpenter, Administrator – Land Management
Ron Duddy, Surveyor/Mapper – Land Management

II. Maine State Agencies

1. Maine Geological Survey

LiDAR Work Efforts and Expanded Data Needs: Maine Geological Survey

The Maine Geological Survey (MGS) has been using coastal topographic LiDAR data from the NOAA Coastal Services Center (2000 and 2004) for a multitude of projects and purposes within the State of Maine.

Accurate topographic data is vital to enhance decision-making, planning, and regulating activities, especially within the coastal zone. MGS regularly uses LiDAR data in various aspects of its advisory role to the Maine Department of Environmental Protection. By combining high-resolution LiDAR data with orthophotographs, MGS remapped the Coastal Sand Dune regulatory boundaries for Maine DEP and in response to regulatory changes in 2006 that defined a 100-year Erosion Hazard Area (Maine DEP, 2006). Previously, the extent of Maine's Coastal Sand Dunes was defined by MGS using aerial photograph interpretation using stereo pair techniques (Dickson, 2001).

The State of Maine has adopted two (2) feet of sea level rise over the next 100 years into its regulatory structure (Maine DEP, 2006). In addition, the Maine Natural Resource Protection Act's definition of a coastal wetland includes a reference to the "highest tide level for each year" (Maine DEP, 2005). In order to determine the potential impacts of sea level rise in support of Maine regulation, MGS has used available LiDAR data to identify existing areas of inundation vulnerability, potential future areas of inundation after sea level rise, in addition to simulating the impacts on marsh systems within a pilot study area, including a portion of the Wells National Estuarine Research Reserve (Slovinsky and Dickson, 2006). LiDAR data was used to simulate different coastal wetland habitats, high marsh and low marsh areas, based on ranges of tidal elevations that occur within those habitats (i.e., high marsh exists between mean high water and highest annual tide, while low marsh exists between mean sea level and mean high water).

The 2004 NOAA LiDAR data was found to be of adequate vertical accuracy (RMSE 6.7 cm) to represent existing marsh boundary conditions, and was thus used for simulations of potential future conditions after sea level rise. This pilot effort was expanded to look at potential sea level rise impacts amongst Maine's coastal communities (Slovinsky and Dickson, 2007). In 2007-2008, MGS has been working with several Maine communities in Saco Bay to identify existing and potential hazards, and develop adaptation plans and ordinances in support of coastal community and habitat resilience in the face of sea level rise (Slovinsky, 2008). Part of this effort included simulating existing and potential future marsh conditions, and identifying undeveloped upland areas adjacent to existing marsh habitats where marshes could potentially transgress in response to sea level rise (Figures 1-2). Additionally, potential future annual inundation depths were determined so that existing and future threatened public and private infrastructure could be identified (Figure 3). Interestingly, the potential future flood depths after 2 feet of sea level rise were roughly equivalent to the flooding from the 2007 Patriots' Day Storm and were ground-truthed with on-site photographs (Figure 4).

As sea level rises, the defined 100-year floodplain elevations, in turn, will also rise. Part of the current efforts by MGS to help develop community resiliency include using LiDAR data to simulate a future 100-year floodplain through a static rise of stillwater flooding within coastal estuaries and watersheds as well as adjacent, low-lying uplands.

LiDAR within the State of Maine has been generally confined to flight swaths focused on beach, dune, and nearshore morphology, extending only 1,500-2,000 m inland.
One of the limitations of the LiDAR datasets in Maine is the inland extent of data coverage - existing LiDAR does not extend into estuaries or watersheds. These areas contain large tracts of sensitive environmental habitat – including coastal wetlands - and also include areas of high intensity development, public and private infrastructure, and differing land uses. Identifying flood vulnerability and infrastructure and habitat impacts and potential responses within these areas is vital to the continued development of resilience of Maine's coastal communities. These areas are currently being excluded from studies and simulations simply due to a lack of adequately accurate topographic data. Expanded LiDAR data collection within a spatial scope that adequately captures these sensitive areas is necessary for future planning, management, and adaptation strategy development in response to climate change.

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2. Maine Floodplain Management Program

SPO Maine State Planning Office
Executive Department

JOHN ELIAS BALDACCI
Governor

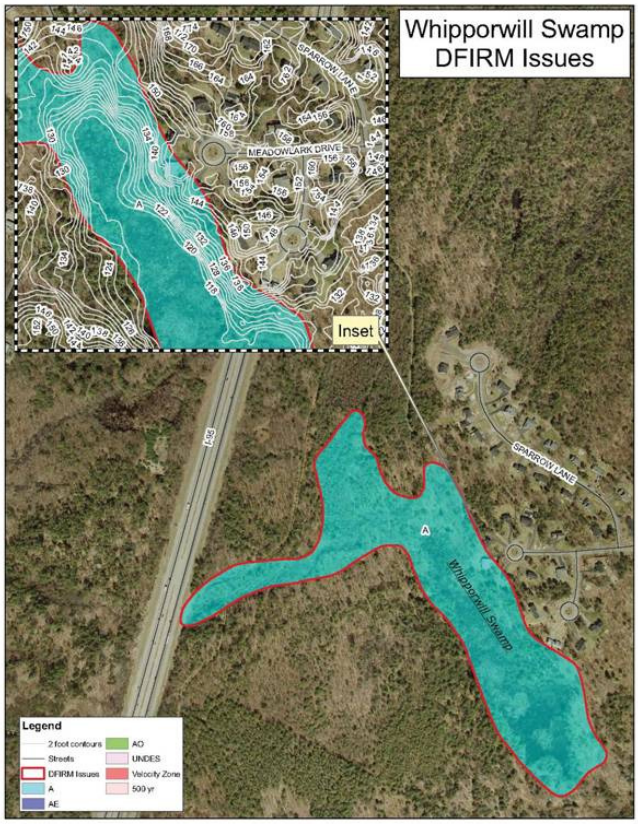
MARTHA E. FREEMAN
Director

January 21, 2009

Kathy Mills
Research Coordinator
Great Bay National Estuarine Research Reserve
225 Main Street
Durham, NH 03824

Dear Kathy,

We here in the Maine Floodplain Program fully support your project on climate change and specifically the acquisition of LiDAR data for the project area. LiDAR is an excellent technology for producing digital terrain models and high resolution topography, both of which are instrumental in the process of developing accurate floodplain maps. We have responded specifically to the questions you put forth below.



How would LIDAR data benefit your operations and projects?

High resolution topographic data is a critical element needed in the development of accurate floodplain maps. The illustration provided shows the effects of plotting floodplains using existing USGS data. This illustration is from the town of York where they have developed their own high resolution topographic data. By overlaying existing floodplain maps with high resolution topography one can see the disconnect between FEMA's floodplain

delineation and the reality of the topography. The conclusion one must take from examples such as this is that we have thousands of acres of floodplain improperly mapped. Many property owners are mistakenly paying for flood insurance when in fact they are not in a floodplain and much worse others are shown to be safe when in fact they are at risk. It has been less than fifty years since the first floodplains were mapped. Many people have been fortunate in escaping the 1% chance of flooding and may be fortunate for many more. We have an obligation to map our floodplains accurately and that can only be done through the acquisition of high resolution topography. It is my understanding that LIDAR is the most effective, efficient and economical means of acquiring this data.

For what purposes would LIDAR data be valuable to you, and how would it enhance your efforts or make new initiatives possible?

With access to accurate LiDAR based topographic information we would be better able to revise our existing maps to reflect the real threat to life and property in these areas. The area in the illustration is part of FEMA's Map Mod program and to the greatest extent possible under the program will see the benefits from delineation of floodplains based on accurate topography. Unfortunately there are nearly 30 other communities in the county that will not have the benefit of high resolution topography and will even with new maps be subject to poorly drafted floodplain maps.

The cost of acquiring new data on a large scale is outside of the scope of our program and can only be obtain for the most critical areas representing the most danger to human life and property. This was accomplished for small sections of the coastal areas of York and Cumberland Counties. By having access to this data for all the communities in the propose project we could begin the task of floodplain re-delineation thereby potentially saving lives and certainly preventing excessive property damage.

Thank you for the opportunity to offer support for your project!

Sincerely,

Joseph Young
Mapping Coordinator
Maine Floodplain Management Program

3. *Wells National Estuarine Research Reserve*

Wells National Estuarine Research Reserve

Research • Education • Stewardship

19 January 2009

Kathy Mills
Great Bay National Estuarine Research Reserve
225 Main Street
Durham, NH 03824

Dear Kathy:

Thanks for sharing your position paper *Rationale for the Collection of Regional LiDAR Data in New Hampshire and Maine.* The LiDAR topographic mapping and data processing you propose for Seacoast watersheds would provide an invaluable resource for our coastal research, outreach, stewardship and ecosystem-based management programs, focused within coastal watersheds from the Piscataqua River east to the Saco River drainage. Our partners and we would apply these data most specifically to our work on:

1) Lagrangian circulation modeling of Seacoast estuaries and nearshore waters,
2) site selection/performance assessment of estuarine and coastal watershed restoration projects,
3) tidal wetland ecologic and geomorphologic response to sea level rise,
4) shoreland protection and conservation,
5) land-cover classification, and
6) spatially explicit models of land-use impacts on aquifers.

These aspects of our programs at the Wells National Estuarine Research Reserve, and the work of program collaborators (colleagues within the National Reserve System, the University of Maine, University of Southern Maine, University of New Hampshire, Brown University, and Dartmouth College) will be greatly enhanced regarding the utility of the ecosystem-based management products delivered.

We will be more than happy to assist your effort in any way we can, so be sure to let us know what we can do to help make this proposed work a reality.

Best regards,

Michele Dionne, Ph.D.
Research Director

4. Maine Department of Transportation

On behalf of the Maine Department of Transportation GIS users, I would like to express support for the establishment of LiDAR data in New Hampshire and Maine. In addition to the current high-resolution topography needs for normal planning and engineering work, organizations such as ours will rely on topographic information even more as we make new considerations with regards to the effects of climate change on infrastructure.

Like many organizations in Maine and New Hampshire, MaineDOT uses topographic data for a wide variety of planning and engineering purposes. These uses include general transportation planning, development of engineering design plans for projects such as highway reconstruction, flight path analysis for airports, noise analysis, hydrology analysis to determine appropriate size of drainage structures and determining elevation of infrastructure (such as roads and rail) relative to water bodies and adjacent slopes.

Existing USGS topographic data is not as helpful for the Department's needs regarding engineering and detailed analysis. Consequently, MaineDOT budgets for and develops topographic data for specific projects when new topographic data is needed. New topographic data would be helpful for planning and pre-engineering work, while final engineering projects require much more accurate topographic data (such as contour lines at one and two-foot intervals). High resolution topographic data would be very beneficial to transportation planning and the Department is committed to collaborating with other state, local and federal agencies to facilitate the acquisition of this data, which can help us in providing for safe, productive and efficient development and maintenance of transportation infrastructure.

Nathan Kane
GIS Administrator
Maine Department of Transportation

5. Maine Department of Marine Resources

The Maine Department of Marine Resources makes use of topographic and bathymetric data for study and management of migratory fish and other marine species and the habitats that support those species. We have not had the budget to support Maine State LiDAR data acquisition but have collected high resolution non-LiDAR bathymetric data.

Most recently we have lead a multi-state/multi-year National Marine Fisheries Service funded Species of Concern study which includes the study of coastal Rainbow Smelt and Atlantic Sturgeon. We have found ourselves hampered by the lack of high resolution topographic data for the majority of the Maine coast, New Hampshire, and for parts of Massachusetts. This data would be of value for better characterizing coastal drainage areas for the streams that support Rainbow Smelt populations as critical spawning habitat and would help to better model and understand threats to species.

Our need for better topography extends below the coastline or mean high water. Important intertidal and subtidal hydrographic and habitat features are much in need of better resolution, accuracy, and definition. LiDAR systems are not typically deployed to collect this type of data and often opportunities to collect orthophotography and multispectral data coincident with LiDAR are overlooked.

We give our support of efforts such as this knowing that wide and varied use of data collected will be made in the future.

Best Wishes,

Seth L. Barker
Bureau of Resource Management
Maine Department of Marine Resources
194 McKown Point Road
West Boothbay Harbor, ME 04577

III. Regional and Municipal Groups

1. Southern Maine Regional Planning Commission

I am writing in support of the effort to acquire a comprehensive set of LiDAR data for coastal New Hampshire and Maine. Since the Spring of 2008, the Southern Maine Regional Planning Commission has partnered with the Maine Geological Survey, with funding from the Maine Coastal Program, on the Coastal Hazards Resiliency Tools Project. The existing narrow swath of accurate LiDAR data has gotten our project off to an excellent start, but so much more could be accomplished, with full coverage of our service area.

The SMRPC sees its mission has providing guidance and technical assistance to coastal and inland municipalities, particularly by enhancing and revamping their regulatory schemes, to deal with more frequent and severe flooding associated with climate change and sea level rise. In Maine, the DEP Minimum Shoreland Zoning Guidelines and the SPO Floodplain Management Program, are each relied upon to provide municipalities with a minimum level regulatory framework. In each program, municipalities are mandated to adopt ordinances that are largely written out for them, with a variety of minimum standards. The geography used to regulate floodplains comes from FEMA flood insurance rate maps, which utilize 30+ year old analog technology. Of course, under Maine law, towns and cities have the "home rule" authority to enact stricter regulations. Some do, but the mandated minimums provide the basic backstop for the whole system.

It has been the experience in the recent Mother's Day and Patriot's Day storms, both in York and Old Orchard Beach, that the minimum regulatory scheme as envisioned and promoted by FEMA, SPO and DEP is not accurate enough at predicting flood heights or the geographic extent of inundation, giving overall rising tide levels. LiDAR data can be used to assign new locations of locally designated flood plain, far more realistic than maps derived by older methods.

The Coastal Hazard Resiliency Project has begun to assist a handful of coastal towns, in those areas about 1500 feet from the ocean coast, analyze the newest predictions of flood heights, and display where the new floodplain will probably be. Hopefully, the result will be new, locally-designated floodplains based upon LiDAR data, with increased freeboard requirements, for post-flood reconstruction in currently developed areas. With full LiDAR coverage for the entire watershed areas proposed, we will be able to build upon these current pilot projects, and bring more accurate flood prediction west to Route 1, and beyond, up to the White Mountains.

Sincerely,

Jonathan T. Lockman AICP
Planning Director
Southern Maine Regional Planning Commission
21 Bradeen Street, Suite 304
Springvale, ME 04083

2. *Strafford Regional Planning Commission*

BARRINGTON
BROOKFIELD
DOVER
DURHAM
FARMINGTON
LEE
MADBURY
MIDDLETON
MILTON

NEW DURHAM
NEWMARKET
NORTHWOOD
NOTTINGHAM
ROCHESTER
ROLLINSFORD
SOMERSWORTH
STRAFFORD
WAKEFIELD

Support Letter for the Collection of Regional LiDAR Data

On behalf of the Strafford Regional Planning Commission (SRPC) I am writing in support of the effort to collect regional LiDAR Data. The SRPC region is compromised of 18 communities that are mostly located in the Coastal Watershed of New Hampshire. I'm sure many of the details of LiDAR data have been brought to your attention already and explaining them again is probably not necessary. However, highlighting the importance and potential uses within our region is necessary in understanding our strong support for the acquisition of this data.

SRPC is one of the nine regional planning commissions located in New Hampshire. Our focus is to assist our member communities' efforts to better the quality of life locally as well as regionally. With the increasing occurrence of damaging floods and other natural disasters there is a growing need to update local/regional emergency preparedness and hazard mitigation plans. As I'm sure you've heard, the accuracy and resolution of LiDAR data allows for more accurate natural resource analyses such as hydrologic modeling and floodplain evaluation. There are many other uses and studies that can be completed using LiDAR, but for these reasons alone LiDAR is the best means available for preparing the region for future emergency situations.

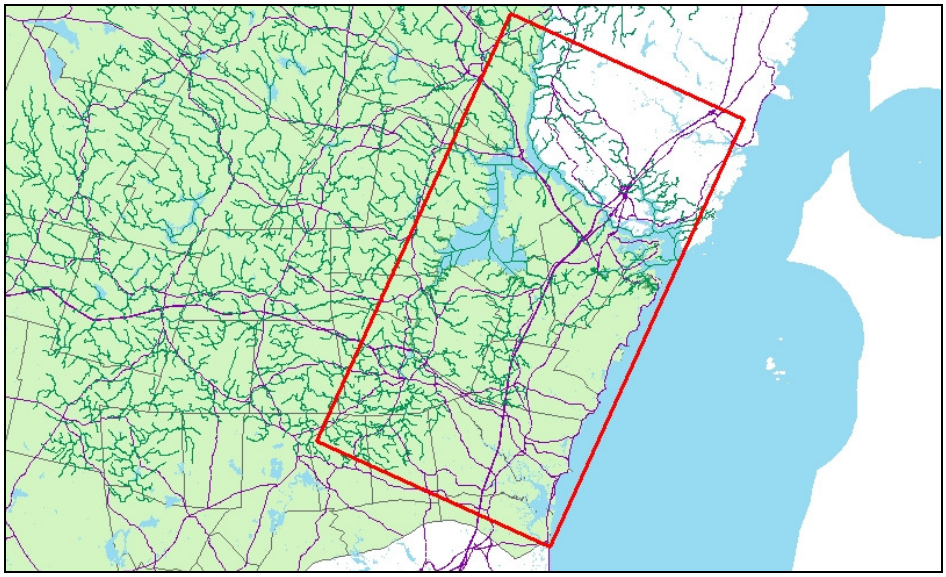
I ask that you please consider the importance that LiDAR plays in helping our region to better plan for emergency situations. With the current fiscal situation that we all face it is imperative that we direct our efforts to high priority projects. SRPC's hazard mitigation plans are one of our highest priorities and could be greatly improved with the incorporation of quality LiDAR data.

Sincerely,

Dan Camara
Transportation/GIS Analyst
Strafford Regional Planning Commission

3. The Nature Conservancy, New Hampshire Chapter

The NH Chapter of The Nature Conservancy (TNC) is the lead agent for acquisition and protection of more than 5,000 acres of land in the NH coastal block (below). To protect this investment from impacts of future sea level rise, TNC seeks to partner with regional seacoast collaborators to acquire complete LIDAR coverage of the seacoast. The current piecemeal approach to LIDAR acquisition in coastal NH has resulted in coverage of less than 50 square miles of the 250 square mile seacoast region (below). With high fixed costs and expansive desired coverage, it is increasingly obvious that a coordinated approach to LIDAR acquisition is needed in NH and elsewhere. The NH Chapter of TNC is actively developing requests for legislative appropriations, public grants, and private donor support for comprehensive LIDAR acquisition. We strongly endorse collaborative efforts and promote this ME/NH proposal from our standing as both a state and regional partner.



TNC planners in Atlantic Coast states from New England to North Carolina have identified LIDAR acquisition as a foremost objective in comprehensive conservation planning. As we engage at a regional level, we seek to leverage LIDAR acquisition for the following uses:

- Identify which estuary sites and shoreline areas are most vulnerable to sea level rise;
- Document vulnerable areas where seawalls or other shoreline hardening proposals are more likely to occur, and of those areas which will result in the most detrimental ecological impacts as sea level rises;
- Identify upland areas most suitable for salt marsh migration;
- Develop analyses that show cumulative impacts of potential flooding for different land uses;
- Identify areas subject to flooding for implementation of stormwater BMPs;
- Target waterfront tracts for increased protection; and,
- Inform decisions for management of conserved shorefront properties.

4. Piscataqua Region Estuaries Partnership

The Piscataqua Region Estuaries Partnership (PREP) is part of the U.S. Environmental Protection Agency's (EPA's) National Estuary Program, which is a collaborative local/state/federal program established under the Clean Water Act with the goal of promoting the protection and enhancement of nationally significant estuarine resources. PREP receives its funding from the EPA and is administered by the University of New Hampshire. The mission of PREP is to protect, enhance, and monitor the environmental quality of the Piscataqua River and Hampton-Seabrook estuaries and their associated watersheds. The watershed area that is the focus of PREP's work encompasses forty-two towns in New Hampshire, and ten towns in southern Maine. The area proposed for LiDAR acquisition as detailed in this position paper would encompass all of the land and waters within the PREP management focus area.

In 2007, PREP obtained funding from EPA to collect hyperspectral imagery for the Great Bay Estuary. The imagery was processed to develop high-resolution maps of eelgrass and nuisance macroalgae in the estuary. These maps were used to test the hypothesis that an important eutrophication response to nutrient increases in the Great Bay Estuary has been the proliferation of abundance of macroalgae, which supplants eelgrass. While the results of the study confirmed the hypothesis, the data analysis was limited by uncertainty in the water depth and its effects on the returning signal from the water bottom. This uncertainty could be removed if high-resolution topographic data were collected for the intertidal zone of the estuary. The intertidal bathymetry around the Great Bay Estuary is currently not charted because large areas in the estuary are too shallow for standard marine surveying. An elevation model from airborne topographic LiDAR measurements at low-tide would fill this data gap. The digital elevation model from the LiDAR could be used to calculate water attenuation on the returning optic signals from the water and allow a more accurate calculation of bottom reflectance for mapping eelgrass and macroalgae.

The LiDAR acquisition and floodplain mapping proposed in this paper would provide an essential foundation upon which PREP would assist the region's communities adapt to climate change impacts. PREP is actively working on climate adaptation planning in our region, and is one of six National Estuary Programs funded for adaptation planning work under the EPA's Climate Ready Estuaries initiative. PREP provides environmental planning grants and technical assistance to the 52 towns in our planning region. Adapting to climate change impacts associated with sea level rise and increased storm intensities will require both regulatory and voluntary proactive planning measures at the town level. But to make these adaptation measures a reality, communities need scientifically-defensible maps of specific locations that are vulnerable to climate change impacts. The low resolution of the existing elevation data for our region, combined with the low relief of the coastal plain, make it difficult to generate maps of vulnerable areas at this time that would be of high enough quality to use for regulatory measures such as restricting new development in high hazard areas. There is a high level of interest in local communities to work with PREP on climate adaptation planning, but we see the acquisition of LiDAR data as a fundamental first step in developing practical place-based strategies. The updated 100-year floodplain scenario mapping proposed in this paper would thus serve as the foundation for PREP's climate adaptation planning work.

5. New England Interstate Water Pollution Control Commission

NEIWPCC
New England Interstate Water Pollution Control Commission

Fostering Collaboration on Water Issues
Training Environmental Professionals
Coordinating Water Research
Educating the Public

January 20, 2009

Ms. Kathy Mills
Research Coordinator
Great Bay National Estuarine Research Reserve
225 Main Street
Durham, NH 03824

RE: "Rationale for the Collection of Regional LiDAR Data in New Hampshire and Maine" position paper

Dear Ms. Mills:

This letter reflects NEIWPCC's support of the position paper titled, *"Rationale for the Collection of Regional LiDAR Data in New Hampshire and Maine"* authored by yourself, Ms. Fay Rubin, and Dr. Cameron Wake.

The New England Interstate Water Pollution Control Commission (NEIWPCC) is a congressionally authorized organization formed via a federal compact in 1947. NEIWPCC's role is to coordinate and assist the efforts of our compact states on Clean Water Act and Safe Drinking Water Act programs, and ultimately to improve water quality throughout the Northeast. As a result of our efforts to serve and assist our member states, NEIWPCC has led or played an integral role in the development of regional modeling tools that use regional data layers, such as digital elevation model (DEM) data. These tools include: the development of the Northeast AVGWLF (Generalized Watershed Loading Function using an ArcView geographic information systems interface) which models nonpoint source pollutant loads to a watershed; and the regional SPARROW (SPAtially Referenced Regressions On Watershed Attributes) model which relates in-stream water-quality measurements to spatially referenced characteristics in a watershed. Both of these models use DEM data to calculate pollutant loads coming from the landscape. In the case of the Northeast AVGWLF, we used 30 meter DEM data; this decision was made due to the increasing file size of a regional elevation data layer as you enhance the resolution of that data. Although we opted to use the 30 meter DEM data for various reasons, primarily the sheer size of the higher resolution data files- our state partners would have preferred the use of higher resolution data- LiDAR had it been available because the AVGWLF model output would have been more accurate using higher resolution data layers.

NEIWPCC staff working on efforts in Lake Champlain have also come to appreciate the value of LiDAR data acquisition. Partner agencies are currently working to set priorities for information and analysis with an overarching goal of informing agencies of conservation measures that can reduce the delivery of phosphorus to the Lake Champlain watershed. The groups are anticipating that the addition of high

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Massachusetts
New Hampshire
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Rhode Island
Vermont

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p: 978-323-7929
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resolution elevation data, acquired with LiDAR technology will provide opportunities to quantify the erosion problem, and prioritize limited agency funds toward real improvement. In stressed economic times, this is just one example of how LiDAR data can help guide decision makers in priority setting related to pollution control, and we certainly can see the value of this application in other watersheds throughout the Northeast.

In the past twelve months, NEIWPCC established a Climate Change Workgroup. This workgroup is made up of staff from our member states, the U.S. Geological Survey, the U.S. Environmental Protection Agency, and academics from regional colleges and universities. This workgroup has identified several priority projects, many of which would benefit from accessible LiDAR data from the coasts of New Hampshire and Maine, as well as from the rest of the region. These projects include (but are not limited to): the localization of large-scale climate models, and determining the potential impacts of sea level rise on water infrastructure both in coastal New England and New York and on inland areas. As is with both of these projects, data at more refined scales would enable state managers to better prioritize facility and infrastructure maintenance, upgrades, and adaptive measures based on vulnerability to sea level rise.

NEIWPCC strongly supports the acquisition of LiDAR data for coastal New Hampshire and Maine, as well as the entire Northeast. If you have any questions, please do not hesitate to contact me at 978-323-7929 ext. 233.

Sincerely,
Rebecca Weidman
Director of Water Resource Protection

6. Great Bay Resource Protection Partnership

January 16, 2009

Ms. Kathy Mills
Research Coordinator
Great Bay National Estuarine Research Reserve
225 Main Street
Durham, NH 03824

Dear Ms. Mills;

The Great Bay Resource Protection Partnership supports the proposed Light Detection and Ranging (LiDAR) project for coastal New Hampshire and southern Maine watersheds. LiDAR technology will provide Great Bay Partnership conservation entities with accurate, high resolution topographic data which is important to improving the planning and selection process for a diversity of conservation related projects in New Hampshire's coastal communities.

The Great Bay Partnership is a consortium of the major public and nonprofit conservation organizations and agencies that are committed to protecting the important habitats of the Great Bay region, including coastal New Hampshire. LiDAR technology will provide data that is usable to multiple Partner organizational needs. LiDAR technology will assist the Great Bay Partnership in the prioritization process of land protection projects, evaluation of saltmarsh restoration, land cover analysis, and furthering our understanding of climate change impacts on critical habitat areas.

If you have any further questions, please contact me.

Sincerely,

Dea Brickner-Wood
Great Bay Coordinator

Great Bay Resource Protection Partnership
1 Colony Cove Road
Durham, New Hampshire, 03824
(603) 868-6112

7. Casco Bay Estuary Partnership

January 26, 2009

Dr. Katherine Mills, Research Coordinator
Great Bay National Estuarine Research Reserve
225 Main Street
Durham, NH 03824

Dear Katherine:

The Casco Bay Estuary Partnership strongly supports your efforts to obtain high-accuracy LIDAR data for the Casco Bay watershed. Accurate elevation data would enable improved natural resource management throughout the watershed, especially within the context of anticipated climate change. While some LIDAR data for the Casco Bay coastline has recently become available, its quality is not sufficient for many of our needs. More importantly, there is currently no LIDAR coverage at all for most of the watershed. Given concerns about climate change, those gaps are critical.

Perhaps the most direct use of LIDAR -derived elevation data would be to identify areas at risk from sea level rise, which would have a serious impact on coastal and marine resources. We are already using the relatively low-resolution LIDAR data available for most of the Casco Bay coastline to examine impacts of sea level rise on coastal wetlands, particularly concentrating on salt marshes, which are highly sensitive to tidal elevations. Unfortunately, the limited quality of those data has been a significant impediment to that work. Indeed, a Casco-Bay wide evaluation may be impractical without more reliable data.

For example: we know that sea level rise will lead to flooding of the lower elevation portions of existing marshes and migration of wetlands into adjacent uplands. But high-resolution elevation data would allow us to evaluate where wetlands will be lost, and to identify current areas of adjacent uplands where lands might be protected to permit migration of wetlands in the future.

Sea level rise may also affect the livelihoods of coastal clammers and worm diggers. As sea levels rise, the area of mud flats accessible to harvesters will change. We do not know whether the net effect will be to increase or decrease harvestable area, although available evidence suggests declines are likely. But the resolution and precision of the available LIDAR coverage on tidal flats is not good enough to tackle such analysis.

Inland, our interests in LIDAR data revolve around improving our understanding of river and stream hydrology and geomorphology, primarily for purposes of stream restoration and infrastructure planning. Stream restoration requires a fine understanding of the forces shaping sediment transport dynamics in

streams and rivers on a reach by reach scale. Higher resolution elevation data both act as an important source of reach-scale information to guide interpretation of geomorphic patterns and processes. They can also provide the underlying information to support numerical modeling of hydrology, including flood flows. Changes in precipitation and evapotranspiration in a greenhouse world are expected to lead to changes in stream flow. Most analyses suggest both more frequent floods and more frequent low-flow events. We anticipate that higher resolution elevation data – and the potential for hydrologic modeling based on such data – will sustain conversations with our municipal partners on hazard mitigation planning, planning of infrastructure investments and management of local water resources.
We also anticipate that as we and our partners gain experience working with LIDAR data, additional uses will evolve. Use of LIDAR data in association with other geospatial data products is likely to enhance our understanding of land use change, forest condition, and stream habitat.

Please let me know if we can provide you with any other examples of how we would use high-resolution LIDAR data, or what else we might do to support your efforts to obtain such information for the benefit of the entire Casco Bay watershed.

Sincerely yours,

Curtis C. Bohlen, Ph.D.
Director

8. Southeast Land Trust of New Hampshire

The Southeast Land Trust of New Hampshire supports the effort to acquire LiDAR for coastal New Hampshire and Maine, as it would enhance our ability to steward our conservation interests and aid in prioritizing future land protection.

As a holder of over 100 conservation easement interests (and counting!), we have a responsibility to accurately monitor the condition of nearly 6,000 acres of land. Our method of detecting baseline property conditions and changes over time includes use of USGS topographic maps as well as aerial monitoring through orthophotography. While orthophotography can show major changes in land use (such as new structures or clearing of land), both data sources are currently limited in their value for detecting changes to soil surfaces (a common easement restriction) or the introduction of man-made structures on a property. Acquisition of LiDAR data would allow us to couple orthophotography with high resolution topographic data in order to establish a powerful and accurate baseline of the existing structures and topographic features on all of our conservation properties -- including those obscured by forest cover -- as well as enhance our ability to detect future property alterations and potential violations. Moreover, for the lands we own, it would provide much-needed information to improve the quality of our planning that seeks to balance wildlife habitat, water quality, and recreational interests.

In addition to aiding our easement monitoring and land management, LiDAR data would be a powerful tool in prioritizing lands to protect. By facilitating the projection of changes in floodplains, acquisition of LiDAR data would help conservation organizations identify and protect lands that will be important for future flood storage, wildlife habitat, and productive agriculture and forestry.

9. Friends of Casco Bay

I am writing in support of the combined efforts by the Great Bay National Research Reserve, the Complex Systems Research Center and the Institute for the Study of Earth, Oceans and Space, University of New Hampshire, to acquire LIDAR for coastal New Hampshire and southern Maine. We foresee using this data directly or indirectly through collaborative partnerships. The higher resolution elevation models generated through LIDAR will allow us to examine or predict various scenarios, as for sea level rise to compare the impacts of a range of forecasted heights. We can further extrapolate a range of impacts on coastal habitats from projected sea level rise such as the inland migration of salt marshes and eelgrass beds. LIDAR models can also help us analyze how shoreline development and impervious surfaces may inhibit the landward extension of these coastal habitats.

R. Michael Doan
Research Associate
Friends of Casco Bay
43 Slocum Drive
South Portland, ME 04106
207-799-8574

IV. Federal Agencies

1. U. S. Geological Survey

The U.S. Geological Survey (USGS) is the lead federal agency in the development of the National Spatial Data Infrastructure (NSDI). Elevation is one of eight framework layers underpinning the NSDI. USGS seeks local, state, academic and private partnerships on an ongoing basis to increase the coverage, accuracy and resolution of the nation's elevation database in support of the NSDI. In recent years, LIDAR has become the technology of choice for improving our national elevation database. It has become more cost-effective than traditional photogrammetric methods for large projects and provides a more useful and robust database.

USGS is also interested in better elevation data to support USGS products and services like The National Map and USGS priorities for homeland security and emergency response. The scientific research undertaken by USGS would also benefit from better resolution elevation data derived from LIDAR. Coastal mapping, geologic, biological and hydrological research projects are utilizing LIDAR technology, and the data is becoming increasingly valuable for climate change research including efforts to model sea level rise and the effects of changing precipitation patterns on communities.

While funds cannot be committed at this time, USGS would support a high resolution LIDAR elevation project covering the coast of New Hampshire and a large portion of the coast of Maine. Please include USGS as a project collaborator. We will work with the University of New Hampshire to identify potential federal funds as the project materializes. We highly recommend the USGS Center for LIDAR Information Coordination and Knowledge website for reference information and access to expertise. http://lidar.cr.usgs.gov/

Lin Neifert
USGS Geospatial Liaison for
Vermont and New Hampshire
US Geological Survey
617 Comstock Road Suite 7
Berlin, VT 05602
lineifert@usgs.gov

Dan Walters
Geospatial Liaison for Maine
USGS Maine Water Science Center
196 Whitten Road
Augusta, MA 04330
danwalters@usgs.gov

1. EPA Region I

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 1
JOHN F. KENNEDY FEDERAL BUILDING
BOSTON, MASSACHUSETTS 02203-0001

January 20, 2009

Kathy Mills
Research Coordinator
Great Bay National Estuarine Research Reserve
225 Main Street
Durham, NH 03824

USEPA recognizes the need for access to high resolution LIDAR data throughout the New England States. State agencies, watershed programs, and local communities in southern Maine and New Hampshire have clearly and urgently conveyed the need for high accuracy LIDAR data, particularly in the face of climate change-induced sea level rise and changes in precipitation patterns.

For example, the Casco Bay Estuary Partnership, which receives major funding through EPA, has noted that existing LIDAR data for the Casco Bay coast is not of sufficiently high resolution to evaluate potential coastal wetlands losses and to identify areas of adjacent upland that should be targeted for protection. Potential wetland losses include salt marshes that serve as feeding and nursery areas for fish and coastal birds and as natural buffers against coastal storms, as well as valuable intertidal clam flats.

In the Casco Bay watershed and throughout the state of Maine, LIDAR data is generally not available for the inland areas. Access to high resolution elevation data is essential for hazard mitigation planning and management of community infrastructure including homes and businesses, roads, culverts, drinking waters supplies, and sewage treatment facilities.

Similar needs have been voiced by state agencies and communities in New Hampshire. High resolution elevation data has been identified as essential for fine resolution watershed modeling, for assessment of flooding impacts, and to understand sediment transport and stormwater impacts in a changing environment.

In short, the LIDAR data currently available in Maine and New Hampshire is insufficient to assess the range of impacts to natural systems and to infrastructure likely to result from climate change and to allow for adequate adaptation planning. US EPA supports the development of high resolution LIDAR data for the New England region as a key step in developing adaptive strategies to protect both our ecological and key infrastructural resources.

Sincerely,

Melville P. Coté, Jr.

U.S. Environmental Protection Agency

Office of Ecosystem Protection

Manager, Ocean and Coastal Protection Unit

3. NOAA Restoration Center

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
NORTHEAST REGION
55 Great Republic Drive
Gloucester, MA 01930-2276

JAN 16 2009

Ms. Katherine Mills
Research Coordinator
Great Bay National Estuarine Reserve
225 Main Street
Durham, NH 03824

RE: LiDAR Data for New Hampshire and Maine

Dear Ms. Mills,

I have read you position paper entitled "Rationale For the Collection of Regional LiDAR Data in New Hampshire and Maine" with great interest. The NOAA Restoration Center provides technical and financial assistance to undertake a wide variety of habitat restoration projects that are intended to restore NOAA trust resources such as shellfish beds, eelgrass, salt marsh, as well as anadromous fish and their habitats. Most, but not all, of the projects we sponsor require detailed topography survey data to plan, study and implement. Having more detailed and higher resolution topography data that could be provided through the use of LiDAR would certainly assist in restoration planning and implementation.

The NOAA Restoration Center been involved with implementing a number of past projects in your proposed study area we are in the initial planning stages for new projects that could potentially utilize the proposed LiDAR data. Please keep us informed about the progress completing this new topography data layer and feel free to contact me again to discuss how NOAA supported restoration projects may be able to support your efforts.

Sincerely,

Eric W. Hutchins
Gulf of Maine Habitat Restoration Coordinator

United States Department of Agriculture

NRCS

Natural Resources Conservation Service
Federal Building
2 Madbury Road
Durham, NH 03824-2043 (603) 868-7581 Fax: (603) 868-5301 www.nh.nrcs.usda.gov

January 27, 2009

RE: Statement of support for wide-area LiDAR acquisition

Fay Rubin
GRANIT Project Director
Complex Systems Research Center
Morse Hall
University of New Hampshire
Durham, NH 03824

Dear Fay,

The United States Department of Agriculture- Natural Resources Conservation Service (USDA-NRCS) recognizes the value of high resolution elevation data as critical to the agency in carrying out its mission of conserving and protecting natural resources on public and private lands.

LiDAR (Light Detection and Ranging) is an efficient and proven method used for obtaining elevation data of high accuracy and resolution over geographical areas of wide extent. The USDA-NRCS in New Hampshire has used and will use LiDAR elevation data for limited and specified areas for watershed and farm conservation planning, wetland and habitat restoration projects and natural resource inventories. Projects where New Hampshire NRCS has used LiDAR data are the Fresh Creek in Rollinsford, NH for tidal flow and habitat restoration; the Old Mill site in Lee, NH for wetlands restoration and watershed protection; the Winnicut River watershed in Greenland, NH for migratory fish habitat restoration; the Bellamy River site in Dover, NH for gulley erosion control for water quality and wildlife management; the White Mountain National Forest for soils resource and forest type mapping.

USDA-NRCS recognizes that economies of scale can be obtained from wide area acquisitions of LiDAR data, and therefore supports efforts by state, other federal agencies and non-governmental organizations to enter into cooperative agreements that would result in a coordinated acquisition of statewide or wide area LiDAR coverage.

Sincerely,

GEORGE W. CLEEK, IV
State Conservationist – New Hampshire

Helping People Help the Land

An Equal Opportunity Provider and Employer

5. Great Bay National Wildlife Refuge

United States Department of the Interior
FISH AND WILDLIFE SERVICE
Parker River National Wildlife Refuge
6 Plum Island Turnpike
Newburyport, Massachusetts 01950

January 16, 2009

Peter Wellenberger
Great Bay National Estuarine Research Reserve

Dear Peter,

I am pleased to be able to provide this letter in support of efforts between the Great Bay National Estuarine Research Reserve, Complex Systems Research Center and the UNH Institute for the Study of Earth, Oceans, and Space to acquire LIDAR for Coastal New Hampshire and Maine.

As you know, Great Bay National Wildlife Refuge will be developing a Comprehensive Conservation Plan (CCP) over the next couple of years that will guide management of the refuge for the following 15 years. The plan will address our current management of existing habitat and wildlife resources at Great Bay NWR, as well as existing public use, and existing facilities. As we progress through the planning process, climate change will be of constant consideration as we try to look ahead and predict what changes may occur.

Of particular interest is how sea level rise may influence current and future habitat management, restoration, and land protection efforts by the Refuge. We are currently having an analysis done using the **Sea Level Affecting Marshes Model** (SLAMM) which simulates the dominant processes involved in wetland conversions and shoreline modifications during long-term sea level rise. Whereas this analysis will yield information that we can consider when developing our CCP, the use of LIDAR would provide a much greater tool for us to utilize not only when considering sea level rise, but also in evaluating the vegetative changes to habitats, especially invasive species such as phragmites, which we understand can be detected with LIDAR.

We look forward to hearing of the success with this effort and if there is anything else we can do to support this effort please let me know.

Sincerely,

Graham W. Taylor
Refuge Manager

Parker River NWR
Thacher Island NWR
Great Bay NWR
Wapack NWR

6. *Rachel Carson National Wildlife Refuge*

United States Department of the Interior

FISH AND WILDLIFE SERVICE

Rachel Carson NWR
321 Port Road
Wells, Maine 04090

February 3, 2009

Kathy Mills
Research Coordinator
Great Bay National Estuarine Research Reserve
225 Main Street
Durham, NH 03824

Ms. Mills:

Thank you for writing. Rachel Carson National Wildlife Refuge does recognize the potential benefits from LIDAR coverage for more of the area we manage. We are happy to write in support of your effort for LIDAR acquisition on the southern Maine coast and coastal New Hampshire.

The 1-meter LIDAR based Digital Elevation Model described in this proposal would be a valuable management tool for Rachel Carson National Wildlife Refuge. Coastal holdings will be among the first areas to be affected by sea level rise due to climate change. Since habitats are closely linked to height, particularly in a salt marsh, having a more precise measure of topography would allow us to better predict and model the effects of rising sea level on our coastal habitats. This level of data will allow us to see the effects of storm surge and river flooding, as well as gradual inundation, with a precision that is not possible with today's information. The capacity to measure and visualize the details of salt marsh topography, pools, streams and ditches, would assist in study or management of the marsh. LIDAR's ability to measure vegetation structure has direct application to refuge management. The points that do not reach the "ground plane" but rather bounce off vegetation before they reach the ground can be used to model the height and density of refuge vegetation. This, coupled with high resolution aerial photography can provide a very detailed picture of land cover and habitat which would greatly assist in managing our upland habitats as well.

Both Rachel Carson and Great Bay National Wildlife Refuges fall entirely within the boundaries of the "Coastal Communities" section of the proposed acquisition plan, making it an especially valuable dataset for both refuges since it will all be collected at the same 1-meter resolution and taken at the same time. It can be seen a "baseline" for the change that is likely to come. As this technology becomes more commonplace, hopefully we will benefit from a drop in price so this kind of project to be repeated at regular intervals to record the predicted change as it unfolds. The USFWS has the technical ability to use this data, after the initial processing, and would be willing to assist others to benefit from it as well.

Sincerely,

Ward Feurt
Refuge Manager

7. NOAA Northeast River Forecast Center

Kathy,

At the NWS/NERFC the use of LIDAR mapping is extremely important when we are being asked to provide more service with our daily river (WFO estuary) forecasts. We are transitioning from a point location stage/flow forecast to a graphical reach inundation forecast. This can only be accomplished by the use of improved mapping to the level of LIDAR mapping. This will allow what we call "static" inundation mapping based on a steady state HEC-RAS solution in the vicinity of our forecast location (about a mile up and downstream) to a total reach inundation mapping based on the unsteady hydraulic modeling on a river. Again, this can only be accomplished with good LIDAR (1 to 2 ft contour interval mapping).

To accomplish this, we are requesting this data from FEMA where they have both the maps and the hydraulic analysis completed on the Connecticut and Blackstone Rivers. This type of mapping with updated H/H is limited across the northeast.

GIS tools, like HEC-GEORas using 3D and spatial analysis is only as good as the map data provided to indicate inundation limits. This tool will fall short of the mark with anything less than good LIDAR mapping. Even with the mapping, someone still has to check spot elevations, gather bridge, culvert, dam, levee, and other man-made structure information to make sure any off-channel inundation areas really flood for the given hydrometeorological event.

From what we have experienced, the only good mapping of inundated flood areas, whether river or estuary, will be from updated LIDAR mapping. The basic H/H needs to be updated in some areas due to data being over 30 years old as indicated by differences in USGS and FEMA return periods for the same locations.

But whether we are looking at return period flood events or real-time inundation mapping on rivers or estuaries, these forecasts and H/H analyses will fall short of the goal if good LIDAR mapping is not available for the study. Rivers like the Saco, Androcoggin, Penobscot, Kennebec, Saint John and a host of smaller rivers and streams will be a benefit to Emergency Managers in times of flooding/crisis based on detailed topography from LIDAR mapping that supports development of good inundation limits for important inland and coastal reaches. I think the SACO Bay/Scituate Harbor studies are examples of what can be produced with good mapping.

Thanks

Ed Capone