

## From the Director



Despite frigid temperatures and a landscape covered in snow, it's been a very active and productive winter at the TRC, to say the least.

Top among recent happenings is our participation in the Transportation Research Board (TRB) Annual meeting from January 12 through 17 in Washington, DC. Twenty-one faculty and graduate students were involved in presentations there. Such a presence at this premiere gathering of almost 12,000 transportation professionals from around the world is an excellent illustration of the maturity and vitality of the research agenda at the University of Vermont. The Schools of Engineering, Medicine, Business, Natural Resources and Agriculture and Life Sciences were all represented. Seven years of building interdisciplinary connections and new collaborative opportunities has created plentiful opportunities on campus as well as with our off-campus partners. TRC also co-sponsored a well-attended reception at TRB along with University of Connecticut, and a number of other organizations.

Congratulations to Tyler Feralio (School of Engineering), our Student of the Year for 2012, who was honored at the Awards banquet of the Council of University Transportation Centers at TRB. Also to our Clean Cities Coalition and staff who have been recognized by the US Department of Energy both with a three year renewal of Clean Cities designation, and as a member of a successful application to build a New England coalition effort to advance clean fuels .

I am personally very excited about a new project of ours funded by USDOT which we just started work on in December. This project is developing new approaches to making transportation infrastructure resilient in the face of flood hazards. It will develop methods for automating the detection of flood damage to roads in the immediate aftermath of a major flood using remote sensing imagery and image classification algorithms. It will also use lightweight Unmanned Aerial Vehicles (UAV) programmed to fly over damage road segments to estimate the amount and type of fill material required for repairs using digital surface models. We surmise that this will assist incident managers by helping provide updated routing information, prioritizing and planning repair efforts, and reducing costs of repairs.



*Image left:* Bridge damage in southern Vermont as a result of flooding incurred during Hurricane Irene. Image source: Mansfield Flight LLC.

This is just one of a series of new endeavors we anticipate as we expand our exploration of mitigation and successful adaptation to new and emerging risk factors, building more resilient social and physical infrastructure.

Austin Troy  
Associate Professor and TRC Director

## UVM Transportation Research Center (TRC)

The TRC is a hub for innovative and interdisciplinary research, education and outreach focused on risk and resiliency as they relate to transportation systems, particularly in northern, rural, exurban and micropolitan contexts.



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## Tyler Feralio, 2012 Outstanding Student of the Year



*Photo:* Feralio accepts his award, presented by Greg Winfree, Deputy Administrator of RITA.

Tyler Feralio has been named the University Transportation Center 2012 Student of the Year. Tyler Feralio received his Bachelor's and Master's Degrees in mechanical engineering from Rensselaer Polytechnic Institute in 2004 and 2005, respectively. His thesis work involved computational modeling of an internal combustion engine. He then worked at Honda Research and Development as a design engineer in the chassis group. From there he transitioned to designing aftermarket suspensions for all terrain vehicles for a small company in the northeast.

He decided to return to academia in order to shift his focus to more environmentally conscious endeavors. He enrolled at the University of Vermont in August of 2009 in the department of civil and environmental engineering. His current research focus is on quantifying and modeling the differences in particulate emissions from light duty diesel engines fueled by diesel and biodiesel fuels.

Tyler's UVM advisor commented that his hands-on mechanical skills, organizational abilities, ability to quickly master new concepts, combined with his enthusiasm and dedication to his research project have resulted in the very significant development of our unique light-duty diesel particulate emissions sampling apparatus in the TAQ Lab that will be a valuable resource to future UVM students studying vehicle emissions and their control.

Dissertation Title: Prediction of Transient Diesel and Biodiesel Particulate Emissions through the use of an Artificial Neural Network

## Tracking Emissions at the UVM Transportation Air Quality (TAQ) Lab



*Photo:* TRC Graduate Scholar Tyler Feralio explains his work in the TAQ Lab

**Are biodiesel vehicle emissions less damaging to human health than burning petroleum-based diesel? Do hybrid vehicles have lower tailpipe emissions compared to traditional gas-fueled vehicles?** These are the types of questions that students in UVM's Transportation Air Quality (TAQ) Laboratory are taking big strides to answer. As part of an ongoing effort of the TRC Graduate Scholars to learn about each other's work and find opportunities to utilize the expertise and experience of their peers, on December 7, 2012, the scholars took a peer-guided tour of UVM's TAQ Lab. The TAQ Lab is supervised by Associate Professor Britt Holmén in the School of Engineering (environmental engineering) who specializes in measurement and modeling real-time, real-world vehicle emissions from alternative vehicles and fuels.

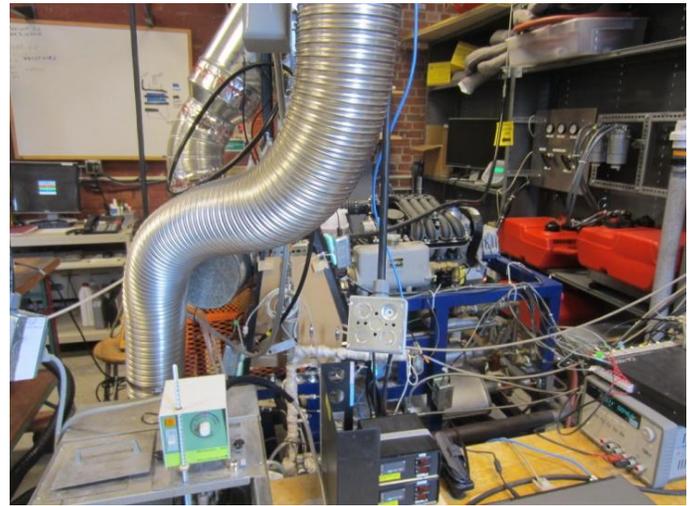
TRC Graduate scholar Tyler Feralio, a PhD candidate in civil and environmental engineering and this year's UVM TRC Student of the Year, and Karen Sentoff, M.S. candidate, also in civil and environmental engineering, led the group through their respective work in the TAQ lab. Using advanced particle and gas pollutant sampling equipment, the TAQ lab researchers focus on quantifying transient emissions from alternative vehicle types under real-world operating conditions. Two types of vehicles are studied - a gasoline-powered hybrid-electric vehicle and a light-duty diesel engine running different blends and feedstocks of biodiesel. *(Continued on next page)*

As part of the TAQ Lab team, Sentoff's research measured tailpipe emissions from a model year 2010 Toyota Camry hybrid electric vehicle and its conventional counterpart. Over an 18-month campaign, she drove the vehicles along the same real-world route while instrumented with state-of-the-art equipment measuring gas- and particle-phase emissions every second. The results of this research will provide needed information on tailpipe emissions contributions of the hybrid vehicle to air quality over broader ranges of road grade and temperature encountered in regions like Vermont with steeper terrain and wider seasonal temperature fluctuations than current data sources.

Feralio's ongoing research in the TAQ Lab includes the comparison of transient tailpipe emissions from a light-duty diesel engine resulting from the combustion of both petroleum-based diesel fuel and blends of different feedstock (soy and waste grease) biodiesel fuels. Feralio has developed a system to accurately collect transient tailpipe emissions data from a 1.9L Volkswagen diesel engine coupled to an eddy current dynamometer. He is currently preparing to embark on a 20-week data collection campaign to compare the particulate emissions generated by the engine running on petroleum based diesel and multiple blends of both used cooking oil (UCO) and soybean oil methyl ester (SME) biodiesels. Using the data collected during this period, Tyler will build and test an artificial neural network (ANN) model to predict the size and abundance of ultrafine particles emitted based on standard onboard diagnostics (OBD-II) parameters that the engine's computer monitors. This model is expected to be capable of running in real time. If this is realized, such a model could be utilized for more advanced pollution control and engine management systems.



*Photo:* John Kasumba, PhD candidate in environmental engineering, explains his work in testing emissions



*Photo:* TAQ Lab sampling equipment utilized in light-duty diesel engine emissions testing

The tour group next visited a nearby laboratory, where Feralio's work meets with that of John Kasumba, a PhD candidate in environmental engineering. Kasumba works as a graduate research assistant with Professor Holmén to characterize the specific organic compounds created by engines burning petro-diesel versus vegetable oil-based biodiesel. He is particularly interested in testing for compounds that may have negative effects on human health and examining their levels in combustion products from biodiesel fuel blends. Kasumba looks to expand on limited research on potential harmful emissions from biodiesel, such as carbonyls, which may be produced in higher quantities from biodiesel than petro-diesel. His work has included developing methods for some of these testing procedures and will soon proceed to testing particle samples generated by Feralio.

Through their efforts, these TAQ Lab graduate students contribute to research on vehicle emissions, creating critical knowledge in this area, covering the use of biodiesel and petro-diesel fuels, as well as hybrid and conventional gasoline vehicles.

For more information about the TAQ Lab research, contact Professor Britt Holmén at [bholmen@uvm.edu](mailto:bholmen@uvm.edu).

## TRC Critical Issues and Chris Cole



Photo; Chris Cole (second from left) discusses transportation issues with TRC 312

The most critical issue facing our state and national transportation system is arguably, "How will we fund it?" This was the topic of discussion with Chris Cole, Director of Policy, Planning, and Intermodal Development Division at the Vermont Agency of Transportation (VTrans), who was a guest at the TRC's graduate seminar, *Critical Issues in Transportation*, taught by Brian Lee. Cole laid out the key concerns that the Vermont Agency of Transportation (VTrans) was attempting to address in planning for the future design, operation and maintenance of the state's infrastructure. These included:

Due to the growing costs of transportation and declining revenues, a study committee determined that the state will be underfunding the system \$250 million per year. Low cost solutions for infrastructure were also examined, as well as best practices for infrastructure.

A vehicle-miles-traveled (VMT) fee has become much discussed as a solution to the declining revenues from the gas tax. Cole noted that the option would only be feasible if implemented nationally due to the loss of payment from visitors. He also mentioned, however, that there are already agreements for commercial vehicles to pay by use of roads to states on a miles driven basis, so this type of fee has proven that it can function nationally.

The agency has prioritized investment in rail and public transit to prepare for a future of high fuel costs. Public transit investment has more than doubled from \$12 to \$27 million over the last 12 years, mainly focusing on commuters as a way to reduce miles traveled.

Cooperation between VTrans and the Agency of Natural Resources has greatly improved. Post-Irene, the agencies were forced to cooperate due to the

damaged roadways and altered rivers. The agencies now meet weekly, discussing issues such as water quality standards for gravel roads.

Cole suggests forming an alliance between rural states and educating legislators to ensure adequate future funding from the federal government. While Vermont is guaranteed level funding for two years through the recent legislation, MAP-21, the prior funding formula has been eliminated. Without this funding guarantee, rural communities may see reduced funds as the federal government focuses on federal priority projects in the near future.

*Critical Issues in Transportation*, a core course in the TRC Certificate in Sustainable Transportation, is offered every fall. Students in the course currently have a wide range of backgrounds, including land-use planning, communications, workforce development, and agriculture. Taught by Prof. Brian Lee, a TRC Associated Faculty member, the course covers the most important topics in transportation over the course of the semester, discussing issues such as transportation modeling and planning, funding, fuel sources, and access and mobility. The class has already visited Burlington International Airport to talk with planning and development director Bob McEwing, traveled to Chittenden County Metropolitan Planning Office to speak with staff, as well as hosted guest speakers Owen Brady of Vermont Natural Gas, Inc. and Tom McGrath of the Vermont Clean Cities Coalition, and attended a lecture by Brown University Professor and "Carjacked" author Dr. Catherine Lutz.

## TRB Meeting 2013



UVM students, faculty, and staff traveled to TRB this year to present their work, as well as many colleagues throughout Vermont. This year there was also successful reception hosted by UVM and UConn. To view abstracts from the UVM presenters, please visit <http://bit.ly/WOSIOx>

## Vermont Clean Cities Coalition: Clean Fleets Certification, Re-designation, & Clean Cities Coordinator Council



*Photo (from left):* Tom McGrath, Vermont Clean Cities Coordinator; Allie Everts, Clean Cities Intern; and Jim Barr, Director of Transportation and Parking Services at UVM stand in front of a UVM Compressed Natural Gas (CNG) bus.

### Clean Fleets Program:

The Vermont Clean Cities Coalition (VTCCC) will be leading the creation a New England Clean Fleets program and certification, which will rate fleets as a way to recognize the efforts of organizations who actively strive to reduce petroleum fuel consumption. The certification is not aimed just at local fleets, but also larger operations that run through the New England region. This project is part of a larger grant award from the US Department of Energy to the New England Regional Clean Cities Coalition, a group including coalitions from Maine, New Hampshire, Massachusetts, Rhode Island, and Vermont. The grant award is for “Removing Barriers, Implementing Policies and Advancing Alternative Fuel Markets in New England.” This covers several projects beyond the clean fleets program, including a fleet manager’s survey, co-led by VTCCC, and projects led by others, such as CNG workshops, biodiesel workshops, safety and training initiatives, and research on barriers to alternative fuels. View the press release at <http://conta.cc/14Ecejh>

### Re-designation:

VTCCC has officially been re-designated for another three years by the US Department of Energy. The DOE cited outreach efforts and awareness building around alternative fuels in their announcement, as well as the coalition’s programs, such as the Campus Transportation Toolkit and Eco-Driving.

### Clean Cities Coordinator Council:

VTCCC Coordinator Tom McGrath was elected as Northeast Representative to the national Clean Cities Council by his peers. This will involve participation in various council activities, such as progress reports, goal setting, and communication with coalitions around the region. McGrath’s specific assignment on the council will be managing the Clean Cities Buddy System, which partners new coordinators with experienced peers for assistance and support in their new role.

### Upcoming Events:

VT Clean Cities Coalition Stakeholder Meeting, Sugar Maple Ballroom, Davis Center, UVM. Featured Speaker: Larry Beaulieu, UPS East Region Automotive Manager. Full agenda to be released soon.

Register at <http://bit.ly/WQOD1B>.

There are also two President’s Distinguished Burack Lecture Series Presentations coming up. Dr. John Landis will be discussing urban growth, while Dr. Jonathan Rubin lectures on low carbon transportation.

For more information on all events, please see the calendar on our website homepage or visit our events page at <http://bit.ly/WQR4ch>

## Officials Weigh In on Future of Transportation Dollars



*Photo:* Sec. Brian Searles answers a question during “The Future of Transportation Funding in Vermont” panel

*(Continued on next page)*

From the federal to local level, the funding of our transportation system is critical to supporting infrastructure, economic development and social goals, but serious funding shortages are forecast in the coming years. On Tuesday, December 4<sup>th</sup>, the Transportation Research Center convened a panel of officials to discuss this problem and take questions at a public event for the last meeting of the TRC graduate course “Critical Issues in Transportation”. Panelists included City Council President Joan Shannon, Assistant/MPO Director for the Chittenden County Regional Planning Commission (CCRPC) Michele Boomhower, Vermont Secretary of Transportation Brian Searles, and Administrator for the Vermont Division of the Federal Highway Administration (FHWA) Matthew Hake. With questions from TRC-associated Assistant Professor Brian Lee, the class of graduate students, and the public, panelists offered perspectives based on a range in experience, position, and outlook on the future of funding for our transportation systems.

FHWA Division Administrator Hake explained his work as helping the state follow the guidelines associated with federal funds, while allowing the state freedom of where it spends funds within those guidelines. At the federal level, there are major concerns about the viability of the Highway Trust Fund to continue funding transportation as gas tax revenues decline. In addition, there is uncertainty over what legislation will follow MAP-21, the most recent transportation authorization act, which lasts only two years, compared to other acts of six years, which allowed for plans with a longer horizon.

Assistant/MPO Director for the CCRPC Boomhower focused on understanding the long-term prospects as her organization is finishing producing a regional transportation plan for 2035. The group expects maintenance costs to be around \$750 million in 25 years, while funds available would total \$1.1 billion. This would leave \$310 million for new projects, but the demand for new projects, totaling \$850 million, greatly exceeds that amount. New prioritization criteria is needed to ensure the most essential projects are covered. City Council President Shannon, meanwhile, offered the most optimism when viewing the situation from the very local level, noting that Burlington voters recently approved measures to provide bike path funding for repair and future maintenance. She also indicated that, looking to the future through a political lens, it was heartening to see what she called a political “alignment” between the politics of the Mayor,

Governor, and President that she sees as critical to moving forward on stalled projects. She noted, however, that increasing funds for improvements requires new revenue and new major projects, even with significant federal contribution, are difficult for the city to afford.

Secretary Searles, who oversees the state transportation system and its 1,300 employees, focused on how the state must make the most of a transportation system with limited funds. He explained that the work in coming years will come from the direction of local communities, who must decide what we want from our transportation system and how much we are willing to pay for it. The state agency is currently focused on preparing for the future by improving public transit and rail and advancing strategies to decrease vehicle miles traveled (VMT), particularly with single occupancy vehicles (SOV). Searles noted, however, that while new options are being examined for state revenue, Vermont does not have the ability to make up the \$200 million annual funding gap it now faces and if the gap is to be closed, this will require federal solutions.

Panelists offered great insight into the future of transportation funding at all levels and provided input on means of addressing this issue that faces so much future uncertainty and many challenges. This event was filmed by Channel 17 TV.

### **Mayor Weinberger Talks Transportation**



*Photo: Mayor Weinberger at a roundtable discussion at the TRC*

What is Mayor Miro Weinberger’s vision for the future of transportation in Burlington? On November 13, the Burlington Mayor visited the TRC for a roundtable discussion with faculty and staff followed by a public lecture at Billings North Lounge, which was attended by many transportation stakeholders in the community. While Weinberger’s top priority remains achieving financial stability for the city, he still sees many options open for improving transportation as well. Highlights from the Mayor included: *(Continued on next page)*

·Progress on the plan to create a downtown transportation center, an indoor location to improve the transit experience for the many individuals who stop at or pass through the downtown area.

·Weinberger sees the Champlain Parkway as a means of reducing congestion by providing another route out of the city and encouraging development along Pine Street

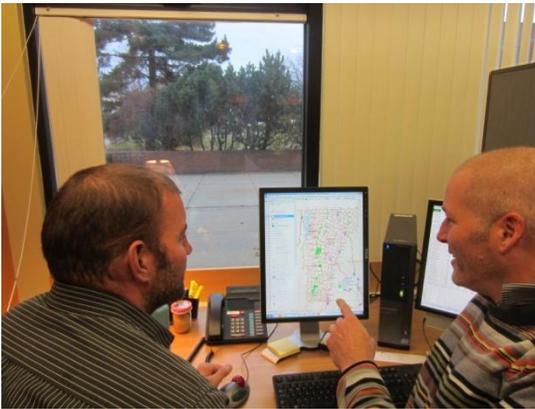
·The Mayor's campaign promise of an interconnected bike network is one of his top priorities, to provide bike users with continuity in routes around the city.

· Investment in the waterfront area will total \$20 to \$30 million over the next 2.5 to 3.5 years, due to funding from Tax Increment Financing (TIF).

·The Mayor also believes it is important to increase the availability of housing downtown to encourage individuals to live in the city, which he notes will require regulation overhauls to improve conditions for investment.

The TRC greatly appreciates the Mayor taking the time to visit, share his plans, and take questions and comments from the public. The discussion also provided many future opportunities for the TRC to coordinate with the city, from research studies to emissions reductions. To watch the public lecture, visit <http://bit.ly/XjJLuH>

## Modeling Travel and Transport in Vermont



*Photo:* Research Analyst Jim Sullivan (left) and Researcher Matt Conger with the Vermont Travel Model

The potential opportunities for applying the statewide model in the future are numerous, as this model can examine the impacts of new transportation projects as well as growth and decline in population and employment around the state. TRC Research Analyst Jim Sullivan works on the Vermont Travel Model for VTrans, using modeling software to examine the effects

of changes to the transportation system. This includes addressing such questions as the impacts of changes in population and economic activity on the transportation network. By providing this knowledge, the model allows effective transportation planning and investment across the state.

Managing the statewide model includes keeping it up to date with the most recent population, employment, and travel behavior information. Recently, the model has been updated from a base year of 2000 to 2010, meaning the model now contains data from the 2010 Census and the 2009 National Household Travel Survey. Adjusting the population in the model to reflect the most current information increases the accuracy of modeling done in the future by better reflecting the number and behavior of travelers in different parts of the state.

TRC Researcher Matt Conger will also begin working on the model after recently returning from visiting Caliper, the developer of TransCAD, in Newton, Massachusetts. At Caliper, he took part in an intensive training seminar in preparation to join Sullivan as part of the TRC Team working on the statewide model.

Conger's training will allow him to work on improving the model, as well as applying changes in the transportation system to estimate the implications for projected land and road use. Conger looks forward to using his training in Discrete Choice Modeling (DCM) in future projects at the TRC. Conger explains, "Discrete choice modeling (DCM) allows the user to predict the travel mode choice of each trip purpose undertaken based upon the estimated 'utility' of each of the available modes - passenger vehicle, carpool, transit, bicycling and walking, for example." Further, Conger's training in Transit Routing allows the modeling of public transit travel in a host of TRC projects to be improved. As Conger notes, "These two TransCAD modules offer important tools in forecasting the effects of changes in infrastructure and land use patterns upon travel behaviors."

Recently, the statewide model was used to examine the impacts of a bypass around Morrisville, VT to move traffic from the north and south around the congested Village Corridor. An analysis was originally conducted in 2002 using the statewide model, but that analysis needed to be updated in 2011 before the project could move forward. The updated analysis examined the results of building vs. not building the bypass, *(Continued on next page)*

forecasting the impacts of each scenario 20 years into the future. Several of the 2002 results were revised due to the improvement of the updated model. The study found that traffic would be reduced almost 80 percent in the village center due to use of the by-pass route, an area which currently faces significant congestion issues.

For the 20-year forecast, the construction of the bypass is expected to increase future settlement near the route, but growth would be lower elsewhere in the town.

Without the change, the downtown corridor may reach its capacity in the evening peak for travel, as the already congested area faces increasing traffic.

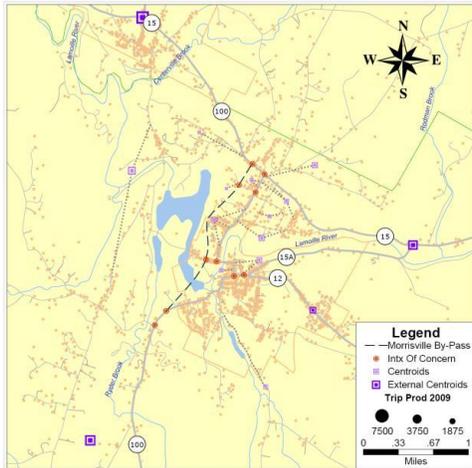


Image: Travel Model for Morrisville Village

These findings were of particular interest to Amanda Holland, a land-use planner at the Lamoille County Planning Commission who worked on this project.

Holland is also currently pursuing the Sustainable Transportation Graduate Certificate from the TRC and enrolled in the course “Critical Issues in Transportation in the 21st Century”. “The model was useful in showing the potential flow of traffic after the truck route is built”, said Holland, “and the expected reduction in volumes that could potentially allow for some design changes along the existing route”. Holland noted the seriousness of the current and forecasted congestion, which is especially troublesome for businesses that rely on freight traveling to and from the interstate efficiently. The modeling results also contributed to the Morrystown North End Business District Circulation Study by Resource Systems Group, Inc. (RSG), which showed that several intersections had a level of service (LOS) of D or F, which would improve due to the reduction in traffic if the bypass is built.

This partnership with VTrans also has involved other

work, such as examining whether national studies are relevant to Vermont. For example, a recent national study by Frontier Group for the U.S. PIRG Education Fund noted many new trends among younger drivers, between 16 and 34 years of age. Using the National Household Travel Survey (NHTS) data from 2001 and 2009, Sullivan found that only some of these national trends (6 of 16) held true for younger Vermonters. These included changes such as reduced vehicle miles traveled and trips, as well as more use of travel options.

While 7 of the trends could not be fully assessed due to data constraints, 3 of the topics showed the reverse of the national report’s findings. Vermonters are taking fewer walking and transit trips, rather than more, and overall length of trips has grown, rather than shrunk. This research provides essential information to policy makers in Vermont, providing accurate data on transportation patterns over time in the state. Policy and action can be informed by using these data sources to examine national findings and their assumptions to accurately determine the conditions in Vermont.

The potential opportunities for applying the statewide model in the future are numerous, as this model can examine the impacts of new transportation projects as well as growth and decline in population and employment around the state. The newly proposed development in the Northeast Kingdom, for example, provides an opportunity to use the model to examine the effects of these large changes to the area. The Northeast Kingdom Economic Development Initiative (Read more at <http://bfpne.ws/S2YXhm>) will create many opportunities and many challenges, including the major issue of transportation, from building sufficient infrastructure to ensuring that the new systems promote development that is consistent with regional plans. The statewide model could prove especially useful for these challenges by evaluating and comparing various scenarios for development, new road construction, capacity expansion, and the effects of disruptions to the road network like heavy snowfall. This evaluation could allow the best planning decisions for the project moving forward with these major investments.

The TRC looks forward to opportunities to continue to work with VTrans, developers, Regional Planning Commissions, and Vermont communities on the many challenging issues facing the state. The TRC anticipates being involved in analyses of transit suitability, roadway vulnerability, freight movement efficiency and positioning of the transportation workforce.

## “Can America Embrace Biking the Way Denmark Has?”



TRC Director Austin Troy recently wrote a piece for Slate, discussing the divide between the popularity of cycling in Europe and the much higher car dependence in the US. Read the article at <http://slate.me/UjwsYe>

### Pervious Concrete Pavement at UVM's Trinity Parking Lot



*Removable pervious concrete slab is being installed*



*Visible difference between the traditional asphalt pavement and pervious concrete pavement during rains*

As a part of sustainable construction, pervious concrete has been found to be a better choice over traditional asphalt pavements. Because of higher voids content, pervious concrete allows water to percolate in the ground reducing the storm water runoff and helping ground water table to recharge. Reduction in runoff has a major advantage of reducing harmful waste and contaminants getting transported to nearby water bodies such as lakes and rivers. Pervious concrete is typically used in areas with light traffic such as parking lots and walkways. Despite its benefits, pervious concrete has not been used widely in cold climates owing to its potential susceptibility to freeze-thaw, salt, and clogging.

The Trinity parking lot on the UVM Campus is first of its kind in Vermont. It is half traditional asphalt and half pervious concrete, and the pervious concrete portion is comprised of removable slabs made by Porous Technologies, LLC. These slabs can be lifted and cleaned, and replaced if desired, as part of maintenance.

In order to monitor the functioning of pervious concrete, a variety of instrumentation has been placed around and under the parking lot. The pervious concrete pavement is supposed to allow the stormwater to infiltrate through the soils underneath as if there was no pavement. The embedded instrumentation is expected to examine this desired performance. Lysimeters are being used to collect water samples to allow assessment of water quality. The moisture probes measure electrical conductivity which is an indicator of changes in moisture content, salt concentration and temperature fluctuations. The pore pressure transducers measure fluctuations in groundwater below different portions of the pavements and nearby. In addition to the embedded instrumentation, a rain gauge and temperature sensors are installed outside to capture all the rain events and monitor temperature fluctuations. In addition, the infiltration capacity of the pervious concrete will also be monitored using a falling head infiltrometer over the next two years and the goal is to relate the measured infiltration to maintenance and cleaning practices.

The research is being conducted in collaboration with the School of Engineering. The sensor measurements and their analysis will be incorporated in some civil and environmental engineering courses at UVM. In fact, a preliminary plan for the instrumentation was developed by a team of civil and environmental engineering seniors as part of their capstone project, which also included preliminary design of this parking lot. The entire study is funded by UVM's Transportation & Parking and the United States Department of Transportation through UVM's Transportation Research Center. The research team is comprised of Prof. Mandar Dewoolkar [Mandar.Dewoolkar@uvm.edu], Dr. Lalita Oka and Ian Anderson.

### Past Seminars

The TRC hosts many events and often records them for those who may not be able to attend. To view a list of past events and links to video or audio, please visit our Seminars page at <http://bit.ly/11pRmhD>

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