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# RESEARCH FINDINGS: POTENTIAL OF STORMWATER RETENTION PONDS TO PRODUCE NUISANCE MOSQUITOES AND WEST NILE VIRUS VECTORS II: FIELD TRIALS FOR NON-PESTICIDAL, SELF-SUSTAINING CONTROL OF MOSQUITOES

*Nancy Scott, Delaware Water Resources Center Intern for 2005, examines retention pond water for mosquitoes.*

**Dr. Jack B. Gingrich and Robert D. Anderson, Department of Entomology and Wildlife Ecology**

**Sponsor: Dr. Marianne Walch, NPDES Program, DelDOT, Dover, DE.**

Storm water retention ponds collect water as runoff from developed lands and roadways. They are found in abundance wherever developments have been built or where highways have encroached on previously unpaved areas. Such ponds hold water for extended periods of time, usually more than ten days, and often create habitats that are ideal for mosquito development. The purpose of this project was to find a low-impact, sustainable treatment method to reduce the number of mosquito larvae in ponds. To that end, we selected a total of thirty ponds that were known mosquito breeders from previous years' studies. In May and early June of 2005, we performed biweekly pretreatment assessments of ponds, including mosquito abundance, phosphate levels, chlorophyll a levels, predator numbers, and major plant families/genera. We then organized ponds into six untreated control ponds, while the other twenty-four were treated in groups of six using various methods to reduce phosphate levels, which appear to be correlated with mosquito abundance. High levels of phosphates appear to relate to food availability for mosquito larvae.

The four methods tested included granular alum (aluminum sulfate), Bacta-pur (a variant of Bacillus subtilis) - with and without circulation pumping; and solar-powered pond aeration. These four treatments proceeded from late June through mid-September, 2005, with post-treatment assessments conducted at biweekly intervals throughout the post-treatment period. It is also a more sustainable method for controlling mosquitoes than most traditional pesticides because it generally requires fewer treatments.

Based on these results, the alum treatment was the most effective method for controlling the number of mosquito larvae in storm water ponds. The alum-treated ponds did not produce as many mosquito larvae as the other ponds. Also, there was a significant reduction of phosphate levels in alum-treated ponds. Chlorophyll a levels, however, increased during the course of the season, and did not follow the expected pattern of the control ponds, which saw an overall decrease. This finding suggests that phosphates may be more important factors in the mosquito life cycle than chlorophyll a. Alum is also a more efficient method for mosquito control method than most traditional pesti-

*Story continued on page 3*

## *In This Issue*

## Message from the Director

*Ardeshir Faghri, Director*

With the publication of the current newsletter, our team kicks off a second five-year term as the executive directorship of the Delaware Center for Transportation. I personally consider it a privilege to have already served a five-year term and to be given the confidence by both DelDOT and UD to serve for another five. Between 2001 and 2006 we accomplished a lot. But the one thing that I consider the most significant is the fact that we stayed together through all the challenges, and are continuing together as a team. I have no doubt in my mind that we can reach even greater heights during our second term.

In August 2001, we started the administration of DCT with a total budget of approximately $650K, and a program consisting mainly of an annual research program. Today, we manage an organization with an annual budget close to $4 million and a program consisting of research, education and training, technical assistance, and technology transfer in all areas related to transportation. Our research projects consist of such important local, state, national and global projects as alternative fuels in transportation, applications of satellite-based global positioning systems in transportation, recycled tire use in transportation, and using composite materials in the design and construction of highway bridges. Our education and training group offers courses and seminars in Intelligent Transportation Systems, Traffic Engineering and Modeling, Transportation Planning, and many others related to design and construction of transportation facilities, all using the state-of-the-art in computing hardware, software, and related equipment. Our seminars have brought such distinguished guests as Nigel Wilson of MIT, Dan Sperling of UC-Davis and Kim Toufectis of NASA-Goddard Space Research Center. During the next five years, among other goals, we hope to expand our operations in the ITS area, and establish even closer ties with our industrial partners.

A huge thanks from all of us for all your support of the past five years. We will strive to be even more responsive to all the transportation research and education needs of our constituents during the next five years.

## Philadelphia Airport Tour

The DCT and the student chapter of the Institute of Transportation Engineers co-sponsored a student tour to the Philadelphia Airport on April 28, 2006. About a dozen students participated in the tour that included stops at the airport control tower, taxiways, and other airport facilities.

Trips to transportation facilities in Delaware and surrounding states are conducted so that students can learn first-hand the important role that transportation civil engineering plays in promoting the mobility of people and goods in our country. Other locations students have visited include DelDOT headquarters and AMTRAK training facilities in Wilmington.

## Annual TRB Visit Includes Stop at DCT

Each year members of the TRB staff visit every state DOT. The Delaware visit always includes a stop at the University of Delaware to discuss active research projects and other activities.

Stephen Maher, Director of Design for the TRB, was at the campus on April 28, 2006. Dan LaCombe, DelDOT Research Manager, said, "Stephen's visit was both informative and enjoyable. We met with a variety of DelDOT and UD personnel to discuss mutual research interests such as roadside safety, hydrology, water quality, materials, and environmental issues, to name a few. It was great to have an opportunity to receive and exchange information across a variety of research areas. He (Mr. Maher) has a wealth of information at the ready and has followed-up with additional information related to resources, contacts, etc."

The TRB is one of the largest transportation research organizations in the country. It is funded by many federal and state agencies including FHWA and DelDOT. Many DelDOT employees and University professors serve on TRB committees.

*continued from page 1*

cides because it is a stable chemical compound, and needs to be applied to ponds less often than other treatments. The aerators and pumps involved in the aeration and Bacta-pur treatments were ineffective methods, mainly because they were prone to power failures and other issues.
None of the treatments appeared to adversely affect invertebrate predators that normally feed on mosquitoes.
Moreover, toxicity tests of alum and Bacta-pur showed no direct toxicity effects on larvae, again suggesting that the mode of action is most probably directed towards food components for mosquito larvae.

In 2006, further investigations are being conducted to test alum treatments over a longer period of time with an expanded number of control ponds. The goal will be to achieve statistically significant data.

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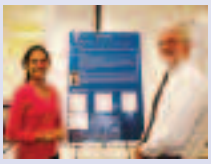
*Dr. Jack B. Gingrich, from the Department of Entomology and Wildlife Ecology at the University of Delaware is the Principal Investigator on Evaluation of the Potential of Retention Ponds and Sand Filters to Produce Nuisance Mosquitoes and West Nile Virus Vectors project.*

## 3rd Annual Transportation Research Showcase

On Monday, May 1,2006, DCT sponsored the 3rd Annual Transportation Research Showcase at the Paradee Center in Dover. The showcase featured poster sessions for each of current research projects which were presented by the Project Investigator and graduate student(s). The posters were divided into six categories: Environmental, Planning, Pavement and Materials, Structures and Bridges, Traffic and ITS, and Transit. Guests who attended the showcase had the opportunity to view the poster and discuss the project with each of the Principal Investigators. Visitors to this year's showcase included DelDOT, the University of Delaware, Delaware Legislature and private industry.

*Rosemary Samick from FHWA views the Roundabouts poster while Graduate Student Evy Vlahos explains the project*



*Graduate Student, Prarthana Banerji presents the Resilient Modulus project to Wayne Kling of DelDOT*

## SUMMER INTERN PROGRAM

Once again in the summer of 2006, DelDOT hired many summer interns referred by the Delaware Center for Transportation. Fifteen undergraduate and graduate students worked at DelDOT headquarters in Dover, at the Traffic Management Center in Smyrna, and other locations throughout the state.

| Number of Interns | Year of Graduation |
|---|---|
| 1 | 2006 |
| 4 | 2007 |
| 9 | 2008 |
| 1 | 2009 |

The summer internship enables students to have real-world work experiences and to investigate DelDOT as a career employer. Conversely, DelDOT is able to make preliminary assessments about workers whom it wants to recruit for the long haul. It must work. Over the years, the University of Delaware has supplied more engineers to DelDOT than any other university.

*The research team works on installation of the MSE wall monitoring system. Five strain gages are attached to each layer of 22-ft-long geogrid. The surface is abraded and heated, and the gages are then attached using epoxy. The layers are spaced vertically at 1.5 feet, and every other layer is instrumented.*

## Bridge Center Collaborates with DelDOT on MSE Walls for IRIB

*by Diane Kukich*

The University of Delaware Center for Innovative Bridge Engineering (CIBrE) is collaborating with DelDOT on a program to monitor the mechanically stabilized earth (MSE) walls associated with the approaches of the Indian River Inlet Bridge (IRIB). The project is part of a larger effort that will also involve developing a long-term monitoring plan for the bridge superstructure, as well as writing a manual for instrumentation and monitoring that describes all aspects of the program, including both the superstructure and the MSE walls.

According to Prof. Dov Leshchinsky, one of the two lead principal investigators on the project, the access road to the new IRIB is over extremely soft soil, requiring special methods to improve the foundation such as the use of PVD's and surcharging. Along sections of this road, MSE walls will be constructed to limit the amount of fill for the embankment approaching the bridge. "The maximum height of the wall exceeds 50 feet, and the expected consolidation settlement is as much as 60 inches, or ten percent," Leshchinsky points out. "That is a substantial amount of settlement."

Although MSE walls have performed well over soft soils, the state of current design for such cases is limited, especially when very large settlements are expected. Proper field instrumentation and close monitoring of performance will therefore not only provide information about what is going on with the current installation but also help to refine existing designs for complicated applications.

In addition, the project is contributing to the education of a CEE graduate student working in the area of geotechnical engineering. Scott Berkheimer, a master's degree candidate, has been gaining hands-on experience in the installation of the monitoring system since February. He will also be assisting the faculty PI's and Research Technician Gary Wenczel with data collection and analysis over the next year.

"This is a critical element in the work we get involved in," says Prof. Michael Chajes, Chair of the UD Department of Civil and Environmental Engineering and PI on the IRIB monitoring project. "We are interested in projects that will enable us to educate the next generation of civil engineers. This program will generate novel data regarding tall MSE walls undergoing large consolidation settlement, and Scott will be involved in all stages of the work from design and installation of the monitoring plan to testing and analysis. The field experience he is gaining is invaluable."

## Maryland T² Center Hosts 2006 Roadway Management Conference

The Maryland T² Center hosted the 14th annual Roadway Management Conference on March 20-22, 2006, in Ocean City, MD. The Roadway Management Conference is jointly sponsored by the T² Centers in Delaware, Maryland, Pennsylvania, Virginia, and West Virginia. Delaware last held the conference in 2004 at Clayton Hall on the University campus, and will again host it in 2009. Virginia will be the next host in the spring or summer of 2007.

The 2006 conference attracted more than 300 participants, mostly from state DOTs and local governments. Conference activities include plenary and breakout sessions, vendor displays and product demonstrations, and a bus tour to active transportation projects in the area. This year's bus tour included a visit to Americana Bayside, a large newly planned community west of Fenwick Island, DE. At its completion in several years, Americana Bayside will feature 1700 residential units, a town center, a golf course, and a post office and fire station that will both serve the surrounding area of Sussex County. The bus tour focused on the transportation network that the developer and DelDOT are both constructing as part of a public-private partnership. Major projects include the realignment of the DE 20 – DE 54 intersection, upgrades of several existing DelDOT maintained roads, and improvements to wetlands and Native American burial grounds. Alan Kercher, our T² Engineer, played an important role in setting up this bus tour.

Breakout sessions are designed to attract both professional and non-professional transportation workers. Topics included motivating personnel, temporary bridges, asset management, road safety audits, incident management, winter maintenance, and bicycle and pedestrian safety issues.

## Fuel-Cell Speaker Draws Large Crowd

*By Diane Kukich*

Guest lecturer Daniel Sperling from the University of California–Davis spoke to a standing-room-only crowd on Tuesday, April 11. More than 150 people came to hear his talk, "The Next Generation of Motor Vehicles and Fuels," which was part of the DCT Distinguished Guest Speaker Series.

Sperling is a Professor of Civil Engineering and Environmental Science and Policy, as well as founding Director of the Institute of Transportation Studies, at UC–Davis. He is also co-director the Hydrogen Pathways Program and New Mobility Center there.

"There is no obvious answer to the problem of energy," Sperling said. "Most alternative fuels developed during the twentieth century have failed." He then presented a number of statistics to support his belief that the need to address energy issues is urgent.

Transit accounts for only 2% of passenger miles in the U.S., and our country now has 1.1 cars per licensed driver. Not only is vehicular travel in the U.S. increasing much more rapidly than the population and highway expansion, but developing countries are also experiencing explosive growth in motorized travel.

"The good news," said Sperling, "is that we have lots of energy. The bad news is that unconventional sources have large economic and environmental costs. And tweaking the internal combustion engine isn't going to get us where we need to go to keep CO levels stable."

"One environmental success story," he continued, "is that vehicles are much cleaner than they used to be, which is a success in terms of air pollution. But energy is much more problematic. We've had tremendous gains in engine efficiency, but all those gains have been used up in making vehicles heavier and more powerful. The average fuel consumption hasn't changed in 20 years; all of the gains have been private rather than public."

Sperling then reviewed three sets of opportunities for major reductions in oil use and greenhouse gas (GHG) emissions: cellulosic ethanol (i.e., trees, switch grass), battery electric vehicles and pug-in hybrids, and fuel cells using solar hydrogen, which will yield the greatest GHG reduction.

Capitalizing on fuel-cell technology will require " transforming the vehicle."

"The fuel cell will open up the envelope of how cars are designed," Sperling said. He explained that a tremendous variety of vehicles could be built on just three basic platforms.

He also pointed out another benefit of fuel-cell vehicles—the potential to recapture the unused energy to provide power for things such as tools, barbecue grills, and hot tubs.

According to Sperling, hydrogen could, in theory, replace all other energy sources. But there are currently only about 500 fuel-cell vehicles in the world, most of them buses and various prototype vehicles.

Recognized as a leading international expert on transportation technology assessment, energy and environmental aspects of transportation, and transportation policy, Sperling has authored or co-authored over 200 technical papers and reports and eight books. He earned his Ph.D. in Transport Engineering at the University of California–Berkeley.

## Upcoming T² CenteR Events

*NHI Course 131050*
*Asphalt Pavement Recycling Techniques*
*November 1-2, 2006*
*Dover*

*NHI Course 151042*
*Safety Conscious Planning*
*November 8-9, 2006*
*Dover*

### *Courses Under Development*

- *Ethics for Engineers*
- *Preparing Convincing Technical Reports for Your Supervisor and the Public*
- *Intersection Design*

*For current T² offerings visit the T² Center at www.ce.udel.edu/dct*

# Fall 2006 Opportunities

DelDOT relies on the DCT to manage and sponsor much of its educational and training needs. This is particularly true for the "hard skills" otherwise labeled technology. The list below shows the names of the hard skills courses that the University will offer during the Fall 2006 semester.

This list is provided as a guide. For more information about a particular course, see the Fall 2006 Educational Opportunities for the Transportation Community, an online course catalog that is available for view on our Website, http://www.ce.udel.edu/dct/education/education.htm

Also refer to the Fall '06 Undergraduate and Graduate Registration Booklet and the Fall 2006 Professional and Continuing Studies Bulletin, both available in print, or visit the Engineering Outreach site (http://www.engr.udel.edu/outreach/grad_studies.html) for part-time credit and non-credit graduate level engineering opportunities, or contact enggoutreach@udel.edu; 302-831-4863.

## Construction

Introduction to Land Surveying
Welding & Metals
Wood & Steel Structures
Construction Methods & Management
Drilled Shafts: Construction, Inspection & Design
Geotechnical & Foundation Design
Mechanically Stabilized Earth Walls & Reinforced Soil Slopes

## Environmental Engineering

Introduction to Environmental Engineering
Environmental Engineering Processes
Fluid Mechanics
Solid Waste Management
Water & Waste Water Engineering
Applied Environmental Statistics & Data Analysis
Chemical Aspects of Environmental Engineering
Contaminant Transport & Separation in Environmental Systems
Green Technology Design for Storm Water Management
Land and Water Management
Storm Water Management
Waste Water Treatment Systems
Energy Policy and Administration

## Geotechnical Engineering

Soil Mechanics
Soil Mechanics Lab
Drilled Shafts: Construction, Inspection & Design
Geotechnical & Foundation Design
Mechanically Stabilized Earth Walls & Reinforced Soil Slopes

## Government Policy

Civil Infrastructure Systems
Energy Policy and Administration
Solid Waste Management
Planning Theory and Urban Policy
Energy Policy and Administration
GIS in Public Policy
Case Studies in State & Local Management
Political Economy of the Environment

## Licensing Review Courses

Fundamentals of Engineering (FE) Review Course
Professional Engineer (PE) Licensing Review Course

## Management & Leadership

Civil Infrastructure Systems
Construction Methods & Management
Measuring & Defining Planning Problems
Introduction to Comprehensive Planning
Introduction to Zoning and Land Use Controls
Data Analysis & Quality Management
Introduction to Public Relations
Public Relations Writing
Public Management Statistics
Economics in Public and Nonprofit Sectors
Energy Policy and Administration
Project Management for Civil Engineers

## Roadway Capacity & Design

Traffic Engineering & Modeling
Civil Infrastructure Systems

## Structural Engineering

Statics
Structural Analysis
Building Design
Introduction to Bridge Design
Geotechnical & Foundation Design
Wood & Steel Structures
Resilience Engineering
Structural Dynamics Design
Advanced Mechanics of Materials
Technical & Computer-aided Drafting
Fundamentals of Statics & Strength of Materials
Composite Materials Structures
Drilled Shafts: Construction, Inspection & Design
Mechanically Stabilized Earth Walls & Reinforced Soil Slopes

## Traffic Engineering

Traffic Engineering & Modeling
Transportation Engineering Laboratory

## Transportation & Land Use Planning

Traffic Engineering & Modeling
Transportation Engineering Laboratory
Civil Infrastructure Systems
Land and Water Management

## Introduction to Land Surveying

Storm Water Management
Measuring & Defining Planning Problems
Introduction to Comprehensive Planning
Introduction to Zoning and Land Use Controls
Planning Theory and Urban Policy

## Other

Introduction to GIS
Research Methods and Data Analysis
Public Management Statistics
Geographic Information Systems in Public Policy

## Certificate Programs

Graduate Certificate in Composite Materials
Geotechnical Engineering

# Research

The Center is getting ready for the start of the FY'07 Annual Research Program. In January 2006 we met with DelDOT's Research Committee to identify and prioritize the most important transportation problems facing DelDOT. In June 2006, the DCT Policy Council approved the following projects for the start of our fiscal year on July 1, 2006:

**A Comparative Analysis of Best Management Practices in Transportation Design, Construction and Management, Planning to Accommodate Growing Elderly Needs in Delaware**

Delaware, like most states, is experiencing a growing elderly population (60+) due to aging baby boomers. Also, like a number of other northeast corridor coastal states, the state is experiencing an influx of retiree's seeking residency, particularly in Sussex and Kent Counties. The number of elderly drivers with longer life expectancies than generations past is likely to present a challenge to the state's transportation system and produce greater demands and needs for transportation services and programs in certain areas. These include services and programs to accommodate the increasing number of elderly drivers, provide alternatives to driving, and improve overall elderly-friendly mobility standards.

| | |
|---|---|
| Principal Investigator: | Bernie Dworsky, Institute for Public Administration |
| Problem proposed by: | Bernie Dworsky, Institute for Public Administration |

**Asset Management as a Strategic Decision-Making Tool in DelDOT**

Asset management has been receiving greater attention at both the state and national level. Escalating demands by the public for increased accountability, aging infrastructure, increasingly constrained resources, new funding challenges, and increasing emphasis on the private provision of public service and public-private partnership all point to the need for asset management. Asset management is a data driven process that is rooted in comprehensive inventory of physical assets and their condition, and the quantification of the impacts of alternative decision.

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|---|---|
| Principal Investigator: | Sue McNeil, Department of Civil and Environmental Engineering |
| Problem proposed by: | Sue McNeil, Department of Civil and Environmental Engineering |

## NEW PROJECTS FOR THE CENTER FOR INNOVATIVE BRIDGE ENGINEERING FOR FY'07:

**Scour Monitoring of the Indian River Inlet Bridge**

There is considerable concern regarding the scour near and around the existing Indian River Inlet Bridge. As a result, the bridge is scheduled to be replaced. However, since the initial design was deemed too expensive to build, the design process will need to start over again. This will result in the existing bridge needing to remain in service for longer than anticipated. As a result, there is concern over the safety of the existing bridge into the future. It is suggested that a research project be initiated that: evaluates existing scour detection technologies, develops a scour detection system for the existing bridge, and assesses the structural integrity and safety of the bridge throughout its remaining service life.

| | |
|---|---|
| Principal Investigator: | Jennifer Righman, Jamie MacMahan, Jack Puleo, Michael Chajes, Department of Civil and Environmental Engineering |
| Problem proposed by: | Michael Chajes, UD, Department of Civil and Environmental Engineering |

## THE CURRENT ACTIVE RESEARCH PROJECTS INCLUDE:

*As each project is completed, an abstract will be available on the DCT website: http://www.ce.udel.edu/dct.*

**Examination of GIS and Current Information System Plans and Responsibilities**

To provide an appraisal of the current strengths and weaknesses of the existing and proposed GIS and information system efforts in DelDOT as they pertain to the Division of Planning.

| | |
|---|---|
| Principal Investigator: | David Racca, Center for Applied Demography and Survey Research |
| Project Manager: | Joseph Cantalupo, Division of Planning |

**Investigating the Cost, Liability and Reliability of Anti-Idling Equipment for Trucks**

Investigating the cost, liability and reliability of anti-idling equipment for trucks.

| | |
|---|---|
| Principal Investigator: | Young-Doo Wang and John Byrne Center for Energy and Environmental Policy |
| Project Manager: | Mark Glaze, Division of Planning |

**Succession Planning – Phase II**

Continuation of Succession Planning Project. Phase II would be the implementation of the current project. There are a high number of retirements coming up this summer; a high number of leadership people will be leaving.

| | |
|---|---|
| Principal Investigator: | James Flynn, Institute for Public Administration |
| Project Manager: | Margaret Failing, Department of Human Resources |

**Rating of 4-way Stop Intersections for Conversion to Roundabouts**

Continuation of Roundabouts Project. Roundabouts are safer, cleaner and improve traffic flow. Phase II would be the rating of 4-way stop sign intersections for switching to roundabouts.

Principal Investigator: Ardeshir Faghri, Department of Civil and Environmental Engineering

Project Manager: Dan LaCombe, Division of Planning

**Scrap Tire Research**

Determine the environmental and engineering properties that should be monitored during the construction of shredded tire embankments. Include instrumentation, installation, monitoring and an analysis plan. Implement the monitoring. What instruments are needed and how to construct and monitor them. The issue in Delaware is that the temperature is much higher in the summer than it is in New England.

Principal Investigator: Nii Attoh-Okine, Paul Imhoff, Victor Kaliakin Department of Civil and Environmental Engineering

Project Manager: Wayne Kling, Division of Materials and Research

**Historic Bridges Study**

What constitutes a historic bridge? How to designate between old and historic. How are other states handling this? Life cycle cost strategies. Mobility and congestion issues involved in keeping the older structures. Re-evaluate the
current State historic bridge list.

Principal Investigator: David Ames, Center for Historical Architecture and Design

Project Manager: Glen Lovelace, Division of Bridge Design

**Hot Mix Asphalt Specification Research**

A continuation of analysis of DelDOT's Hot Mix Asphalt Quality Assurance Specifications. Include an updated comparison to other states, particularly Pennsylvania and Maryland.

Principal Investigator: Nii Attoh-Okine, Department of Civil and Environmental Engineering

Project Manager: Wayne Kling, Division of Materials and Research

**Laboratory Determination of Resilient Modulus of Unbound Materials and Hot Mix Asphalt**

Review of Resilient Modulus Project and check for any gaps between products from that project and the recently released pavement design procedure.

Principal Investigator: Nii Attoh-Okine, Department of Civil and Environmental Engineering

Project Manager: Wayne Kling, Division of Materials and Research

**A Practical Application/Implementation of the ADA Eligibility Model for DART First State Paratransit**

This would be a practical application/implementation of the project "ADA Eligibility Model for DART First State Paratransit."

Principal Investigator: Michael Gamel-McCormick, Center for Disability Studies

Project Manager: Cathy Dennis, Delaware Transit Corporation

**Characterization of SR-1 Concrete Test**

Prioritization of concrete used for SR-1 pavement (shrinkage & modulus evaluations)

Principal Investigator: Danny Richardson, Department of Civil and Environmental Engineering

Project Manager: Wayne Kling, Division of Materials and Research

**Bike Path Adjacent To Residential Areas – Property Value/Desirability**

Quantify that bike paths can increase real estate values. Economic benefits of bike paths/trails adjacent to residential properties.

Principal Investigator: Dave Racca, Center for Applied Demography and Survey Research

Project Manager: Anthony Aglio, Division of Planning

**Succession Planning**

Transfer of institutional knowledge to the next generation of DelDOT professionals: Retirement/Succession planning; evaluate pros/cons of increased use of consultants vs. in house expertise; work force assessment (present & future); what are other state DOT's doing to address this issue? Develop aggressive plan.

Principal Investigator: James Flynn, School of Urban Affairs

Project Manager: Margaret Failing, Department of Human Resources

**Durability of Thin Overlays**

What do you replace it with on a new structure? Compare to more traditional ways.

Principal Investigator: Nii Attoh-Okine, Department of Civil and Environmental Engineering

Project Manager: Wayne Kling, Division of Materials and Research

**Letting Scenic and Historic Roads in Delaware Tell Their Story**

A web-based manual to facilitate the identification, designation and management of scenic and historic highways

Principal Investigator: David Ames, Center for Historical Architecture and Design

Project Manager: David Petrosky, DelDOT, Division of Planning

**2005-2006 GPS Travel Time and Delay Data Collection and Analysis**

This project uses the state-of-the-art equipment in receiving satellite position information for collecting real-time state-wide traffic data. The data is then analyzed and displayed by Geographic Information Systems software.

Principal Investigator: Ardeshir Faghri, Dept. of Civil and Environmental Engineering

Project Manager: Dan Lacombe, Division of Planning

**Surface Treated Roads**

DelDOT maintains 1800 lane miles of surface treated pavement. It is along many of these roads that major new development is occurring. Is there a better surface treatment method or inexpensive technology that DelDOT could be using to address this issue?

Principal Investigator: Danny Richardson, Department of Civil and Environmental Engineering

Project Manager: Jennifer Pinkerton, Division of Preconstruction

**Estimating Current Modal Splits**

This project will produce a new, more reliable estimate of travel mode choice in Delaware to be used for planning and evaluation of services and assist in the establishment of systems to better judge the consequences of alternative solutions to transportation problems.

Principal Investigator: David Racca, Center for Applied Demography and Survey Research

Project Manager: Michael DuRoss, Division of Planning

**Enhancing Delaware's Highways: A Natural Vegetation Project**

The project will Investigate vegetation models conceived to restore Delaware's roadside landscapes to a more natural state reflecting the regional flora.

Principal Investigator: Sue Barton, Department of Plant and Soil Sciences

Project Manager: Chip Rosan, Roadside Environment

**Toward New Transit Services in Newark: Transit Center-Circulation Service Survey of Existing & Potential Riders**

Principal Investigator: Shinya Kikuchi, Department of Civil and Environmental Engineering

Project Manager: Dave Gula, Delaware Transit Corporation

## CURRENT ACTIVE PROJECTS FOR THE CENTER FOR INNOVATIVE BRIDGE ENGINEERING:

**Instrumentation and Monitoring of the Indian River Inlet Bridge: Phase I**

To develop and install a long-term structural monitoring system for the new Indian River Inlet Bridge for both the substructure (the high MSE walls used to support the bridge approaches) and for the bridge superstructure.

Principal Investigator: Chajes, Department of Civil and Environmental Engineering

Project Manager: Jiten Soneji, Division of Planning

**Development of State-Specific Truck Weights**

Principal Investigator: Dennis Mertz and Baidurya Bhattacharya Department of Civil and Environmental Engineering

**Assessing the Fatigue Life of Delaware's Steel Bridges**

Principal Investigator: Dennis Mertz and Baidurya Bhattacharya Department of Civil and Environmental Engineering

RESEARCH PAYS OFF

# Improving Guide Sign Legibility

## *New Lettering Reads Larger, Clearer, Farther*

PAUL J. CARLSON

*The author is Division Head, Operations and Design, Texas Transportation Institute, Texas A&M University System, College Station.*

The traditional font—or lettering design—used for text on highway guide signs was developed in the 1950s and was tested on signs using white text on black backgrounds. The test conditions were nearly static—subjects walked toward the signs until they could read the words correctly.

### Problem

In the past 50 years, sign fabrication techniques and materials, driver characteristics, and highway speeds have changed substantially. The text on guide signs usually is fully retroreflective, incorporating the latest and most efficient types of retroreflective sheeting materials. The sign lighting can be reduced, along with the costs of sign construction, maintenance, and operation.

Some older drivers, however, have difficulty reading the fully retroreflective text—the reflected light causes the edges of the characters to appear fuzzy. This effect is known as blooming and can be particularly acute for older drivers.


Clearview lettering on highway signs in Texas.

A 1994 study by the Federal Highway Administration (FHWA) found that guide signs did not provide adequate viewing distance and reaction time for older drivers. The report recommended enlarging the size of the letters on signs by 20 percent to increase the legibility distance.

The use of larger letters, however, would require increasing the size of the signs by 40 to 50 percent. Signs would cost more, as would the supporting structures.

### Solution

For more than 10 years, a new font, Clearview, has been under development and testing to improve the legibility of highway guide signs. The Pennsylvania Department of Transportation (DOT) cosponsored research on Clearview in the early 1990s at the Pennsylvania Transportation Institute (PTI), Pennsylvania State University.

In the first study, subjective field evaluation and objective laboratory studies with computer simulation identified deficiencies in the current font, Series E Modified (Figure 1), and guided the development of Clearview as an alternative (Figure 2). Two major improvements—a reduced and variable stroke width and larger holes in letters like "e" and "o" —reduced the blooming effect. A second study concluded that a 5-inch tall Clearview font was legible at substantially greater distances than was a 5-inch tall Series E Modified font.

To build on these findings, Texas DOT sponsored a full-scale legibility study of the Clearview font at Texas Transportation Institute (TTI), part of the Texas A&M University System. Working with larger sizes of letters revealed minor improvements that could be made to the font.

In a second study by Texas DOT and TTI, 60 participants—20 young, 20 middle-aged, and 20 older—drove along a closed course and read full-size guide signs. Each guide sign had a randomly selected test word in either the Clearview or the Series E Modified


FIGURE 1 Guide sign with Series E Modified lettering, which has served as the standard font.


FIGURE 2 Clearview version of guide sign increases legibility at greater distances without increasing letter or sign sizes.

font. The legibility distance was recorded when the participants correctly read the guide sign aloud.

This study showed conclusively that the legibility distance for the Clearview font is 12 percent greater on average than that for the Series E Modified font. This corresponds to an approximately 25 percent increase in reading time at 70 miles per hour. In addition, older drivers experienced the largest gains in legibility distance and reading time with the Clearview font.

A third Texas DOT–TTI study used the Clearview font on guide signs to determine the best combinations of retroreflective sheeting for the white Clearview text on a green background. The study showed that the greatest legibility distance was obtained with the most efficient microprismatic materials; moreover, high-intensity retroreflective material in the green background did not compromise the legibility distances.

A combination of the most efficient microprismatic materials for the legend with high-intensity materials for the background yields win-win results. The signing agency gains durability and cost-efficiency in the signs, and drivers gain contrast, which is beneficial for legibility in dark conditions.

## Application

As a result of the research, in September 2004 FHWA's Office of Transportation Operations granted interim approval for use of the Clearview font on guide signs.[1] At least 12 states, including Pennsylvania and Texas, have adopted the Clearview font for signs.

Research on Clearview continues. Texas DOT and TTI are evaluating the Clearview font for regulatory and warning signs. Because these signs have nonreflective black letters instead of the bright white letters used on guide signs, separate research is needed to evaluate the font's performance.

[1] http://mutcd.fhwa.dot.gov/res-ia_clearview_font.htm.

## Benefits

The research shows that use of the Clearview font can improve sign legibility and reading time substantially without increasing the size of the sign. This helps all drivers—particularly older drivers—and will decrease the occurrence of navigational errors and crashes.

Quantifying these effects, however, is not possible, because data on navigational errors are not available, and crash reports do not indicate if the signs were a contributing factor in the crash. A before-and-after study is unlikely to develop a statistically significant crash-reduction factor for the Clearview font because so many other factors are involved.

A definite benefit is that the Clearview font can meet FHWA's recommendations for accommodating older drivers without having to increase the sign size. This allows state DOTs to improve service for drivers age 65 and older at a minimal cost.

*Critical to the successful development of the Clearview font is the collaboration and coordination between the developer of Clearview (Don Meeker of Terminal Design), the PTI research team (Phil Garvey and Martin Pietrucha), and the TTI research team (Paul J. Carlson, Gene Hawkins, and Sue Chrysler). The vision, guidance, and support of Art Breneman, formerly with Pennsylvania DOT, and of Greg Brinkmeyer, Texas DOT, were equally vital. For more information about this research or this article, please contact Paul J. Carlson, Division Head, Operations and Design, TTI, at 979-845-6004; paul-carlson@tamu.edu.*

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