A GREAT UNIVERSITY ON A GREAT LAKE

University of Minnesota Duluth

Natural Resources Research Institute

NRRI Now

Autumn 2009

Roof panels are removed from the box they were shipped in as House[3] is assembled in Coleraine.

~Growing Strong Industries
~Developing New Ideas
~Nurturing Natural Resources

THINKING INSIDE THE BOX

In 2007, the concept of a transportable, deployable, and ready-to-assemble house, developed by NRRI's Patrick Donahue and Scott Johnson, caught the attention of FEMA's Joint Housing Solutions Group. Charged with preparing for future disasters, the FEMA representatives saw merit in the idea.

But first, FEMA needed 200 technical questions answered, and then they wanted a full-scale, working model. That meant Donahue, Johnson, and their newly formed team had to get busy.

This October, the first House^3 (House-cubed) was assembled on-site at NRRI's Coleraine Minerals Lab to serve two functions: a demonstration of the unique housing method, and temporary office space for the growing staff at the lab. And they've taken it one step

HOUSE^3 makes its debut at C





Pat Donahue, Robert Berquist, James Berry and Scott Johnson

further. Three of the team members—architect Robert Berquist, engineer James Berry, and builder Weston Wehr—formed a company to work with the University to launch the House^3 product on the open market.

"I think the market potential for this design will be significant," said Julee Herdt, an award-winning architect and professor of architecture at the University of Colorado. "The modular design is strong and logical. There's great potential for 'daylighting,' solar and use of landscape design to enhance heating and cooling the interior. It looks excellent and I think it's headed for great success."

The house is transported on a flat-bed semi-truck. It is part house/part box packed with building and roof panels that attach to the box itself, transforming it into a 650-square-foot, three-bedroom house. Plumbing and electrical components are in place, ready to connect, and House^3 meets International Residential Code when fully constructed. It even has front and back porches.

Donahue is enthused about using Minnesota's primary and secondary wood industries to build a unique niche product. His hope is that House^3 can meet housing needs in a wide variety of applications throughout North America.

"We have wood from all over Minnesota in this—cabinets from Princeton, wood floors from Cook, studs from Bemidji, and specialty framing from Grand Marais," said Donahue, project lead and director of NRRI's Market Oriented Wood Technology Program. "We're using Minnesota workers to build a Minnesota product. That's our NRRI economic development charge."

A unique feature of the design is the ability to disassemble, pack away, and store House^3 for future deployments.

"The design incorporates a series of proprietary connectors that allow the prefabricated building components to be secured into place, on site, with a few simple hand tools," said Johnson, the project's lead scientist. "It is the connectors that allow for a clean disassembly and repacking of the module for relocation."

Another advantage: the use of solid wood components limits the presence of materials containing formaldehyde. This chemical has been a concern with other temporary housing solutions that were criticized following the Hurricane Katrina floods in New Orleans.

By early December, a second House^3 will go up to help the team work through any kinks in the assembly process and serve as a staff lunch room.

Coleraine Lab

From gravel pit to wonde

NRRI works with Mn/DOT to mitigate wetland impa

Swamps, marshes, bogs, sloughs … a wetland by any name serves our planet well. They soak up rainwater runoff, purifying it before it enters rivers and streams, and help to prevent flooding. In water-rich northern Minnesota, it's a well appreciated service. Wetlands are also valuable habitat for a wide variety of species.

But people also need safe roads, and as 11 miles of busy Highway 53 were expanded from two lanes to four, some of those valuable wetlands were sacrificed.

The federal and state "No Net Loss" of wetlands policies require that wetlands impacted by development be replaced or mitigated. Regulatory agencies prefer wetland mitigation within the same watershed and with the same wetland type—a tricky thing to pull off for the Highway 53 project.

First, there's not a lot of opportunity for restoring drained wetlands because St. Louis County still has 94 percent of its pre-settlement wetlands. In many other areas of Minnesota, wetlands were often drained to expand farmlands making wetland restoration more easily achievable in those areas.

But new wetland creation was needed for the Highway 53 expansion, and the Minnesota Department of Transportation and the Board of Water and Soil Resources looked to NRRI peat researcher Kurt Johnson to manage this complex project.

"Most of the research on this type of situation has been on making ponds, and we didn't want to do that because ponds were not affected by this road project," explained Johnson. "So we're using some new techniques to establish a sedge meadow, shrub swamp, wooded swamp and bog wetlands in the gravel pits abandoned after the road construction."

Some unique opportunities came with the Highway 53 construction. The gravel needed for road construction was handy—right by the road—and the gravel pits created were dug deep enough to hit the water table, making them wet enough for wetlands.

The donor soil displaced by the construction was salvaged from the impacted wetlands before the road went through. Then it was used to replicate native wetlands of the same type in the new space. Special seed mixes developed for wetland mitigation were spread on the sites to establish native vegetation. Johnson also leaned on his knowledge of short-rotation forestry to plant native willow trees with cuttings hoping, as research suggests, that the shading will help keep invasive species from establishing.

By mid-summer 2008, the sites were completely revegetated with the number of species and percent of native vegetation cover was steadily increasing. The willow cuttings are thriving with a survival rate of about 65 percent after the first year.

There have also been a few challenges—like the unfortunate flooding in the spring of 2008 that wiped out the tamarack and black spruce seedlings in one mitigation site. It required some extensive ditching and replanting this past spring. Invasive species—reed

NRRI lab technician Noah Kroening wears snowshoes to keep from sinking while planting willow cuttings.

rful wetland

acts

canary grass, purple loosestrife and narrow leaf cattails—have also started to creep in, but are being pulled or spot-sprayed with herbicide.

For the Minnesota Department of Transportation, this project is an opportunity to have solid, long-term research to show that wetland creation can work for necessary mitigation.

Mn/DOT Wetland Program Coordinator Sarma Straumanis says she understands the skepticism out there about whether or not wetland creation works as well as restoration.

"Intuitively it makes sense that restoring is preferred. You just put back the water, and if the soils are still in place, a natural wetland returns," said Straumanis. "But we've created wetlands that work. We just didn't have the long-term research that NRRI is doing to show that."

Johnson said it will take some time for the research to show if it's completely successful or not.

"The regulatory agencies require a minimum five-year monitoring period to ensure that the created wetlands meet standards. You could say we're just getting our feet wet," he added with a grin.

Project botanist and representatives from MN/DOT and the Board of Water and Soil Resources look at the new wetland's progress in October 2008

Peat appeal

NRRI researcher gains international recognition

Tom Malterer's long career in peatland research at NRRI culminated on a high note this year. As he begins a slow transition into retirement, Malterer received an honorary membership in the International Peat Society.

"Some of the value I've received from this group is simply the lifelong friendships, the ability to email or phone at a moment's notice with a question or for advice," said Malterer. "The trust is there."

The Society's chairman, Donald Grubich, praised Malterer's work with resource evaluation, permitting and gaining state and local cooperation to develop three new horticultural peat operations in Minnesota. He also cited the importance of Malterer's recent project to restore a drained sphagnum moss peatland, gaining wetland mitigation credits for Minnesota's Department of Transportation.

"His accomplishments are great," said Grubich. "He has experience, not only in research, but also in working with peat producers. The [International Peat Society] has been an important part of his life and I believe it will be for many more years."

Important, yes. Malterer has been involved with the Society for 30 years, leaning often on this access to information through the work and research of its 1,550 members around the world. He learned about their successes and failures, allowing him to develop NRRI's successful peatland restoration program sooner, better and more effectively.

"This group has always been at the forefront of what was needed in research and environmental issues," said Malterer. "Our information on peatland restoration research, for example, largely came from Peat Society members in other countries.

The International Peat Society's initiatives in sustainable peatland harvesting and product development have also been important inroads for Minnesota's peat industry.

Malterer is one of only 22 current honorary members and the third to be nominated from the U.S.

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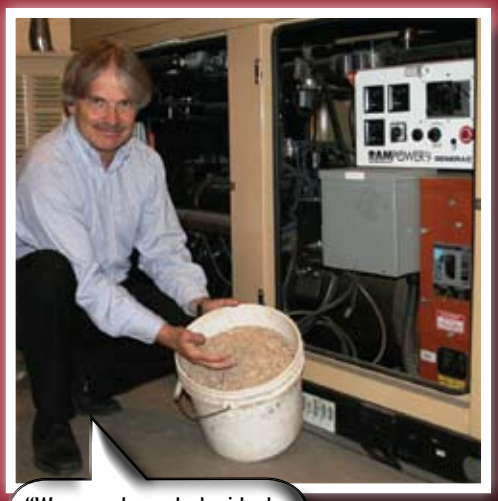
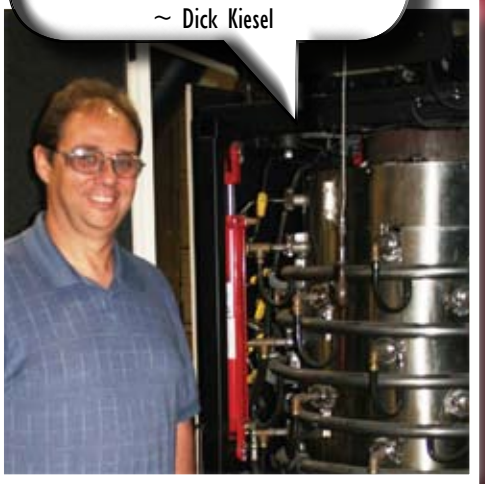


"We recently worked with the Gas Technology Institute to separate hydrogen from synthetic gas made from woody biomass."
~ Dave Hendrickson

"We are converting taconite tailings into a glass-like tile that has the ability to absorb energy, and that is also esthetically pleasing."
~ Kyle Bartholomew

"I am doing research to remove polyvinylchloride (PVC) from wast plastics. With the chloride remove petroleum-based plastics could potentially be burned as a readil available fuel source."
~ Iwao Iwasaki

"We have one of four gasifers in Minnesota that we can use to characterize biomass fuels—their physical and chemical properties and emissions—and convert biomass to various forms of alternative renewable energy."
~ Dick Kiesel



"I was appointed by Governor Tim Pawlenty to serve on the Clean Energy Technology Collaborative to help identify the most promising research and development in clean energy technology that may be beneficial to Minnesota."
~ Don Fosnacht

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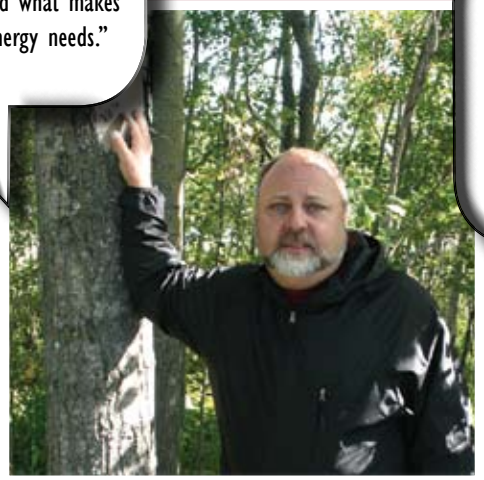
"I am working to understand the availability of forest biomass, develop fast-growing trees, and improve the productivity of forests and other energy crops for alternative fuel resources in Minnesota. I have also analyzed the efficiencies and costs of various forms of fuels to understand what makes the most sense to meet future energy needs."
~ Bill Berguson



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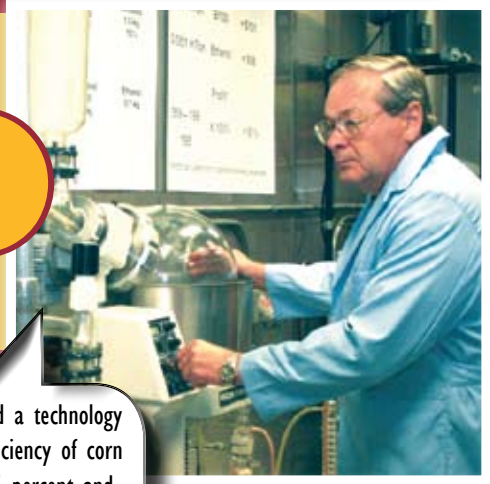
"NRRI is working with other collaborators to improve the knowledge of Minnesota's geothermal energy potential by collecting and mapping additional deep temperature data statewide."
~ Steve Hauck

"I am developing a quick-assembly, deployable housing concept that can be transported to emergency situations or used as semi-permanent housing for a variety of needs. The three-bedroom house is extremely energy efficient, both to live in and to construct."
~ Pat Donahue

"We have found that certain taconite products have excellent heat absorption and retention properties. Our test apparatus, made of low cost components, efficiently captures solar radiation with the heat absorption materials. It could potentially be used to produce hot water in remote locations."
~ Don Fosnacht and Steve Kossett

NERGIZED



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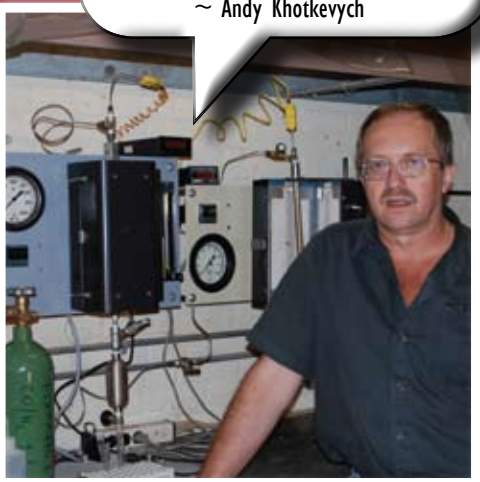
of microwave energy."
~ Don Fosnacht and Larry Zanko

"Our lab has invented a technology that increases the efficiency of corn ethanol plants by 15 percent and makes other value-added products from Distiller's Dried Grains (DDGS)."
~ Pavel Krasutsky

"I am working on processing renewable fuels as part of the catalytic conversion of synthetic gas to liquid hydrocarbons. We are also introducing a new approach for preparing inexpensive catalysts using a Minnesota mineral called Ilmenite."
~ Andy Khotkevych



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Matt Aro

"I use computational fluid dynamics applied to fluid flow and heat transfer in mining companies to optimize the energy efficiency of their operations."
~ Dave Englund

WASTED ENERGY?

NRRI has special equipment to analyze the BTUs of waste materials

As our nation seeks ways to fuel itself, industries are looking around at their waste and wondering, could it generate energy? Shrubby tree limbs and branches left from the logging industry, piles of potato skins at a potato chip factory, corn husks and stalks at animal feed processing plants—is this potential fuel?

We know it's possible to transform this biomass into fuel, but there are a lot of unanswered questions. What are the energy outputs? What gas emissions do they generate? What happens to them at high temperatures? What is the content of the ash after it's burned, and is it useful for something? Is there a way to make the biomass more efficient as a fuel? What happens when various biomass feedstocks are burned together?

NRRI is seeking answers with some very unique equipment—a Thermogravimetric Analyzer (TGA) designed and built at the Coleraine Lab, and a newly-purchased calorimeter. The TGA gathers data on feedstocks as they are burned as a fuel source under a variety of processing conditions (oxygen rich, oxygen starved, etc.). After that processing, the calorimeter measures the energy density (BTUs per pound). The higher the density, the higher the quality of the fuel.

And while Thermogravimetric analysis isn't new, the size of NRRI's newly designed analyzer is—it can measure samples up to 100 grams in mass.

"TGA measures changes in weight as the temperature is increased, and tests like this are typically done on the milligram scale, like maybe five milligrams," explained Kyle Bartholomew, lead researcher on this project. "We've built an analyzer that can test up to 100 grams at a time."

This large tester allows NRRI to process samples more representative of those in the real world, and it produces a volume of gaseous and solid byproducts large enough to conduct useful tests, such as chemical analysis and potential for corrosion.

This is timely news for industries evaluating fuel possibilities from various byproducts, coal, and agricultural waste. Characteristics of the materials—degradation temperatures, absorbed moisture content, level of inorganic and organic components—are critical information in the field of alternative fuels.

Future plans are to emulate the database of CSIRO, the Commonwealth Scientific and Industrial Research Organisation of Australia, to categorize NRRI's TGA analysis of biofuel characterization. The hope is that industries will use the NRRI-generated biomass database to find the fuel content, ash byproduct, and BTU output of thousands of materials.

"The MPCA and other organizations are already very interested in the new biomass characterization data this instrument will provide," said Dave Hendrickson, director of NRRI's Coleraine Lab.

Above: Kyle Bartholomew uses NRRI's specially designed Thermogravimetric Analyzer to gather data on potential biomass feedstock.

Emerald Ash Borer leaves lumber in its wake

NRRI researches uses for infested trees

Despite efforts to quarantine and regulate the transport of ash trees and ash wood products, the destructive Emerald Ash Borer (*Agrilus planipennis*) has found its way to Minnesota. The effects in Michigan and Wisconsin have been devastating—loss of valuable trees for timber, as animal habitat and along urban boulevards—and the same is expected in Minnesota.

NRRI's response is to make the best of the situation with research on how the dead ash trees can be used for the highest value.

This is NRRI's third research project related to the Emerald Ash Borer. The first was to develop a heat treatment process to allow firewood sellers to continue selling firewood without concern for spreading invasive species. The second project evaluated the process and helped firewood producers implement the system.

"But the question in the field, especially to landowners and in communities, is what is the best use for the trees once they remove them? Firewood is not the highest value option," explained NRRI adjunct researcher Xiping Wang.

Working with NRRI from the USDA Forest Products Lab in Madison, Wisc., Wang is now focusing his efforts on pulling together the scattered information available on invasive species and their effect on wood. Working with the Forest Products Society and the Wisconsin Department of Natural Resources, his goal is to develop comprehensive guidelines for utilization of wood infested with invasive species.

"There has been a lot of research done and the information is out there," said Wang, "but the access to the information isn't there. There's no central location that addresses this need."

With funding from the Forest Service's Wood Education and Resource Center, Wang and cooperators will publish a book and develop a user-friendly Web site and online Webinar focused on wood utilization options.

"Ash, elm, maple... they can all be used for many products, like millwork, flooring, cabinets, and other special products," said Wang. "We will study the properties of the wood to see if there has been a reduction in quality, but most of it should still be good for the local wood products industry."

A cargo hitch-hiker from China, the Emerald Ash Borer has migrated from Michigan, where it was first discovered.

Photo credit:
David Cappaert, Michigan State University

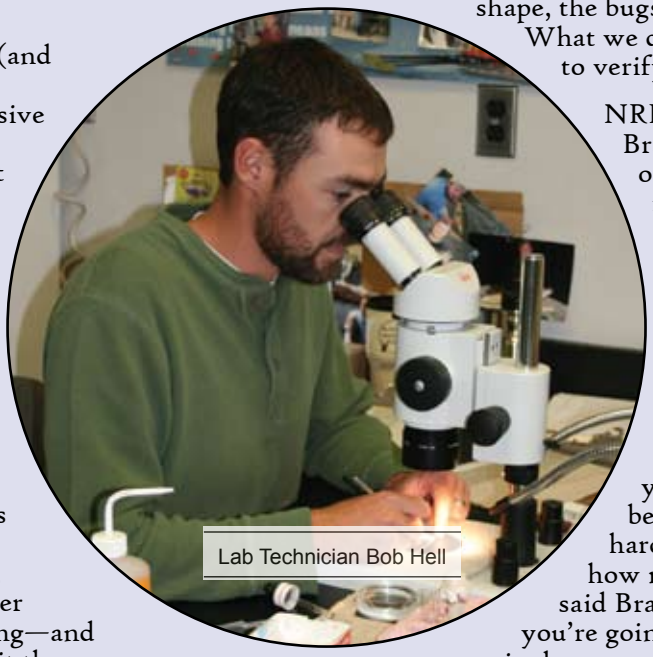
Tiny critters unravel big problems

NRRI's Bug Lab helps answer water quality questions

NRRI's Bug Lab—formally known as the Microscopy Lab—has become well known by those who keep an eye on regional water quality and the health of the aquatic communities. Regulatory agencies and industry alike are leaning on the lab's 20-plus years of experience and research protocols.

Minnesota is getting down to the nitty-gritty when it comes to monitoring fresh water resources. The Pollution Control Agency's goal is to identify impaired water systems (those that fail to meet water quality standards), prioritize them, and eventually try to fix the problems. A Total Maximum Daily Load (TMDL) establishes the maximum amount of pollutants a water body can receive and still meet water quality standards for its designated use.

In the land of 10,000-plus lakes (and many more streams, creeks and marshes), there is always extensive monitoring, sampling, testing and processing done throughout the state in a wide variety of ecosystems. And the TMDL studies add even more need for data gathering.



Lab Technician Bob Hell

"Water quality monitoring is already very standardized," explained NRRI scientist Dan Breneman who oversees the work in the Bug Lab. "But for biological sampling, there's never been established protocols because the habitats are very different—bedrock and boulder, silt and sand, small to large water bodies, fast flowing, slow moving—and many insects and critters inhabit those places through changing seasons. With that much variety, there isn't one single 'best' method that works everywhere."

Over the years, Breneman has helped establish Standard Operating Procedures and Quality Assurance Plans for biological monitoring in a variety of aquatic habitats. This provides defensible data right from the start that pays off later, especially for in-depth projects like TMDL studies.

"It's especially important if someone wants to know what you did and wants to repeat it, they can go back and look at the technical details in the procedures," he said.

NRRI's Standard Operating Procedures have been used in several TMDL stream studies and are being used for two related projects: Surface Water Assessments of the North Shore and the St. Louis River Watershed. The Pollution Control Agency is sampling 132 sites in the St. Louis River watershed in 2009 with a quick "triage" check. NRRI will then sample 30 sites "triage-style" and then 12 again with NRRI's more in-depth protocol to compare results.

The scientists will also test a technique developed at NRRI that categorizes watershed "stress" on stream condition using Geographical Information Systems. They want to know if this computer-based technique—a summary of mapped data about land use, roads and other activities on the land—really correlates with impaired stream condition. The Bug Lab scientists hope "ground-truthing" will make this GIS tool useful for managers who prioritize areas needing attention.

"The GIS stressor gradient might put an area on the 'bad' end of the spectrum because there are a lot of people, development and roads in the watershed," Breneman explained. "But the real condition of the stream may not be degraded. If the habitat is in good shape, the bugs and fish might be just fine. What we do in the Bug Lab is still needed to verify actual conditions."

NRRI Aquatic Scientist Valerie Brady appreciates the high quality optics in the lab to accurately identify the tiny bug species. Mistakes in identification could lead to erroneous conclusions about the condition of a stream or lake. And data consistency from decade to decade is important so that it can be used well into the future.

"If the protocols from 20 or so years ago don't match what's being done now, we have a very hard time saying whether or not, or how much, conditions are changing," said Brady. "You don't know how you're going to use the data in the future so it always pays to collect it following our best protocols whenever we can."

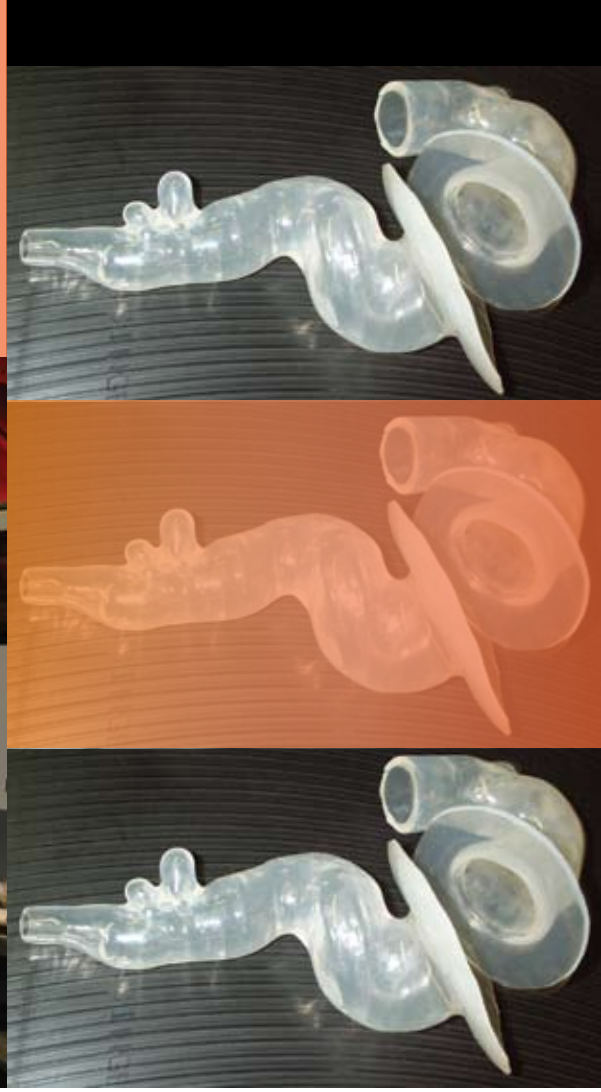
The mining industry also turns to NRRI when dealing with environmental issues. NRRI's aquatic experts can provide technical advice and background data for an Environmental Impact Statement. NRRI can provide information that is used to determine potential risks to any nearby water bodies, which can then be evaluated before permits and approval are given.

Even local Native American Tribes that must comply with water quality standards tap NRRI's Bug Lab skills. Tribal programs can use NRRI as needed to meet their goals rather than hire a full-time biologist to develop the protocols, process water samples and summarize the conditions of their tribal waters.

"Some of these things have been done for decades by other labs," said Breneman. "It's just that we have a well-established system now, and we can help complete the work with the tribes and agencies and the TMDL studies, using standard protocols that ensure the data will be useful now and more than 20 years from now."

Medical modeling

NRRI technologies improve stent manufacturing



Prototype lab director Steve Kossett uses stereolithography to make a model used to improve medical stents.

To some it might seem a bit Frankenstein-ish—a replica of a heart so real it pumps fluids through arteries as it rests in a body-temperature chamber.

But to medical stent manufacturers that realism is critical, and NRRI's rapid prototype technologies helped make it happen.

Metal Professionals, a machine shop in South Range, Wisc., makes silicone models of hearts and blood vessels from CT scans (Computed Tomography) or MRIs (Magnetic Resonance Imaging). These real-sized models of diseased anatomy—an abdominal aneurysm, say—could then be tested to see if it can be repaired, and what specific equipment would work best to repair it, before touching the human patient.

NRRI's role was the first step in making the silicone models. Prototype Lab Director Steve Kossett took the provided CT scans or MRIs, prepped the images as needed so they could be translated into an actual three-dimensional object, and then made a solid plastic "pattern" of the anatomy. From there, Metal Professionals coats the pattern in silicone that, when removed, models the diseased anatomy for multiple practice sessions.

"Based on what the stent manufacturer wants and what they can do at Metal Professionals, the three of us work together to get something realistic enough for the research they need to do," said Kossett.

Stents are used to treat aortic and abdominal aortic aneurysms, caused by a weakened area in the main vessel that supplies blood from the heart to the rest of the body. The pressure can make the weakened wall bulge like a balloon, potentially causing death. Compressed stents are advanced internally to the aneurysm and opened to create new walls in the blood vessel so the blood can pass through freely without rupturing the artery.

"It helps us that Steve [Kossett] can modify the patient files ahead of time on the digital files rather than us trying to do it on the model," said Metals Professionals owner Steve Schick. "With his Magics software and SolidWorks, he can manipulate the drawings better than anyone. He's good to work with."

NRRI tried three of their four rapid prototyping technologies—3-D printing, Fused Deposition Modeling and Stereolithography—and determined the last worked best for this application. Knowing the machine capabilities for various applications is one of the lab's strengths.

"A lot of people need these types of operations," said Kossett. If we can help make a model to improve a medical device, it's very rewarding."

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The Natural Resources Research Institute was established by the Minnesota Legislature in 1983 to foster economic development of Minnesota's natural resources in an environmentally sound manner to promote private sector employment.

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Public sightings of moose needed

Hunters and wildlife watchers are seeing fewer moose in northeastern Minnesota. A scientific study shows higher than expected mortality of adult moose. Calf production is also lower than it has been in the past. In northwestern Minnesota moose declined from over 4,000 to fewer than 100 in less than 20 years.

Could the Arrowhead region—with over 7,000 moose—be starting a similar decline?

NRRI scientists are teaming up with state, federal and tribal natural resource organizations to understand what is happening to moose populations in northeastern Minnesota. And citizens are asked to help.

The study team is asking people to report any moose sightings across northern Minnesota via their Web site at www.nrri.umn.edu/moose. Sick or dead moose should be reported immediately to the local DNR office.

"We regularly count moose in the northeastern corner of the state only and it's logistically impossible to fly over every square mile of moose habitat each year," said Mike Schrage, wildlife biologist with the Fond du Lac Resource Management Division. "Public reports of moose sightings can help us keep track of where moose are doing well in the northeast, and if pockets of moose remain in the rest of the state."

NRRI Biologist Ron Moen added that warming temperatures, increased deer populations, diseases and parasites could all be contributing to a decline of moose in Minnesota. This winter, the study team will deploy GPS radio collars on moose in Voyageurs National Park and on the Grand Portage Indian Reservation. The collars will provide the researchers with activity data and up to 96 moose locations each day.

"Our goal with the overall project will be to use existing research and new data to understand their world better," said Moen.

Research cooperators and sponsors include The U.S. Geological Survey Biological Resources Division, Voyageurs National Park, the Minnesota Deer Hunters Association, the 1854 Treaty Authority, the Superior National Forest, the Fond du Lac Resource Management Division, the Grand Portage Indian Reservation, the Minnesota Zoo, the Minnesota Department of Natural Resources and the University of Minnesota Duluth Natural Resources Research Institute.