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Tidal Inundation of Wetlands in the Murderkill Estuary

By Thomas E. McKenna

A coupled hydrodynamic and water-quality model is being developed to investigate causes of low dissolved oxygen in the tidal Murderkill River located in Kent County. Low concentrations of dissolved oxygen are common in the tidal Murderkill River during the summer and is one of the primary reasons that the Department of Natural Resources and Environmental Control (DNREC) declared the river and its tributaries as impaired for uses such as recreation, aquatic life, and water supply.

In 2007, DNREC and Kent County established the Murderkill River Study Group (MRSG) to plan and implement a comprehensive monitoring and research effort to investigate controls on dissolved oxygen concentrations in the tidal river, to understand the biogeochemical interaction between the river and salt marsh, and to incorporate the river's interaction with an extensive fringing salt marsh into a hydrodynamic and water-quality model. As a member of the MRSG, the DGS is investigating the feasibility of using thermal imaging to characterize tidal inundation.

In general, the dynamic inundation of a salt marsh by tidal water is a simple concept, but the process remains poorly understood. This is partly due to the sampling requirements to fully describe a shallow flow system on a low relief surface having high temporal and spatial variability. The purpose of this work, which is supported by Kent County, DGS, and DNREC, is to 1) characterize the spatial and temporal inundation of a small salt marsh in the Murderkill River Estuary and 2) to determine the feasibility of using heat as a tracer of flow to characterize inundation in tidal wetlands. The results will be used to evaluate the feasibility of using a smaller suite of temperature measurements to characterize inundation of other tidal wetlands in the estuary. The focus is on using heat as a tracer because heat transfer is tightly coupled with hydrologic processes, temperature loggers are inexpensive and easy to deploy, and thermal imaging allows for remote temperature measurements over broad areas. The latter also facilitates quick field testing of conceptual models and choosing representative areas for placing instrumentation and collecting representative water samples.

The study integrates data from LiDAR and ground elevation surveys and in-situ sensors (water level, salinity, temperature) to estimate the area and frequency of salt marsh inundation by tidal water. Given the low relief on the marsh platform, small changes in water elevation (centimeters) result in large changes in inundated area; therefore, it is critical to reduce all elevation data to a common geodetic datum and to minimize elevation errors and/or biases. Data used in this project come from multiple data providers. Datum conversions and adjustments based on a least-squares-adjusted, real-time-kinematic, global positioning system (GPS-RTK) survey resulted in significant elevation adjustments of up to 55 centimeters. Preliminary evaluation of LiDAR data indicates elevations of salt-

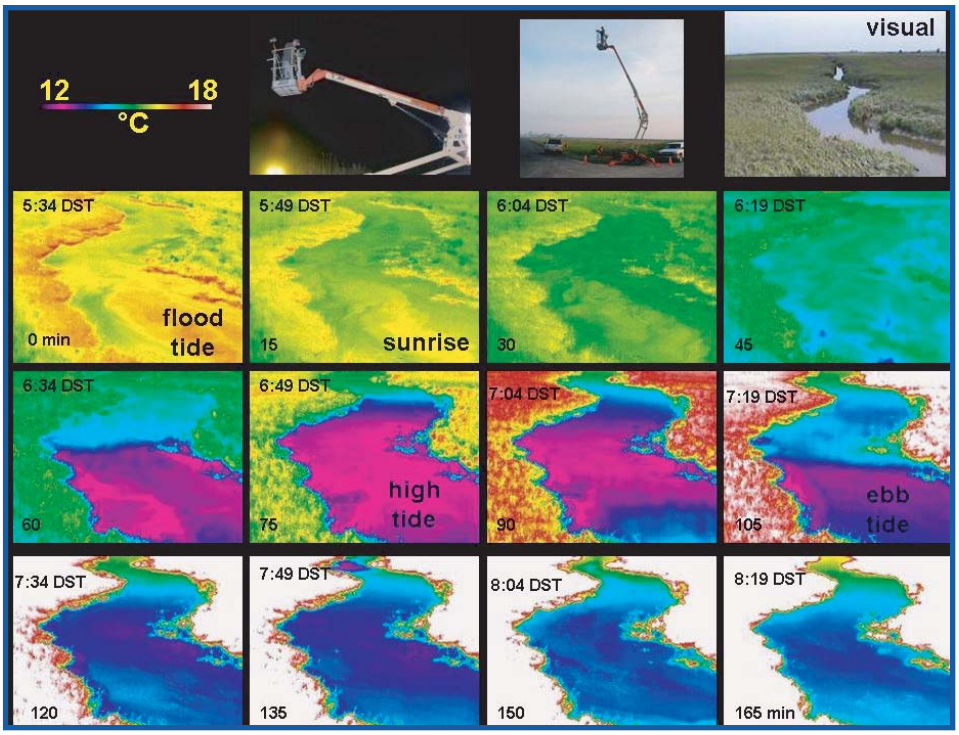


Figure 1. Imaging tidal mixing to support water-quality studies. This is a temperature time series of mixing in a tidal channel in the lower Murderkill Estuary. Images were acquired from a 30-ft bucket-lift platform at 15-minute intervals over a 165-minute period on the morning of May 15, 2008. The confluence of the tidal channel with the Murderkill River is about 1.5 kilometers upstream from Delaware Bay and is behind you as you view the images. Cooler water from Delaware Bay (purple) flows into the tidal channel during flood tide (60-75 minutes) and back out during ebb tide (105-165 minutes). Warmer water from the marsh interior (green) flows toward the viewer at 90-165 minutes.

marsh environments in the lower estuary near Bowers Beach are 15-25 cm higher than similar environments in the upper estuary near Frederica. This is likely to be a significant factor in our subsequent estimates of the frequency, duration, and depth of tidal inundation. Preliminary analyses of data from in-situ temperature loggers on the marsh platform indicate that it is feasible to determine timing of inundation from temperature time-series under certain environmental conditions. Signals of inundation are readily detected when air temperature is dropping in the evening and relatively warmer water is flooding the marsh plain. It is also feasible to capture spatio-temporal dynamics of flow in tidal creeks (Figure 1) and inundation (Figure 2) using ground-based and aerial thermal imaging.

The University of Delaware (Michael O'Neal, Department of Geography and Jack Puleo, Center for Applied Coastal Research) recently acquired an 18 m (60 ft) remote-control airship capable of carrying a 36 kg (120 lb) scientific payload for coastal and environmental research (Figure 3). The airship can fly to altitudes of at least 600 m (2000 ft) reaching speeds between zero and 18 m/s (35 knots) in winds up to 13 m/s (25 knots). The first science mission for the airship (Spring 2009) will be imaging tidal inundation of a salt marsh in the Murderkill River Estuary. This will supplement preliminary aerial observations already conducted by helicopter. Time-sequenced imagery will be collected using a ten-megapixel camera and a thermal-infrared imager mounted in remote-control gimbals on the blimp. Live video-feeds will be transmitted to instrument operators on the ground to enable real-time decisions related to data acquisition. Data will be used to update independent estimates of inundation based on LiDAR elevations and the existing suite of tide and temperature gauges.

The MRSG has proven to be an effective means for acquiring and synthesizing technical information for complex scientific analyses to support decision-making related to TMDL and pollution-control strategies. Many of the researchers in the group have been involved in other "multi-disciplinary" studies that did not include close collaboration between colleagues. The MRSG has fostered close collaboration and the transfer of knowledge between researchers and managers and is resulting in truly multi-disciplinary interaction. Group members recently gave nine presentations on preliminary results at the biennial Delaware Estuary Science & Environmental Summit sponsored by the Partnership for the Delaware Estuary in Cape May, NJ in January 2009 (www.delawareestuary.org/scienceandresearch/Science_Conf/Scnc_Conf_Main.asp). More information including a list of MRSG members and descriptions of study elements is available at the Group's website (www.wr.udel.edu/murderkillstudygroup).

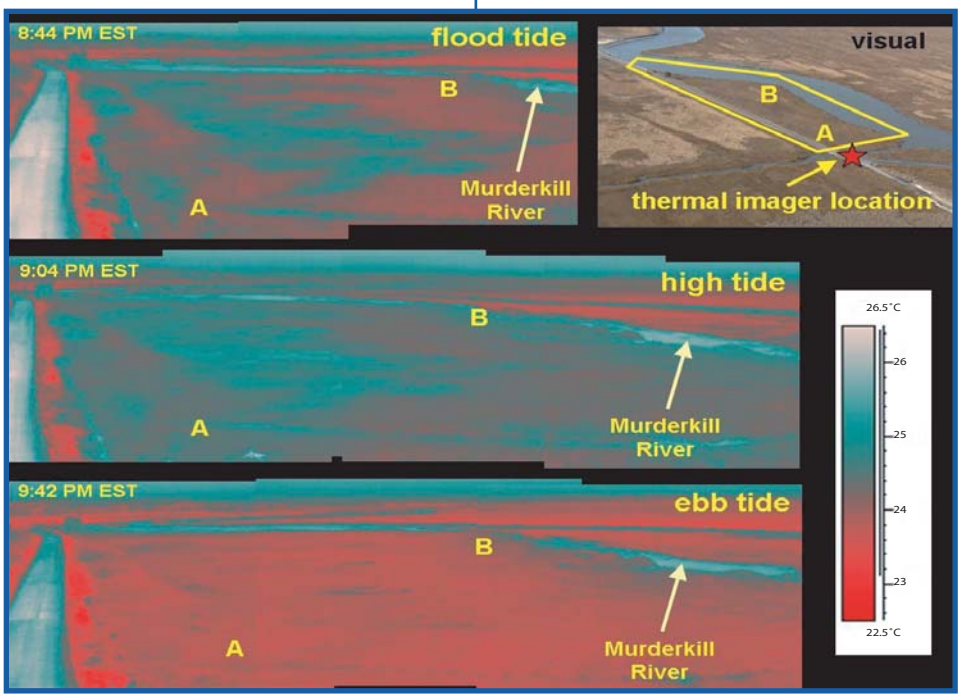


Figure 2. Temperature time series of tidal inundation of a salt marsh acquired from a 30-ft bucket-lift platform during the early evening of July 31, 2008. Relatively warmer water (gray blue) from the Murderkill River is detected on the cooler subaerial marsh (red) during flood and high tides. Most of the marsh appears relatively cool (red) during ebb tide as the warmer water returned to the river.

Figure 3. The University of Delaware's recently acquired remote-control airship for coastal and environmental research

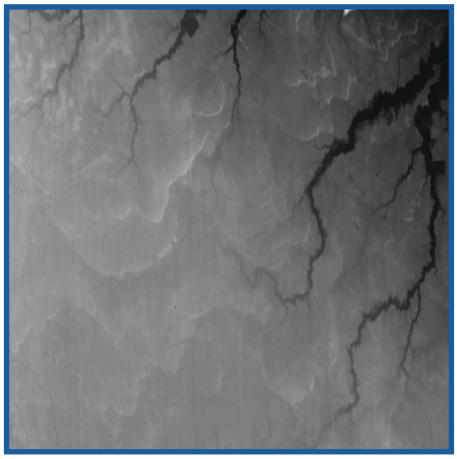
Delaware LiDAR Products Available on DataMIL

By William S. Schenck

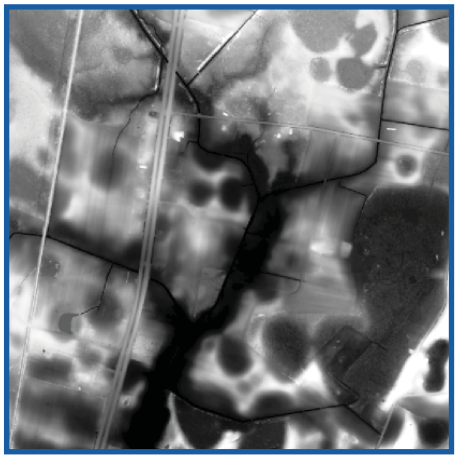
The state received final deliverables and several by-products from the 2007 spatial data contract with Sanborn Mapping Company. In addition to orthophotography, updated land-use land-cover, and impervious surface, the state received 2-foot contours for New Castle and Kent counties. Together with 2-ft contours derived from 2005 LiDAR for Sussex County, a completely new 2-foot contour elevation spatial data framework layer for Delaware is being disseminated through the Delaware DataMIL.

The 2-foot contours replace the 1993 U.S. Geological Survey 7.5-minute digital line graph contour lines. Many major landscape changes have taken place in Delaware since 1993 including the completion of State Route 1 with its many cut and fill areas, growth of developments, continued sand and gravel excavating, and on-going disposal of waste in landfills.

By using LiDAR technology, a very detailed dataset of Delaware's bare-Earth surface elevations was obtained. A bare-Earth surface is one in which the data are processed to remove any objects that may obstruct true land surface such as trees, vegetation, buildings, bridges and structures, and vehicles.



A digital elevation model showing dunes south of Milford, Delaware. The dunes show up as lighter-colored features that resemble dripping wax and are a mere 15 to 30 inches higher than the surrounding landscape.



A digital elevation model showing undrained depressions (darker-colored circular-shaped areas) in southcentral Kent County, Delaware.

In order to avoid elevation contours appearing on open-water areas such as lakes, ponds, and streams, the final datasets for New Castle and Kent counties were processed using the 2007 land-use land-cover layer. The Sussex County dataset was processed similarly but instead used the 2001 National Hydrography Dataset. Byproducts of creating contours for all three counties include digital elevation models (DEMs), which are available for download from the Delaware DataMIL (http://datamil.delaware.gov/geonetwork) More information about downloading the DEMs is provided below.

The new contours show a more detailed, realistic view of the actual land surface. For example, ancient dune fields stretch out across the middle of Sussex County (above, left). These dunes are only 15 to 30 inches higher than the surrounding land surface, but are obscured from our sight by soybean and corn fields. In addition, all sizes of undrained depressions can be seen (above, right) in central and southern Kent County and in Sussex County. These periglacial features are sometimes so subtle that they go unnoticed from the ground-level perspective.

Current work on combining the New Castle, Kent, and Sussex datasets is being undertaken by the Department of Natural Resources and Environmental Control Coastal Programs through the NOAA Coastal Services Center. Once completed, a statewide dataset will exist that will be used by our stakeholders, including but not limited to, state agencies, planners, the construction and consulting industry, and educational institutions.

The DEM and contour datasets are available for download from the DataMIL web site (http://datamil.delaware.gov/geonetwork). The DEM can be downloaded by tile and the contours will be available as zipped ESRI shapefiles. The New Castle County contours are divided into 4 blocks due to the large file sizes involved. The contours are also available for viewing in the DataMIL Map Lab. You will need to be zoomed below 1:10,000 scale to see the contours. The contours are also available as internet map services for direct access by GIS packages through the DataMIL web site. Current plans are to create a new shaded relief view of the entire state to replace the 30-meter grid USGS version currently available in the Map Lab. Keep watching the DataMIL web site for upcoming news on these latest products and their availability.

DGS Establishes a Geologic Mapping Advisory Committee

The DGS recently established the Delaware Geologic Mapping Advisory Committee (DGMAC). The committee has six stakeholder members, appointed by the state geologist, who represent state and county government, water utilities, the geologic and engineering consulting industry, and the University of Delaware. The primary purposes of the DGMAC are to provide: (1) advice and guidance on priorities for geologic mapping; and (2) to review DGS geologic mapping proposals under the STATEMAP component of the National Cooperative Mapping Program, which is managed by the U.S. Geological Survey in cooperation with the Association of American State Geologists. The committee may also provide advice and guidance in support of DGS general responsibilities for improving knowledge of the state's geology, hydrology, mineral resources, natural hazards, and data dissemination that support the Survey's mission to provide objective earth science information, advice, and service to its stakeholders, the citizens, policy makers, industries, and educational institutions of Delaware.

The DGMAC held its first meeting on October 20, 2008. Agenda items included presentations on Delaware's participation in the STATEMAP component of the National Cooperative Geologic Mapping Program, the DGS STATEMAP proposal for 2009, the DGS proposed 5-Year STATEMAP Plan (2009-2013), and a summary of several recently completed and ongoing geologic, hydrologic, and data dissemination projects.

Publications

Report of Investigations

No. 75, Stratigraphy and Correlation of the Oligocene to Pleistocene Section at Bethany Beach, Delaware, **Peter P. McLaughlin, Jr.**, Kenneth G. Miller, James V. Browning, **Kelvin W. Ramsey**, **Richard N. Benson**, **Jaime L. Tomlinson**, and Peter J. Sugarman, 41 p.

Other Publications by DGS Staff

A Remote-Control Airship for Coastal and Environmental Research, Puleo, J.A., M.A. O'Neal, **T.E. McKenna**, and T. White, Eos Trans. AGU, 89(53), Fall Meet. Suppl., Abstract OS13D-1220; Characterizing tidal inundation of wetlands in the Murderkill Estuary (Kent Count, Delaware), **Thomas E. McKenna**, 2009 3rd Delaware Estuary Science and Environmental Summit, Abstract.

Staff Notes

Presentations

A. Scott Andres, "There's wastewater in the geology: Effects of land based wastewater disposal on sediments and water," invited presentation, University of Delaware Department of Geological Sciences Fall Seminar Series, Newark, October 16; "Time Scales for Transport of Nutrients from Field to Surface Water – Implications for Nutrient Management," Mid-Atlantic Crop Management School,

Ocean City, November 19; "Update on RIBS research," invited presentation, Center for the Inland Bays, Scientific and Technical Advisory Committee, Lewes, December 5; "There's Wastewater in the Geology--Introduction to RIBS Research," Center for the Inland Bays Executive Committee, Lewes, December 12; "Water Resources Monitoring in Delaware," a poster presented at the Environmental Sensors Workshop, Delaware Biotechnology Institute, Newark, January 9.

Changming He with **Scott Andres,** "Hydrogeological Evaluation of a Rapid Infiltration Basin Site in Coast Area: Field Investigation and Numerical Modeling," American Geophysical Union Fall Meeting, December 16-19.

Thomas E. McKenna, "Using Thermal-Infrared Imaging to Characterize Wetland Hydrology," 11th Annual Watershed & Wetlands Workshop, Ocean City, October 27-30; "Characterizing Flow Between Tidal Channels and a Salt Marsh Platform by using Heat as a Tracer of Hydrologic Processes," joint seminar - UD Department of Geological Sciences and Delaware Geological Survey, Newark, December 4; "Thermal-Infrared Imaging as a Tool for Investigating Natural Processes: Examples from Investigations of Wetland Hydrology," a poster presented at the Delaware EPSCoR Environmental Monitoring and Sensing Workshop, Newark, January 9; also gave multiple presentations about Webbs Marsh to the Murderkill River Study Group convened by Kent County Levy Court and Delaware Department of Natural Resources and Environmental Control, Divison of Water Resources, Watershed Section.

Peter P. McLaughlin, "Delaware Geological Survey's Sussex County Ground Water Study," 2008 Delaware Board of Water Well Drillers Seminar, Dover, December 8.

Muserref Turkmen, "Performance of Wastewater Treatment Plants Serving Rapid Infiltration Basin Systems (RIBS) in Delaware and Neighboring States," Delaware Onsite Wastewater Recycling Association, Dover, October 14.

Lillian T. Wang, "Publishing Surficial Geologic Maps of Delaware," ESRI International User Conference, August 6.

Service and Awards

Thomas E. McKenna judged the student presentations, Delaware Estuary Science and Environmental Summit, Cape May, January 11-14; presenter, Delaware Business, Industry, Education Alliance, "What in the World" Program, January 16 and January 21.

Miriam L. Pomilio presented information to 7th grade students regarding the use of spatial technologies and how they are used in many career fields, Smyrna Middle School, September 25; helped organize GIS Day, a statewide event held at the Dover Air Mobility Command Museum at the Dover Air Force Base, November 19; taught 5th grade lesson on "Westward Migration in the United States Using GIS Software," McVey Elementary School, November 21.

William S. Schenck was asked to serve as the National States Geographic Information Council (NSGIC) liaison to the National Digital Elevation Program (NDEP) for 2009; participated as a subject matter expert on the Association of State Boards of Geology (ASBOG) fall council of Examiners Workshop and served as the Delaware Board of Geology Voting Delegate at the 2008 annual business meeting, St. Charles, November 6-8; lead a Piedmont geology fieldtrip for 60 juniors of A.I. DuPont High School along the Wilmington Western Railroad, November 12.

John H. Talley helped organize and participated in the Mid-Atlantic Outer Continental Shelf (OCS) Sand Management Working Group meeting, September 16. Talley is chairperson of the OCS Policy Committee Hard Minerals Subcommittee. He also represented Delaware at the U.S. Department of the Interior OCS Policy Committee meeting, December 9-10. In addition to the Hard Minerals Subcommittee, Talley also serves on the 5-year OCS Oil and Gas Leasing Program Subcommittee, and the Revenue Sharing and Moratoria Area Inventory Study Working Group.

Congratulations to **Stefanie J. Baxter** and **Peter P. McLaughlin** for earning their Professional Geologist licenses.

Delaware Geological Survey
University of Delaware
Newark, DE 19716-7501

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John H. Talley
Director and State Geologist
Stefanie J. Baxter
Editor, First State Geology

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Laura K. Wisk
Delaware Geological Survey
University of Delaware
Newark, DE 19716-7501
302-831-2834
delgeosurvey@udel.edu
www.dgs.udel.edu