Susan J. Riha
Brian G. Rahm
New York State Water Resources Institute
Dept. of Earth and Atmospheric Sciences
Cornell University

February 7, 2014

Greetings,
Below is a final report on our activities under DEC HREP grant for the project "Wetland mitigation of infill development: an evaluation of green infrastructure effectiveness in a near-urban setting."

This grant has led to the initiation and expansion of a number of efforts regarding implementation and effectiveness of green infrastructure at Vassar. These projects have laid the groundwork for ongoing research in the stream system and in stormwater runoff mitigation effectiveness at the local scale. While we are now finished with the funding in the present HREP grant, all these initiatives will be continuing in the coming years as construction and landscape restoration around the Fonteynkill continue and as we use classes and summer research time to understand the stream system. In this report we make note of final activities and expenditures up to the end of December 2013. This report builds on findings noted in our interim report, May 2013, which is attached to the end of this document.

This funding has been extremely beneficial in supporting, motivating, and gaining recognition for our work on green infrastructure.

Best wishes,
Mary Ann Cunningham
Department of Earth Science and Geography
Vassar College

Faculty and Staff Collaborators:
Kirsten Menking,
Marshall Pregnall
Jeff Walker
Margaret Ronsheim,
Peter Grauman.
Laura Livingston
Nick Veazie

**Green Infrastructure symposium:** May 8, 2013, Speakers included Marshall Pregnall, Vassar ERI; Dr. Tom Ballestero, University of New Hampshire Stormwater Center. Emily Vail, DEC Hudson River Estuary Program, and representatives of Siena College, Bard College, SUNY New Paltz, and Vassar College. Morning presentations were followed by roundtable discussions and a campus tour of the early stage stormwater retention wetland.

**Green Infrastructure tours:** June 17, 2013:15 faculty, students, and staff visited GI installations at Vassar, at the DEC Regional Office in Staatsburg, at Marist College, and at SUNY New Paltz. This tour has

given us an opportunity to see alternatives in practice and to discuss options, and it continues to inspire a variety of conversations in classes and committees on campus.
August 9: Meg Ronsheim and Mary Ann Cunningham toured green infrastructure with Carolyn Carr of the Minneapolis Greenway Coalition, Minneapolis, MN.

**Green infrastructure conversations on campus:** Following up on enthusiasm after the Green Infrastructure Symposium in May 2013, ERI faculty have initiated conversations with Buildings and Grounds and staff, and we will be continuing these discussions in the coming semester. This timing is good because members of our administration are becoming increasingly interested in long-term planning, including stormwater management, and in finding ways to enact more green infrastructure activities.

**Lawn Naturalization:** Included in these discussions are three courses in which students worked on studies of lawn naturalization, an approach that theoretically reduces runoff and improves water retention on the landscape. Proposals were initiated in Essentials of Environmental Science (ENST 124) in fall 2012, continued in GIS: Spatial Analysis (GEOG 224) in spring 2013, and in Conservation Biology (BIOL 352) in fall 2013. The most recent proposals have been approved by the College Committee on Sustainability and will be funded in spring 2014.

**Educational programming:** Collaborated with Cary Institute for Ecosystem Studies in bringing environmental science classes to visit streams on campus; classes will revisit in spring to look at stream invertebrate community; brought an ecology class for three visits to campus stream and wetlands; assisted in planning and running field day at the Casperkill by 5th grade class; met twice with high school students in the Cornell Cooperative's No Child Left Inside program to sample the beaver pond and to examine the Fonteynkill project; led a walk for Poughkeepsie Middle School students to Vassar Lake.

**Presentations:** Group members have given a number of oral and poster presentations in the past year, including at the following events:
Irene and Lee (9/19/12) , L. Livingston: Casperkill sonde poster
URSI Symposium, J. Walker, P. Donohue, M. Zeltzer, M.A. Cunningham, S. Brown, M. Ronsheim, J. Thaw, K. Lee, E. Cheung, M. Schlessman, M. Pregnall, J. Josimovich, K.Czechowski (9/24/12)
HRWA Conference, L. Livingston: Sediment in Hudson River (10/12/12)
Stormwater Conference, L. Livingston: (11/7/12)
Hudson River Estuary Society Conference, Laura Livingston (4/24/13)
Green Infrastructure poster symposium, L. Livingston, MA Cunningham, M. Ronsheim (5/8/13)
CCEDC Sustainability Conference, MA Cunningham, (9/13/13)
URSI Symposium, J. Walker, A. Jones (9/25/13)
NCSE MA Cunningham, A. Hall, T. Porcello, N. Veazie (1/29/14)

**Budget Report**
(numbers correspond to lines in original budget)
1. Faculty stipends and student salaries received by participants in Vassar College's Undergraduate Research Summer Institute program (10-week commitment at 40 hrs/week).
Student research assistants during the academic year work work 8 hours/wk for 26 weeks at $8/hr. Two student research assistants thus cost $3,328*: These funds were spent as intended, from both federal funds and matching Vassar funds*.

3.  Non-federal funds were used to purchase four YSI sondes. Each of YSI water quality multiprobe sondes (600XLM V2 model) includes a conductivity/temperature probe kit and costs $4,248.  Two additional probes, turbidity ($1,530) and pH ($235), are also necessary for each sonde. The calibration standard for the turbidity probe costs $250: *These items were purchased as intended and remain in the stream for monitoring. Federal funds were used to purchase 3 Onset HOBO Shallow water pressure sensors costing $495 per sensor; other equipment was purchased with Vassar matching funds*.

4.  We have budgeted $1,250 for IC and ICP calibration standards and fecal coliform supplies; standards are needed for anions, cations, and chloride (IC) and metals (ICP), at cost $250 each for 4 x 200 ml bottles, as well as Coliscan coliform bacteria test kits and sonde turbidity standards. *These funds were spent during the first calendar year of the grant, and standard solutions have been in use for sonde and probe calibration.*

5. Consultants: visiting scholars and education specialists: *These activities were carried out as planned. Both were less expensive than initially anticipated, so we used a portion of the funds to cover costs of materials for visiting school groups, in addition to costs of visits.*

6. Vassar faculty and students will visit one of the regional academic institutions to learn about research design and instrumentation for stormwater management and green infrastructure. We have budgeted $200 each for 10 students and faculty for 2-3 days, including the costs of college van transportation, for a total of $2,000. *These funds have been spent according to plan*.

8. The Stormwater Management and Stream Health Symposium is budgeted at $2,400 ($400 federal + $2,000 matching) to cover mailings, catering of the event, and other incidental costs. *Our presenters at this symposium ended up refusing honoraria and travel expenses, so our expenses for this event were considerably smaller than expected.*

Interrim Report ,May 2013

**Water Monitoring on an Urbanized Stream:**
**Preliminary findings on the Fonteynkill, Poughkeepsie NY**

Mary Ann Cunningham, Laura Livingston, Clara Cardillo
Vassar College Environmental Research Institute

The main aim of this project is to study impacts of "green infrastructure" for stormwater management, particularly constructed wetlands and restoration of a riparian corridor, in an urbanized environment. We are therefore studying the stream before and after installation of these features. Because we are currently in the "before" segment of our long-term monitoring project, we report here on preliminary results regarding water quality in the stream. Portions of these findings were presented at a meeting of the Hudson River Environmental Society (HRES) meeting in New Paltz, in April 2013, at the Northeast Geological Society of America meetings, Bretton Woods, NH, in March 2013, and to the Vassar College community in July and September 2012 and May 2013. Further public outreach is being done by way of informational signs in our study area, collaboration with Poughkeepsie High School environmental science teachers, and multi-college and on-campus conversations about green infrastructure.

Our study focuses on the Fonteynkill, an urbanized tributary of the Hudson River that drains portions of the City of Poughkeepsie and of the Vassar College campus (fig. 1). One of or central questions is how much green infrastructure is needed to reduce impacts of urbanized tributaries on water quality in the Hudson River. At the time of writing, we have done one year of monitoring before installation of the planned stormwater management wetland. We have installed water-monitoring sondes and employed nine Vassar students in studying various physical and biotic characteristics of the stream. Our monitoring has helped us understand various aspects of the hydrological and ecological functions of this urban stream, the extent and geological foundations of its watershed, and its functions as urban riparian habitat. Here we discuss measurements of salinity in the stream.

**Figure 1** the Fonteynkill is a small urbanized stream, but its riparian corridor is also a wooded oasis for wildlife in this developed watershed.

**Water quality measurements**

One of our most important measures of water quality is specific conductance, a temperature-adjusted indicator of ion concentrations (mainly salt ions) in the water. Specific conductance is a measure of electrical conductivity and is reported in milliSiemens/cm (mS/cm). Previous work in nearby watersheds has shown that road salt dominates salinity in these streams and that salt is one of the primary stream contaminants in this area, along with elevated nutrients and fecal coliform bacteria (Cunningham et al. 2009).

To monitor water quality, we installed three sondes, battery-powered sensors that record conductivity, temperature, turbidity, and other measures at 20 minute intervals. One of these sondes is situated above Vassar Lake (TH, for Townhouse site, fig. 2); one is below the lake but above the construction site (RC, for Raymond Culvert site); the third is below the construction site (SG for Shakespeare Garden site).


**Figure 2** The urbanized headwaters of the Fonteynkill, with the above-ground watershed (light green), the presumed urban storm drainage (blue-green), and the three sonde sites.

**Summer and winter conductivity responses to precipitation**

Summer and winter responses to precipitation differ. In summer, precipitation temporarily dilutes streamflow with fresh precipitation (fig. 3). Winter precipitation events raise salinity levels as new road salt washes into the stream (fig. 4; Grauman et al. 2012).

Summer-pattern responses persisted through most of winter 2011-2012, a season with few major snow and salting events. In 2012-2013, we had winter-type precipitation responses once in November and several times in late January, which is the end of our compiled record at this point. Despite the long interval with infrequent road salting in 2011-2012, specific conductance of baseflow did not change during our current data record of more than a year (fig. 5). This underscores the point found by Kelly et al. (2008) that salt reservoirs stored in soils and ground water are likely to take many years or decades to deplete.

Normal baseflow in the Fonteynkill, dominated by groundwater seepage, has a constant and elevated conductance of just over 1 mS/cm (fig. 3). This is near the high end of what can be classified as fresh water, which can range from 0-1.3 mS/cm. December-March peaks of specific conductance reached between 4 and 8 mS/cm. Average specific conductance did not differ between winter and summer (fig. 4).

High chronic salt levels may be especially problematic during the summer season, when stream invertebrates are most rapidly growing and reproducing. Future climate conditions may further exacerbate this problem: in the Northeast, climate change is likely to bring drier summer conditions and higher evapotranspiration rates in hotter weather. Long-term impacts on the instream biotic community may be important to understand better.

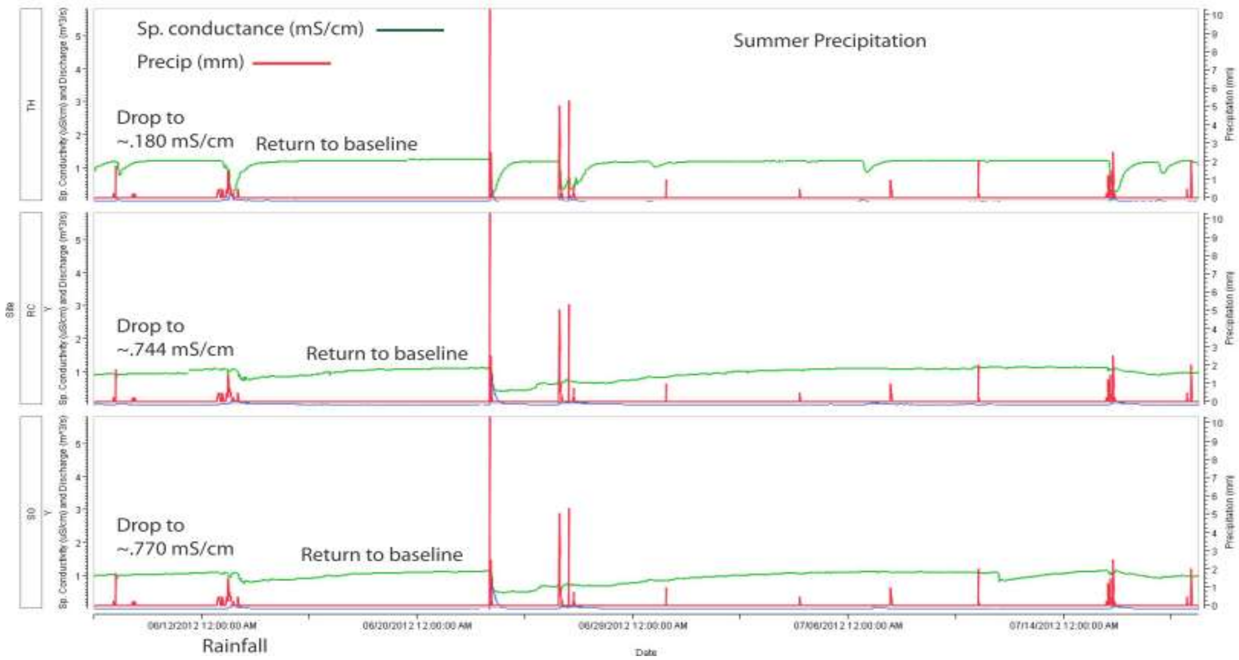


**Figure 3** Summer pattern responses of specific conductance to precipitation.

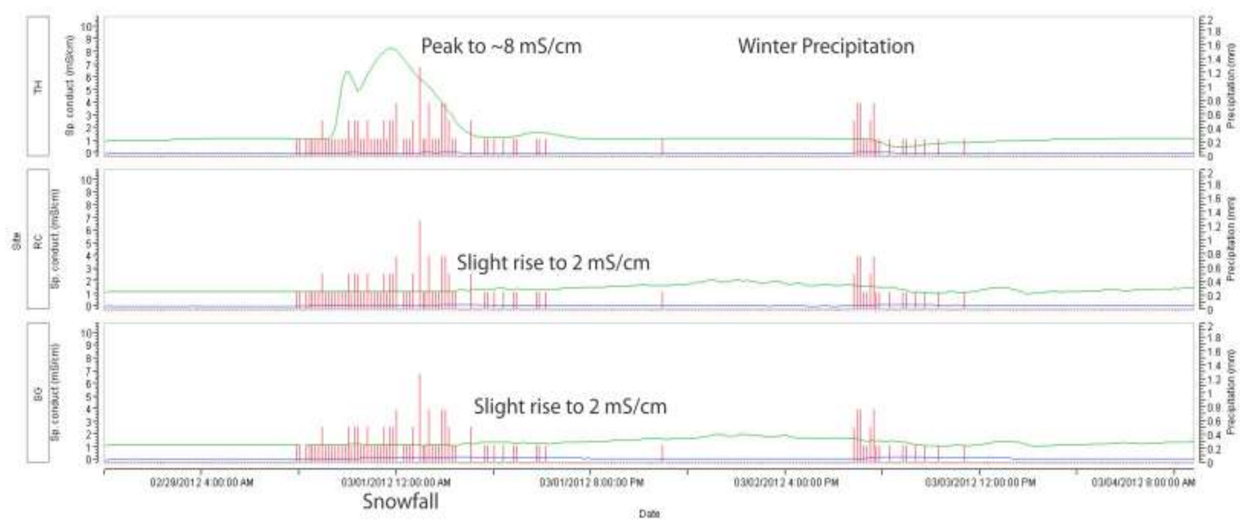


**Figure 4** Winter pattern responses of specific conductance to precipitation.

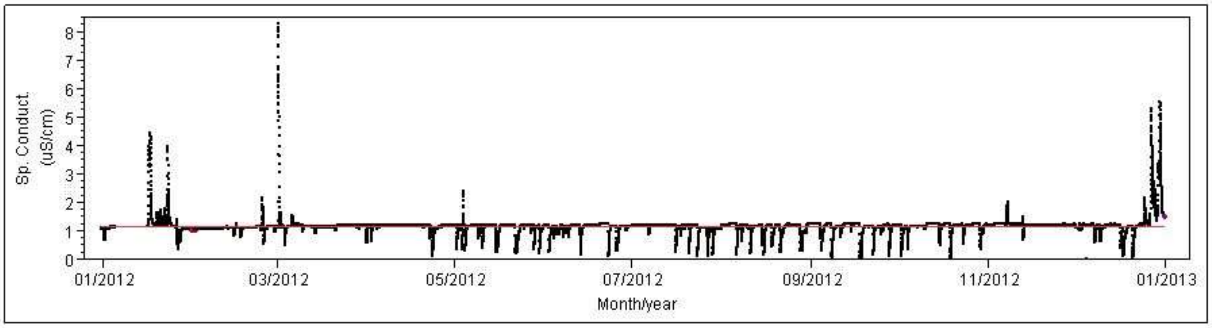


**Figure 5** conductivity over approximately one year at the TH site. The red line shows that the mean conductivity has not changed markedly.

## Effects of an impounded lake on baseflow salt and water levels

Our uppermost monitoring site drains mostly urban neighborhoods and sits above a small impounded lake (fig. 2). The lake has an average depth of about 1 m, and water in the lake has a residence time on the order of a few days or less. Donohue and Walker (2012) have shown that this lake is perched on an impervious till layer, overlain by loose glacial delta deposits composed of gravel and sand. The landscape composed of these delta deposits drains relatively rapidly into the impounded lake.

Although it is a small and shallow water body, Vassar Lake markedly diminishes peaks in both salt and discharge in the Fonteynkill. Sonde sites below the lake show much lower peaks in specific conductance and in discharge (fig. 2, fig. 3). Overall average values for specific conductance varies little between the sites, however: mean conductance varies only from 1.18 mS/cm (above lake) to 1.05 mS/cm (at the two sites below the lake). Thus chronic conditions vary little, but acute salinity exposure is considerably less below the impounded lake than above it. Drainage from the surrounding landscape, and mixing with water resident in the lake, accounts for lower peaks in the salinity curve, and in the discharge hydrograph, for the sites below the lake.

## Future work

In the coming years we will be continuing to use the sondes to monitor effects of runoff and nutrient retention in a constructed wetland, of building construction, and of vegetation change the riparian zone, in terms of temperature, DO, nutrient abundance, changes in sediment. As we gather data, we continue to make it available to the public on the Dutchess Watersheds website (www.dutchesswatersheds.org/research)

## Acknowledgments

This report represents a substantial team effort. Discharge data shown in figures 3 and 4 were produced by Kirsten Menking, Marshall Pregnall, Jillian Josimovich, Katherine Czechowski, and others. Kirsten Menking provided precipitation data. Findings on watershed extent and surficial geology are from Jeff Walker, Patrick Donohue, and Matthew Zeltzer. This project was funded by the New York State DEC and Hudson River Estuary Program, through a grant on which collaborators include M.A. Cunningham, Marshall Pregnall, Kirsten Menking, and Margaret Ronsheim, and Peter Grauman.

**References cited**

Cunningham, M.A., O'Reilly, C. M., Menking, K.M., Gillikin, D.P., Smith, K.C., Foley, C.M., Belli, S.L., Pregnall, A.M., Schlessman, M.A., and Batur, P. (2009). The suburban stream syndrome: Evaluating land use and stream impairments in the suburbs. Physical Geography 30(3): 269–284.

Donohue, P. and Walker, J. (2012) Concrete and storm sewers: baseline study of an urban stream. Poster presented at meeting of the Hudson River Environmental Society, SUNY New Paltz, April 24, 2013.

Grauman, P., Cardillo, C. Menking, K., and Cunningham, M.A. (2012). Non-point source pollutants in an urban stream: The next challenge for the Clean Water Act. NY DEC HREP meeting: The Clean Water Act at 40. Vassar College, Poughkeepsie NY, May 7, 2012

Kelly, V. R., Lovett, G. M., Weathers, K. C., Findlay, S. G., Strayer, D. L., Burns, D. J., and Likens, G. E. (2008) Long-term sodium chloride retention in a rural watershed: Legacy effects of road salt on stream water concentration. Environmental Science and Technology, Vol. 42, 410–415.