Environment

Colorado State University

COLLEGE OF ENGINEERING
Engineering has always been an essential element of society, but in a changing global society, it isn’t enough to maintain our current systems of thought, construction, and interaction. The engineer of the future is charged with revolutionizing the ways that we impact the world around us in order to build a healthy future.

With respect to natural sciences and the engineering solutions they apply to, Colorado State continues to develop itself as the “Green University,” which gives its students unparalleled access to knowledge and research that push the boundaries of environmental monitoring and true sustainability.

As an undergraduate environmental engineering student, I’ve enjoyed the opportunity to learn both foundational engineering concepts and innovative methods in the fields of water quality, ecosystem restoration, and resource management. I’ve also developed my professionalism and leadership while planning student events, serving on advisory boards, and working directly with the College of Engineering’s administration.

Our professors are among the finest experts in their fields, and the research they complete alongside students is astounding in its complexity and potential impact on our world. As if national rankings in research weren’t enough, the upcoming construction of Colorado State’s Engineering II Building will expand our capacity to develop the brilliant minds of our students. It’s a great time to be an engineer and a CSU Ram, and I couldn’t be more excited for the future of our profession and the university that makes this great work possible.

Jesse Jankowski, junior, environmental engineering student, is a member of the University Facility Fee Board, which was integral in securing a $30 million contribution by CSU’s students for Engineering II. Jesse also serves as a Colorado State presidential ambassador, vice president of the Engineering College Council, a peer mentor for the University Honors Program, and a member of the Environmental Engineering Society.
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To the casual observer deciding on appropriate attire for a day’s activities, an assessment of the sky may include color, cloud cover, and the presence or absence of precipitation. But when Colette Heald looks up into the atmosphere, she “sees” a far more complex picture – one filled with tiny organic aerosols that make up a chemical soup undetectable to the naked eye yet critically important to developing accurate long-term global climate models.

Heald, an assistant professor in the Department of Atmospheric Science, recently had her groundbreaking research featured on the cover of the American Geophysical Union’s prestigious journal *Geophysical Research Letters* (28 April 2010, V37, No. 8). Her innovative investigations are making it easier for climate modelers to take into account the impact of organic aerosols when designing models that will accurately depict how the atmosphere will behave under changing factors and influences.

Growing up in Ottawa, Canada, Heald was interested in the environment and science and linking those interests to benefit society. She attended Queens University, where she received her undergraduate degree in engineering physics, and then went on to Harvard University, where she received her doctorate in earth and planetary sciences. She then was awarded a prestigious, two-year National Oceanic and Atmospheric Administration Climate and Global Change Postdoctoral Fellowship, which she completed at the University of California, Berkeley, before joining the faculty at Colorado State University.

At CSU, Heald’s work focuses on using observations of the atmosphere from all scales (satellite imagery to air sampling) with global models to understand the composition and chemistry of the troposphere, the lowest portion of the Earth’s atmosphere.

Of particular interest to Heald’s research team are aerosols. Aerosols are particles suspended in the atmosphere that have both natural and anthropogenic (caused by humans) sources. Through their interaction with radiation, these aerosols can affect climate as well as contribute to urban smog and reductions in visibility. Understanding the sources of aerosols, and how they form and transform when in the troposphere, will help atmospheric scientists better characterize the role organic aerosols play in climate and air pollution. For example, some particles scatter radiation (essentially acting as coolants), while others absorb radiation (acting as heat sinks). Particles that scatter radiation, like sulfate formed from coal-fired power plants or the organic particles in which she is interested, are what Heald calls “beautiful and sinister” – they can cool the planet, but you can’t breathe them. Heald wants to both better understand these chemical species as well as be able to incorporate their impacts more vigorously in climate modeling systems.

“The challenge for atmospheric scientists is how to characterize the hundreds of thousands of organic aerosols with varying lifetimes, properties,
and sources in order to make sense in a climate modeling system,” says Heald. “Characterization is further complicated by the ephemeral nature of some of the chemical species – forming and degrading faster than they can be sampled.”

In the research published in *Geophysical Research Letters*, Heald was interested in seeing if she could simplify that characterization of organic aerosols as they change in the atmosphere. She plotted hydrogen-to-carbon and oxygen-to-carbon ratios from observations of aerosols in the laboratory and in field experiments (primarily sampling from airplanes) from Mexico City, the Amazon, and Los Angeles. Even though the studies looked at different aerosols from different environments, she found she could classify them into groups based on their overall oxygen and hydrogen content.

“The longer aerosols have been in the atmosphere, the more their composition has been altered through oxidation,” notes Heald. “Things in the atmosphere are very reactive. As things age, we can describe their fundamental change.”

This oxidative “calling card” allowed researchers to categorize and quantify based on age, from the freshest emissions (perhaps from a passing diesel truck in Mexico City) to those that have been in the troposphere for several days (such as forest fire emissions from California that reach Colorado several days later). The result is data that can be added to climate models to more accurately reflect the changing chemical composition of organic aerosols as they adjust to changes in the environment and then better predict their impacts.

As society grapples with concerns over global climate change, accurate climate models are essential to better understand the risks and consequences of organic aerosols from both natural and anthropogenic sources. A more thorough understanding of the chemical species themselves may help to develop technologies that will mitigate risks and minimize consequences.

“We need to know what the global climate will look like 50 to 100 years from now, so that our societies can make informed choices based on the best scientific evidence we currently have,” says Heald. “In order to do that, we have to establish confidence in our models.”

There are hundreds of thousands of different chemical species in the atmosphere, some of which have never been measured before.

Colette Heald graduated in 2005 from the Ph.D. program in earth and planetary sciences at Harvard University, focusing on atmospheric chemistry. After two years of postdoctoral research in Berkeley, Heald joined the faculty at Colorado State University. In her free time, she loves to watch black-and-white Hitchcock movies, but science and environmental issues provide real excitement for her.
During World War II, military radar operators noticed a strange phenomenon when scanning the skies for enemy aircraft: extra noise in returned echoes from outgoing pulses that varied depending on weather conditions. Soon thereafter, weather radar was born. Today, at Colorado State University, researchers continue to scan the skies, but advances in radar technology are giving greater detail to complex weather systems – advances that could mean the difference between life and death during severe weather events.

“If we can see a tornado three to five minutes earlier and add to the warning lead time, that could result in lives saved,” says V. Chandrasekar, deputy director of the National Science Foundation Engineering Research Center for Collaborative Adaptive Sensing of the Atmosphere, or CASA, and professor in the Department of Electrical and Computer Engineering. “And it’s not only tornadoes. We have significantly improved our ability to estimate precipitation types and amounts, which also will help us better predict flash floods and severe winter weather.”

Chandrasekar’s research team is a part of the CASA multi-sector partnership, which includes academia, industry, and government agencies. The goal of CASA is to develop weather-sensing networks that detect the region of the lower atmosphere currently below conventional radar range. Most weather forecasting and warning systems use data from high-power, long-range radars that have limited ability to observe the lower part of the atmosphere because of the Earth’s curvature, notes Chandrasekar. This means that radar systems can miss or take too long to recognize dangerous meteorological conditions in the lower troposphere.

CASA’s Dual-Polarization Radar Helps Researchers ‘See’ the Skies

CASA overcomes this shortfall by deploying networks of radar, with stations just tens of miles apart, that can be installed on existing structures or be freestanding. The radars operate collaboratively within a robust information technology infrastructure, constantly adapting to changing atmospheric conditions. In addition, the networks use polarimetric radars, also called dual-polarization radars, to transmit radio wave pulses that have both horizontal and vertical orientations.

“Dual polarization gives us significant improvements in rainfall estimation and precipitation classification, providing us with data quality and quantity to advance the science of severe weather detection,” says Chandrasekar, who also is co-principal investigator of the CSU-CHILL radar facility and deputy director of the National Science Foundation Center for Collaborative Adaptive Sensing of the Atmosphere.

Test beds of the dual-polarization radar network were initially deployed...
in Colorado, then in Oklahoma and in Puerto Rico. The test systems have already proven their worth in the early detection of a tornado in Oklahoma and prediction of severe weather at the Caribbean Games kick-off in Puerto Rico this summer, which resulted in delaying the opening ceremony. Many dual-polarization radars have also been deployed to a number of metro systems in Japan to help avert flood damage in parts of the country. CASA has now moved from developing technology and deploying technology to transitioning into the manufacturing phase for low-cost systems that meet the needs of a global marketplace. (Wade Troxell, associate dean in the College of Engineering, is assisting with the sustainability and manufacturing phase.)

“We are just beginning to understand the full range of applications of dual-polarization radar networks, but already we can see their value in forecasting severe weather events,” says Chandrasekar. “Other important areas of focus are under development, including research for the Department of Energy, which is interested in the radar system for earth radiation budget measurements and global climate change research, and the Department of Homeland Security, which is interested in monitoring low-flying aircraft currently undetectable in standard air traffic control systems.”

Chandrasekar said that in addition to the scientific component of CASA, education is a key element of all CASA programs. Each CASA program is responsible for teacher training institutes for K-12 teachers, undergraduate courses, undergraduate and graduate research opportunities, and outreach and education for the general public.

CASA is a prestigious National Science Foundation Engineering Center with more than $40 million in federal, university, industry, and state funding. CASA is a collaboration among four academic partners: the University of Massachusetts (lead institution), the University of Oklahoma, Colorado State University, and the University of Puerto Rico. Other collaborating academic institutions are the University of Delaware, the University of Virginia, McGill University, Indiana University of Pennsylvania, and the University of Colorado at Colorado Springs. Industry and government partners include Vaisala, Raytheon, NOAA, ITT, OneNet, EWR Weather Radar Systems, KWTV (9 News), and the National Research Institute for Earth Science and Disaster Prevention of Japan.

“When I first came to CSU, radar research was completely new to me. Now, I work with Dr. Chandra on developing the algorithms for microphysical retrievals as well as hydrometeor phase detections from both space and ground radar data.”

Minda Le (shown above with fellow Ph.D. student Matthew Martinez) worked at a semiconductor company as a designer prior to starting her Ph.D. program in electrical engineering at Colorado State.
On Colorado State University’s Foothills Research Campus, just south of the Atmospheric Science Building, a small wetland of bulrushes and cattails rustles softly in the winter wind. Deer, fox, waterfowl, and songbirds are frequent visitors, finding food and shelter in otherwise harsh environs. What these furred and feathered guests may fail to appreciate is that their sanctuary is part of an experimental venture to investigate the viability of graywater reuse as part of a greater endeavor to upgrade water reuse and conservation practices.

Researchers in the Urban Water Center, Department of Civil and Environmental Engineering, are working to come up with new solutions to an intransient freshwater supply problem that only promises to intensify as the global population ticks upward.

Worldwide, approximately one billion people lack access to clean drinking water, and more than 80 countries – representing 40 percent of the world’s population – regularly experience serious water shortages. The United Nations estimates that, by the year 2040, water demand will outstrip supply by more than 30 percent. In the United States, more arid parts of the country – including Arizona, southern California, Colorado, and Nevada – already face challenges to a sustainable and stable water supply.

“What we are working toward is a new paradigm in urban water management,” says Larry Roesner, Harold S. Short Chair of Civil Engineering Infrastructure Systems and director of the Urban Water Center. “We will not be doing water and wastewater management in the future the way we are doing it today. We simply can’t afford to, given the wastefulness of the way we manage urban water and the large amount of energy required to supply municipal water and wastewater services under current practice.”

Sybil Sharvelle, assistant professor in civil and environmental engineer-
ing, and Roesner are collaborating on a project funded by the Environmental Protection Agency to assess the viability of constructed wetland systems to treat graywater, particularly looking at the quality of water produced by the system. The team also has a three-year study awarded by the Water Environment Research Foundation to investigate the effects of using household graywater for residential landscape irrigation. Graywater is nonpotable water generated from showers, baths, hand basins, and washing machines. Blackwater is generated from sources including toilets, dishwashers, and kitchen sinks.

At his home in Fort Collins, Roesner has a graywater system around which urban water researchers and engineering students (right now, 10 graduate students and even more undergraduates) have designed studies to examine the impact of graywater on plants and soils, as well as look at concerns surrounding potential releases of pathogens into the environment. A two-pronged approach, Roesner posits – including basic science and pilot studies – will illuminate a better path forward.

For Sharvelle, work in urban water systems is an Earth-based variation of an earlier NASA research program, in which she focused on developing sustainable systems for long-term space travel. The concept, she notes, is the same (though the spheres of travel through space are widely divergent): a closed-loop system that optimizes how resources are used to save every drop of water and capture every nutrient.

“The overarching issues, and what drives the work at the Urban Water Center, are water quantity and water quality,” says Sharvelle. “We have a need to support agriculture and grow food, yet urban areas continue to grow and buy water rights back from agricultural areas. We need to look at ways to conserve water in urban areas so that agricultural needs are met. Energy use also is an important part of the equation. So much energy is used to supply and treat water that we could radically reduce the amount of energy municipalities need by changing how we use and treat water.”

Potential water and energy savings from water reuse and recycling are substantial. The average city uses 35 percent of its energy for wastewater/water treatment, and more than 25 percent of a city’s carbon footprint is generated through activities around procuring, delivering, and treating water. On a smaller scale, reuse of graywater for toilet flushing could significantly reduce water usage in homes and multi-residential facilities, where 30 percent of water is used to flush toilets.

Urban Water Center areas of basic research and pilot programs to advance sustainable water use include:

• Impacts of graywater on soil chemistry, plant health, and microorganisms.
• Use of constructed wetlands to treat graywater.
• A pilot project to plumb one wing of a new residence hall at Colorado State University, Aspen Hall, to capture graywater, as well as plumb the building to use either irrigation water or conditioned graywater for toilet flushing.
• Treatment levels of graywater required to make it suitable for toilet flushing.
• Installation of an anaerobic digester at the Atmospheric Chemistry Building to treat blackwater and test it as a source of renewable energy.
• Innovative design of stormwater and water treatment systems.
• Development of regulations and legislation for graywater use in Colorado.
• Development of partnerships around water use issues, from municipal utility departments to nonprofit organizations.

“Today, Colorado State University is an international leader in urban sustainable water use research and development, and much of that is due to the support from University administrators and the team at University Facilities,” says Roesner. “We would not be here today if it weren’t for their belief in the importance of this work and their commitment to a better future for our planet.”
Researcher Uses Bacterial Enzymes to Signal Health of Groundwater Systems

Monitoring the health of groundwater, and determining the presence and extent of potentially dangerous pollutants, is a challenging task precisely because of where groundwater is found – underground. But a new biosensor technology is helping to provide a clearer picture of what’s happening in groundwater systems, as well as acting as an early warning device for chemical contaminants suddenly released into water systems or even contaminants in food.

“Our biosensors use a bacterial enzyme that recognizes and responds to the presence of specific chemicals,” says Kenneth Reardon, the Jud and Pat Harper Chair in Chemical and Biological Engineering and co-founder of OptiEnz Sensors LLC, a start-up company engaged in the commercialization of the biosensor technology. “The sensor translates that response into a signal we can read to gain insight into what’s happening below the Earth’s surface.”

OptiEnz, co-founded with Colorado State University’s Clean Energy commercialization arm, Cenergy, is built on more than 15 years of bioremediation experience and biosensor development in Reardon’s laboratory and on collaborations with other academic and governmental institutions. The technology developed from Reardon’s work in bioremediation was derived from his desire to improve detection and monitoring technology.

“In a typical groundwater sampling scenario, technicians would first drill a well to the desired depth, insert a slotted PVC pipe to pull in water, then suck up the water to get a sample to send to a laboratory,” says Reardon. “It’s a snapshot of one depth on one day, which is not very efficient and sometimes not very helpful. Even if new wells are drilled, the result is a sparse data set not conducive to a good understanding of underground conditions, nor do the data give the ability to determine the extent of contamination or the effectiveness of remediation efforts in real time.”

OptiEnz biosensor systems consist of three parts: a hardware unit containing a light source with light detection, an optical fiber connector, and an optical fiber tip with a layer of fluorescent chemical and enzymes. When the tip comes into contact with water containing a contaminant, the enzymes cause the chemical to react in such a way that the brightness of the fluorescent chemical changes. “Reading” these changes gives researchers an accurate assessment of the presence and concentration of contaminants of interest. The sensors allow researchers to go into a system and measure contaminants continuously and quickly, providing information that is important to determine the efficacy of ongoing remediation programs or simply monitoring the levels of chemicals of interest. The sensors can be left in place for up to...
The OptiEnz biosensor lets us monitor contaminants continuously and provide precise readings in the time and place we want to measure. This is a huge step forward in developing and monitoring remediation projects.

Kenneth Reardon received his M.S. and Ph.D. from the California Institute of Technology. Reardon has been at the University since 1988 and is responsible for attracting more than $11 million – largely federal research dollars – to Colorado State. Reardon’s research group blends engineering analysis with proteomics and other experimental methods from microbiology and biochemistry to gain insights into biological systems.

a month, and can measure contaminant concentrations at even very low levels. The biosensors are a natural outgrowth of the use of bacteria and bacterial enzymes in bioremediation to consume and “digest” pollutants either in situ (in place) or ex situ (where contaminated material is removed and treated elsewhere).

“We also are developing bundles of fibers with multiple enzyme types that can detect a variety of chemicals at the same time,” says Reardon. “This is especially important when you are looking at sites with multiple contaminants in the environment.

“In addition to multiple contaminant detection and monitoring in groundwater, we are excited about other potential uses for the biosensors including in wastewater treatment plants and in rivers and large bodies of water, where ongoing monitoring would be useful. For example, if a fuel spill occurred in the Poudre River, and biosensors were in place along the river, the water treatment plant could get advance warning of contaminated influent and be ready to protect the municipal water supply.”

OptiEnz, founded in May 2010, is developing and expanding its line of biosensors and, notes Reardon, is soliciting joint development projects with future customers as well as developing additional research, manufacturing, and distribution partnerships. The company named a new president, Chris Thompson, in August and recently hired two new technicians. Reardon hopes OptiEnz will continue to grow to support the local economy, generate new jobs, and provide revenue to Colorado State University, as well as produce products that can help ensure a cleaner and healthier environment.
Predicting the Unpredictable: The Colorado River System

Spanning north to south across America, the Colorado River system is a lifeline for citizens from Wyoming to Mexico. As a major water supply, the system impacts the urban, agricultural, industrial, and recreational economies of much of the West.

Jose Salas, professor of civil engineering at Colorado State University, is also a recognized expert in the area of stochastic hydrology, a scientific approach that helps in forming water-related engineering decisions. Salas has recently been examining flow variability as well as past drought patterns of the Colorado River system, with the hope of helping officials improve the system’s management.

Working in collaboration with the U.S. Bureau of Reclamation, Salas and his research team are improving both the characterization of stream flows through the river system and long-term drought predictions using mathematical modeling of historical stream flows at 29 sites along the Colorado River. The stochastic stream flow modeling and simulations are aimed at estimating possible stream flow scenarios and drought episodes that may occur in the future in the Colorado River system.

Although stream flow records exist for the past 100 years on the Colorado River system, they cannot provide a complete picture of extreme droughts throughout the river system’s past. To solve this problem, Salas is working in conjunction with Connie Woodhouse, associate professor of geography and regional development at the University of Arizona, in analyzing the spacing between tree rings to reconstruct stream flows and drought severity that may have occurred in the past several hundred years. By analyzing past drought patterns, Salas and his team are able to make better predictions of what may occur in the years to come.

The work of Salas and colleagues provide a glance into the future of the Colorado River system and will hopefully serve to improve the current river management system and prepare administrators to cope with unforeseen drought episodes. “These models will tell us what the range of flows in the Colorado River may be in the next 25 years,” says Salas. “However, the models are calibrated based on history and need to be updated from time to time as the climate changes and new information is obtained.”

Salas and his research team, in collaboration with the U.S. Bureau of Reclamation, have also developed the sophisticated stochastic analysis, modeling and simulation, or SAMS, software for the statistical characterization and long-term stream flow prediction of complex river systems. SAMS software involves many alternative models that illustrate short- and long-term stream flow variability, as well as the effects of abrupt changes in climate. SAMS software may be applied to simulate possible hydrologic scenarios that may occur in large-scale river systems. For example, SAMS has been utilized for simulating the net basin supplies of the Great Lakes system, the flows of the Nile River, the Colorado River system, the Poudre River, the Niger River, and many more. The program allows researchers to simulate the possible stream flow sequences that may occur in river systems and provides foresight to water managers in preparing for unforeseen flow scenarios.

“Hopefully, our approaches and our efforts not only will have a significant impact on local, regional, and state water management but also will help to improve systems at national and international levels.”

Jose “Pepe” Salas received his B.S. in civil engineering from the National University of Engineering of Lima, Peru. After completing his M.S. and Ph.D. at CSU, Salas taught in numerous several countries before returning to Colorado State as a professor of civil engineering.

The Colorado River System is not only a lifeline for citizens from Wyoming to Mexico but also a significant source of water for much of the West. Jose Salas, a recognized expert in stochastic hydrology, is working with the U.S. Bureau of Reclamation to improve the characterization of stream flows and long-term drought predictions using mathematical modeling. By analyzing past drought patterns, Salas and his team aim to estimate possible future scenarios and help improve the management of the Colorado River system.

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The Engines and Energy Conversion Laboratory was ranked sixth on the list of 30 Awesome College Labs with “amazing, hands-on programs that are almost too much fun for credit.” The lab was listed as a place for mechanical and chemical engineers to learn to “make a 2,300 hp engine stronger and cleaner.”

This latest recognition is part of a long and growing list for one of the nation’s premier energy laboratories. The lab is acknowledged as a world leader in developing large-scale solutions to global energy problems, with particular emphasis on engine technology, smart electric grids, advanced biofuels, and energy technology for the developing world.

The Engines and Energy Conversion Laboratory is a shining example of our faculty incorporating cutting-edge research into academic excellence. Interdisciplinary research – from chemistry to liberal arts – is not only encouraged at the lab, but embraced.

Bill Farland, Vice President for Research at Colorado State
Every year, 8 gigatons of carbon (8 billion tons) are released into the Earth’s atmosphere through natural combustion of coal, oil, and gas. This number is well established in the scientific community and supported by documentation and regulation of carbon emissions as well as monitoring of natural sources and carbon storage sinks. What is in question is what happens to all 8 billion tons of that carbon. Scientists have general consensus on the amount absorbed by the oceans, plant life, and soil, but a good proportion of atmospheric carbon simply disappears.

Where does all the carbon go? It’s a mystery of global proportions and, if ever solved, could dramatically impact the development of new tools that might help slow global climate change, as well as help regulate changes to the Earth’s biosphere due to ever-increasing levels of carbon in the environment.

BioCycle is a research group within the Department of Atmospheric Science dedicated to the investigation of the global carbon cycle. One of the fundamental questions driving their work is the identity of this “missing sink” of anthropogenic carbon dioxide (the primary form of carbon in the Earth’s atmosphere).

“About half of the carbon dioxide is released by industrial activities every year,” says Scott Denning, professor in the Department of Atmospheric Science and lead investigator with BioCycle. “We’re missing about 2 gigatons of carbon every year and right now don’t completely understand where it’s going. That amounts to about $200 billion per year in avoided emissions – fundamental changes in the global biosphere that are poorly understood.”

What might be taking up the missing carbon dioxide? Denning notes four possibilities. First, plants are taking in the extra CO₂ and are “bulking up.” But as more plants grow, more decompose every year too. Second is nitrogen fertilization, third is land use (reforestation of previously deforested land), and fourth is changes in plant life as a result of climate change – with longer growing seasons come more woody shrubs (which take up proportionately more CO₂).

“Of those, the last three will eventually end, and almost all of them will turn on us at some point,” says Denning. “Any way you look at it, it doesn’t turn out so well.”

To better understand the global carbon cycle and where the carbon is disappearing to, Denning’s research group is using measurements of CO₂ from around the world to map out carbon and produce a data set that shows the “breathing of the Earth and the heartbeat of the biosphere.”

These measurements will help the group develop detailed maps that chart the path of carbon through the Earth’s atmosphere, determine carbon sinks and carbon sources, and develop a better understanding of how the carbon cycle may impact climate change and, conversely, how climate change may impact the carbon cycle.

“Our measurements will enable us to properly map and model processes and explain them, as well as use those models to predict what actions we might be able to take that will make a difference to the future climate of our planet,” says Denning.

Denning’s research is supported by NASA, and he is a co-principal investigator with the National Science Founda-
We’re missing about 2 gigatons of carbon every year and right now don’t have a good lead on where it’s going.

Scott Denning received a B.A. in geological sciences from the University of Maine in 1984 and M.S. and Ph.D. degrees in atmospheric science from Colorado State University in 1993 and 1994. He joined the atmospheric science faculty at Colorado State University in 1998. Denning enjoys hiking and stargazing and lives in Fort Collins with his wife, two teenage boys, a Labrador retriever, two cats, and a lizard named Winston.
One tablespoon of chlorinated solvents – like that used by dry cleaners and industry – can contaminate an Olympic-sized swimming pool full of drinking water beyond drinking water standards. Unfortunately, spills and leaks of chlorinated solvents associated with past industrial practices have caused widespread contamination of groundwater. The result? Complicated dispersal and plume patterns, persistence in the subsurface, and difficult cleanups. ZVI-Clay Soil Mixing, a venture of the Center for Contaminant Hydrology based in the Department of Civil and Environmental Engineering, is taking a new approach to decontaminating chlorinated solvent sites and seeing success in the application of its technology.

“Nobody really knows how many sites are out there,” says Tom Sale, associate professor in the Department of Civil and Environmental Engineering and director of CCH. “It’s easily in the tens of thousands of sites in the United States alone.”

Chlorinated solvents include a large family of chlorine-containing organic compounds used for a wide variety of commercial and industrial purposes, feedstock for plastics, degreasers, and dry cleaning. Concerns about chlorinated solvent contamination – which can have significant toxicity to plants and animals, including humans – began to surface in the 1950s. Unfortunately, clean-up efforts have been expensive and often ineffective. Sale states that given high costs and limited progress, chlorinated solvents are not only an environmental challenge; they also pose large economic burdens for government, industry, and society as a whole.
In 2003, DuPont and Colorado State University initiated a collaborative research initiative focused on developing better solutions for chlorinated solvents and other contaminants. Principal investigators on the project at CSU are Sale and Charles Shackelford, professor in the Department of Civil and Environmental Engineering. The initial focus was development of a promising new technology referred to as ZVI-Clay.

ZVI-Clay involves using heavy construction equipment to mix iron filings and clay with soils containing high concentrations of chlorinated solvents. The iron filings, referred to as zero valent iron, or ZVI, are a common waste product from automotive and other machining operations. Oxidation of the iron in the ground reduces chlorine in toxic compounds to nontoxic chloride – what we have in table salt, notes Sale. At a typical chlorinated solvent source zone, conventional soil mixing equipment is used to add and mix the iron filings and clay into soil columns that can go down to bedrock. The number and size of the columns depends on the size of the contaminated site. The mixing homogenizes the soil and brings all contaminants into close contact with the iron particles. The clay minimizes the hydraulic conductivity of the mixed soil body, isolating it from groundwater flow. The closed system allows for a reductive dechlorination process to progress, decreasing the amount of contaminant discharged from the treated zone and reducing the inflow of competing oxidants that may consume iron.

DuPont’s contribution for ZVI-Clay has included the donation of two related patents to the Colorado State University Research Foundation, nearly $500,000 in research funding, and access to DuPont’s technical and commercial resources. CSU contributions have included 20,000 hours of research effort from students, staff, and faculty members. Working with partners in industry and Colorado State University, ZVI-Clay Soil Mix has been used in 10 field applications including U.S. Department of Defense sites, former dry cleaners, and industrial facilities. Three additional projects are planned for 2011, along with five active laboratory studies. The technology has been used to clean 80 tons of chlorinated solvents (enough to contaminate all potable water in Colorado for 20 years) in 50,000 cubic yards of soil and generated $1.5 million in research revenues for Colorado State University and $250,000 in patent royalties. The initiative has led to $10 million in engineering projects.

“Through ties with industry, we are advancing our academic programs, training the next generation of engineers and scientists, creating a cleaner environment, managing social costs, and driving economic activity at local, state and national levels,” says Sale. ZVI-Clay Soil Mix, notes Sale, is successful to date because of robust partnerships within Colorado State University and industry. Early adopters of the ZVI-Clay technology include CH2M Hill and ARCADIS. Partners include GeoSolutions, USA Environment, AECOM, Adventus, TetraTech, GSI Environmental, Golder and Associates, and URS.
Colorado State University is involved in a partnership that is revolutionizing the production of biofuels. The National Alliance for Advanced Biofuels and Bio-products is a $49 million consortium of national laboratories, industry, and research institutions awarded by the U.S. Department of Energy to commercialize algae into a biofuel. The funding is part of the American Recovery and Reinvestment Act; DOE Secretary Steve Chu announced the award in January 2010.

Anthony Marchese, Kenneth Reardon, and Shawn Archibeque are leading the NAABB effort at CSU. Solix Biofuels Inc., an alternative energy technology company that spun off from Colorado State University’s Engines and Energy Conversion Laboratory, is also part of the consortium.

In addition to the NAABB effort, Marchese and Azer Yalin are working on a separate study on pollution formation from algae-derived biofuel combustion. In fall 2009, the team received a $325,000 National Science Foundation grant to conduct one of the first studies on the emissions produced from algae-derived biofuels.

Algae-derived biofuels have the potential to be a high-yield, efficiently produced, renewable fuel that will not compete with the global food supply. Companies such as Solix are ramping up production of renewable biofuels to help mitigate greenhouse gas emissions and reduce the United States’ dependence on imported oil. New environmental impact studies are underway to ensure that these new biofuels can be engineered so they improve not only the environment but also the health of the world’s citizens.

Scientists know that combustion of biofuels in an engine can increase the quantity and variety of pollutants released, depending on the type of biofuel used. However, little is known about the health effects associated with either diesel or biofuels.

“It’s hoped that we may produce up to 20 billion gallons of algae-based fuel annually in the United States within the next 20 years,” says Marchese. “We currently burn 70 billion gallons of petroleum diesel in the United States, but we still don’t understand much about the production of diesel particulate matter and its adverse health effects. So, now is the time to look at pollutant emissions from algae-based biodiesel and see if there is any danger from a health standpoint.”

Marchese is assembling chemical kinetic models for algae-derived fatty acid methyl esters, or FAME, and renewable diesel. These fuels will be derived from algal biocrude being developed by Solix Biofuels and other entities within the NAABB consortium. The long-range goal is to use the combustion and pollutant formation studies to tailor the production of algae to produce a low-polluting, algae-based biofuel.

The chemical structure of fuels derived from microalgal strains can be quite different from that of terrestrial plants such as soy, canola, and rapeseed. NOx and soot formation from biodiesel is linked to the chemical structure of the triglycerides present in the feedstock. The algal lipids include components with...
carbon chain lengths ranging from 10 to 24 carbon atoms, and the lipid profile can vary with species. In addition, growth, extraction, and processing techniques have an impact on fuel properties. These properties could have significant implications for fuel processing and subsequent utilization, including exhaust emissions and associated health effects.

Yalin is using laser tools to study nitric oxide along with other chemical species that are important in these combustion environments. “You need nonintrusive measurements to study the combustion while it’s happening without perturbing it with probes,” explains Yalin. “The studies will give us experimental images and maps of the different concentrations of various molecules. Combining these results with modeling will shed new light on the combustion.” To do this, they pass a laser through the flame and measure the NO that is produced in that flame around the igniting droplet. The current project is building on the laser ignition diagnostic research that Yalin is conducting at the Engines and Energy Conversion Laboratory at Colorado State.

The mechanical engineering faculty members are collaborating with Jeff Collett in CSU’s atmospheric science department and John Volckens in environmental and radiological health sciences. Current graduate students Tim Vaughn and Torben Grumstrup are focusing on the engine exhaust studies, while Dave McKenna and Brie Hawley investigate the health effects from the engine emissions. Former graduate student Bethany Fisher is now a residential buildings engineer at the Electricity, Resources, and Building Systems Integration Center at NREL. Her earlier involvement with this project enabled them to design the engine so that the tests could be performed with only a couple of liters of fuel.

“We are the first research group to actually burn these fuels in an engine,” says Marchese, “and this is the first NSF-funded study of fundamental combustion chemistry of algae-based biofuels.”

Algae-based biofuels have the potential to mitigate global warming by reducing emissions of heat-trapping gases.

Anthony Marchese is an associate professor of mechanical engineering at Colorado State and a principal investigator at CSU’s Engines and Energy Conversion Laboratory. He holds a Ph.D. and M.A. in mechanical and aerospace engineering from Princeton University and B.S. and M.S. degrees from Rensselaer Polytechnic Institute. In 2001, he was named a Carnegie Scholar by the Carnegie Foundation for the Advancement of Teaching, and in 2004, he was awarded the ASEE Kauffman Outstanding Entrepreneurship Educator Award. He was born and raised in New Jersey and, in 2008, moved to Fort Collins, where he resides with his wife and two sons. In his spare time, he enjoys climbing 14ers and playing soccer and baseball.
Mechanical Engineering Students
LEED the Way at Engineering II

The George H. Glover Building is definitely not an example of a green building. It was built in pre-LEED 1950 as home to the Veterinary Teaching Hospital. In 1984, the newly renovated building was reopened as space for the College of Engineering. But today, energy inefficiency notwithstanding, the Glover Building is helping mechanical engineering students understand how to better design environmentally sustainable structures, including the new Engineering II Building.

Allison Martz, Ryan Slinger, Kevin Cooper, and Andrew Nagle, all mechanical engineering undergraduate students, comprise the senior design team working on Leadership in Energy and Environmental Design, or LEED, certification for Engineering II, which broke ground this spring. Using the Unit Operations Laboratory in the Glover Building as their “green return-on-investment” laboratory, the team set up sensor units to gauge energy usage in the laboratory. This baseline energy study will help determine the effectiveness of LEED components when the laboratory makes its move to Engineering II (completion estimated for June 2013).

“Our first task was to gain a greater understanding of LEED certification and the different requirements of each LEED certification level,” says team member Allison Martz who, after graduation, would like to work with an architectural firm and learn to be a project manager. “We’ve also been working on our sensor technology, meeting with the professional team, and gathering and organizing our data.”

A large part of their capstone project has been to design and deploy sensor units and then gather and analyze data to understand and quantify patterns of energy usage. In addition to the Unit Operations Laboratory, the students are monitoring and collecting data from one of the engineering computer laboratories. Professor Emeritus Gerry Johnson, from the Department of Mechanical Engineering, is faculty adviser on the project.

“Dr. Johnson had in his possession little black sensor boxes that we could use, with some redesign, to record temperature, humidity, electrical plug load, lighting load, and energy usage through the HVAC system,” says team member Ryan Slinger.

“As a longer-term project, once the new building opens, a new senior design team will be able to determine the energy savings from the new lab locations and use that data to develop recommendations for green technologies that can deliver the most savings for the dollar. Laboratories typically have a greater demand on energy systems, so we expect savings to be substantial.”

In the United States, buildings account for 36 percent of total energy use, 65 percent of electrical consumption, 30 percent of greenhouse gas emissions, 30 percent of raw materials use, 30 percent of waste output, and 12 percent of potable water consumption (U.S. Green Building Council). LEED certification takes sustainability into account from project concept to completion, delivering an energy ROI from the foundation up.

I get to see how much energy green buildings truly use instead of what they are simply rated to use. This LEED project gives me the ability to evaluate what actually happens to operational mechanical systems, instead of what I read off a piece of paper.

Kevin Cooper (shown above right in blue) is a senior mechanical engineering student. He interned for Bechtel Corporation twice, and chose his senior design project because of this experience and his interest in HVAC. Kevin is an American Society of Mechanical Engineers member, Pi Tau Sigma honor society member, CSUnity volunteer, and he plays intramural soccer and volleyball.
“The challenge for this senior design team was to create a data gathering system and then be able to analyze that data to provide recommendations that will most significantly impact sustainable construction and building operation,” says Johnson. “Working with the professional design team on an active construction project, rather than a simulation, gives them the added benefit of real-world experience in LEED design and certification.”

LEED buildings have a long list of requirements, ranked in a point system. For example, projects gain points for low-flow plumbing, run-off reduction, renewable energy usage, construction material recycling, and much more. A greater number of points leads to higher certification from the basic level of certified, to silver, to gold, and to the highest level of certification, platinum.

The United States Green Building Council’s list of benefits from implementing a LEED strategy includes improving air and water quality, reducing solid waste, conserving energy, reducing energy costs, optimizing the use of potable water, creating healthier indoor environments, and more. The College of Engineering would like Engineering II to be the first building on campus to achieve a LEED platinum certification, but achieving this goal may require more funding than is currently available.

The LEED senior design team presented their project to the Engineering II professional design team in April after the project showcases at the annual Engineering Days celebration on April 15. In addition, each of the team members hopes to take the LEED Green Associate certification test which has, as one requirement, experience on a LEED project within the last three years.

Additional Engineering II Design Projects

Engineering II: Alternative Energy Study
*Team Members:* Alyssa Wagner, Scott Bednarik, Zachary Jannasch, Jason Lau, and Ahmed Abdelsalam

In this project, team members are exploring alternative ways to provide energy to the Engineering II Building. Technologies they are investigating include rooftop photovoltaic panels and transpired solar collectors. The team, says team leader Alyssa Wagner, who is majoring in civil engineering, is developing a multi-criteria decision model to determine the best alternative energy options for the building. As a part of their research, last fall they visited the National Renewable Energy Laboratory in Golden.

Engineering II: Water Reuse and Conservation
*Team Members:* Kat Adams, Kelly Bergdolt, Fares Alqahtani, Dustin North, and Brian Auer

In this project, team members are investigating water reuse and conservation including the development of a bioswale and the use of graywater. A bioswale is a shallow pond that collects rainwater and irrigation runoff and uses plants to filter pollution naturally. In the first semester, the team completed an overview of water reuse and conservation technologies, as well as a cost analysis, and developed implementation ideas. Kat Adams, civil engineering student and team leader, says they will meet with the Engineering II professional team to share their findings, some of which may be incorporated into the overall design of the building’s exterior and interior.

Engineering II Highlights

Budget: $69 million (current resources $56 million)

Building: Three-story, 122,000-square-foot academic and research facility

Schedule: Construction began April 2011 with planned completion in June 2013

Features include:
- Design studios for engineering instruction.
- Student Success Center.
- Teaching/research laboratories organized in “pods” based on research topics.
- Smaller classrooms for classes of 15 to 50 students.
- 150-seat lecture hall.
- Office space for faculty members, staff, and graduate students.
- A 24-hour study area within the three-story atrium.

www.engr.colostate.edu
You have been dean of the College of Engineering since July 1, 2005, and have recently been reappointed to another five-year term. What were your goals for the College when you were appointed in 2005?

My original goal was to help the college by developing a culture that values collaborations and supports interdisciplinary work across the College, among colleges, and across institutional boundaries. As a result, a mission and vision has emerged that accurately describes our college. We do important work that has global impact and do so in a purposeful way.

Do you feel you have reached your goal, and if so, how did you accomplish this?

I feel as though we have come a long way, but when your goal focuses on the culture of a complex college with hundreds of faculty and staff and thousands of students, you are never done.

Nevertheless, I think we have made extraordinary progress. We established a very strong leadership team with shared values. We have hired really great people and focused our hires on individuals whose interests cross disciplinary boundaries and value working together on important problems.

What changes have you seen in the College during the last five years?

I think we’ve seen dramatic changes in key metrics used to measure progress. We’ve seen substantial increases in enrollments, quality, and diversity of students at both the undergraduate and graduate levels. During the past five years, undergraduate enrollments have increased 27.1 percent, and graduate enrollments have increased 9.2 percent. We’ve seen an expansion of our research program, with many large, new interdisciplinary projects.

Let’s talk about undergraduate programs first. What has happened there?

At the undergraduate level, we created new majors and expanded existing degree programs:

- In 2009, we gained accreditation for a new degree in chemical and biological engineering, which replaced our existing chemical engineering degree. Students who graduate from this program meet the accreditation requirements for both the chemical engineering and biological engineering disciplines.
- This year, we created a new dual degree in biomedical engineering. This five-year program results in two baccalaureate degrees. The first degree is in a fundamental
engineering discipline such as mechanical engineering, electrical engineering, or chemical and biological engineering. The second degree is in biomedical engineering. We have worked closely with industry to develop this dual degree structure and feel our students will be very competitive in the marketplace upon graduation. This is the first program of its kind in the state of Colorado and one of very few in this region.

We have seen a dramatic enrollment increase in the last five years. The number of new freshmen we recruit each year has nearly doubled. Along with this dramatic increase in the size of our freshman class, the academic quality of our incoming freshmen has continued to rise and is the highest in our college’s history. Additionally, we have recruited a more diverse student body. While our overall undergraduate enrollments have increased by 27.1 percent, the number of women in our undergraduate programs has increased by 38.2 percent, and the number of minority undergraduate students has increased by 64.7 percent.

What were your goals for graduate education?

Graduate education is closely tied to research and the vital role of universities in creating new knowledge, disseminating that knowledge, and making significant societal contributions by solving important problems. In the last five years, we have created two new programs at the graduate level:

• We created a School of Biomedical Engineering with faculty in the Colleges of Natural Sciences, Applied Human Sciences, and Veterinary Medicine and Biomedical Sciences. The SBME faculty developed new interdisciplinary M.S. and Ph.D. programs in bioengineering in 2007.

• We have added several graduate programs in systems engineering. This includes a course work-based Master of Engineering degree. Students have the opportunity to complete that program through regular campus instruction or through distance education. In 2010, we added new research-based M.S. and Ph.D. programs in systems engineering focusing on energy systems.

Our research program has grown substantially since 2005. We have secured several large grants such as a new $64 million cooperative agreement with NOAA to support our Cooperative Institute for Research in the Atmosphere. We won a new National Science Foundation Science and Technology Center that focuses on the modeling of clouds and climate (our Center for Multi-Scale Modeling of Atmospheric Processes). We renewed both of our NSF Engineering Research Centers: our Center for Extreme Ultraviolet Science and Technology and our Center for Collaborative Adaptive Sensing of the Atmosphere. Our EUV center explores the development of compact coherent extreme ultraviolet sources and their applications in challenging scientific and technological problems. Our CASA center focuses on creating new ways to observe, detect, and predict atmospheric phenomena such as severe storms and tornadoes (see Page 6).

I am particularly proud of our faculty and their ability to secure very competitive federal funding. Frankly, they are among the best faculty in the nation and work exceptionally hard to secure contracts and grants that support
both graduate and undergraduate students and address important problems. When federal research funding is normalized to the number of faculty in the College, CSU’s College of Engineering faculty members perform at a level that is consistent with some of best colleges of engineering in the United States.

I understand that CSU is constructing a new engineering building. Given our financial climate, how was CSU able to accomplish this goal?

In 2008, the University’s budget included payments for a bond that would construct a new engineering building. As a result of the economic climate, the University removed that line item from CSU’s budget, and the project was postponed indefinitely.

We were very fortunate that one of our alumni, Don Law, and his wife, Susie, recognized the importance of this facility to the University and to our students and faculty. They made a substantial gift that allowed us to begin design.

During the 2009-2010 academic year, students voted to increase their facility fee by $5 per credit, or about $150 per year. This allowed the University to issue bonds to complete several projects. The students allocated $30 million for Engineering II. I could not be more proud of our engineering students and the work that they did to help secure this funding, and I am grateful that the CSU students as a whole recognized the importance of new facilities for the quality of programs.

The University and College agreed to bond an additional $10 million, which we will repay from indirect costs recovered from our research program. The Board of Governors of the Colorado State University System approved these bonds in June 2010. At the end of Summer 2010, we had secured $40 million toward a goal of $69 million.

The University added $2 million, and we are very fortunate in that we have been able to secure additional gifts.
Development Funding by Fiscal Year

![Graph showing annual funding growth](image)

from alumni, foundations, and in-kind services from engineering firms. In the last nine months, we have leveraged the initial $30 million commitment from our students and increased the funding for the building to about $56 million. We honored these amazing donors at our official ground breaking on April 14.

We hope to secure the remaining funding needed to complete Engineering II during the next 18 months and look forward to occupying the building in July 2013.

Dean Sandra Woods Honored With General Palmer Award

The American Council of Engineering Companies of Colorado has honored Sandra Woods, dean of engineering at Colorado State University, with the 2011 General Palmer Award for her significant contributions to Colorado engineering. Woods is one of about 40 female deans in engineering colleges across the country. The General Palmer Award is given to an engineer for significant contributions in Colorado, as well as for accomplishments that have advanced the engineering community and made an impact on future generations.

At Colorado State, Woods has focused on making the College of Engineering more collaborative and building interdisciplinary programs in biomedical and systems engineering. Her leadership in the College has focused on greater interdisciplinary cooperation – within the College and across campus – and created a strategic focus on research programs that have global impact and affect quality of life.

Given your reappointment as dean, what are your goals for the next five years?

Clearly, the last few years have been among the most challenging for universities across the country and for our college. Although we have had substantial budget reductions that have resulted in a smaller faculty and fewer staff, we will emerge from this economic downturn as a stronger college. In the last five years, our college has experienced tremendous growth; we have hired extraordinary faculty; and we have launched the largest building project in CSU’s history. We have been able to accomplish our goals because of the help and support of great people – both within CSU but also from friends and alumni who care deeply about the College of Engineering and our students.

During the next five years, and as budgets recover, we will build the faculty and programs in new areas that address important societal needs. We will continue to add degree programs, both on campus and at a distance. If we continue along this trajectory, the rest will take care of itself.

Engineering II will allow us to recruit and retain the very best faculty, staff, and students. It is critical for the continued growth of our research programs and will provide much needed space for our growing student body and academic programs. We hope that you will consider making a gift to support this important project.

For information on giving to Engineering II, contact the Development Office at (970) 491-7028 or supportengineering@colostate.edu.
1930-1939
Frank J. and Hazel B. Gray

1940-1949
Frank M. and Astrid L. Brown
Gustavus W. and Lucille B. Center
Jack E. Cermak and Gloria E. Garza
Allen C. Gates
Wilbur E. Ingalbe
Vincent D. and Dolores Leone
Bruce A. and Velma L. Peterson
Melda W. Raleigh
Everett V. and Billie K. Richardson
Duward L. Vernon
Leonard P., Jr.* and Betty J. Zick

1950-1959
Robert L. Aspinwall
Terry L. and Katherine K. Bell
Robert J. and Linda L. Bertorello
Mary Lou K. Black
Ted R., and Mary L. Blevins
Edward A. and Beth K. Cecil
Eugene C. and Donna G. Diedrich
Elaine C. (Carlson) and Donald W. Dobler
Edward N. and Nan R. Earle
Max L. and Patricia H. Goracke
Marilyn Green
Raymond L. Gump
Clifford A. and Irene E. Hoelzer
Orval E. and Pauline A. Jones
William P. King
Keith P. Lautenbach
H. Edward and Marjorie P. Lecuyer
Robert C. and Joann J. Lehman
H. D. (Buzz) and Ann E. Bruner

1960-1969
Calvin H. and Carolyn S. Agatsuma
Steven A. Atkinson
N. Kent and Mary E. Baker
Jerald W. Bisterfeld
Charles W. and Shirley M. Boning
H. D. (Buzz) and Ann E. Bruner
Norman S. Burnette
Shawn Z. Chowdhury
Chris J. and Georgia J. Christopher
Jeri A. Danielson
Burton L. and Sylvia K. Darmour
Glenn E. and Carolee DeWitt
David J. and Ruth M. Dingman
Calvin H. and Carol A. Eldredge
Russell L. and Linda L. Elsberry
Norman A. and Jean C. Evans
Philip T. Gibson
Harry L. and Merlene E. Goff
Walter K. and Susan R. Green
Neil S. and Margaret B. Grigg
Robert S. and Carleen B. Grossman
Roger C. Hedlund
Duane D. Helton
Paul F. and Dolores J. Holley
James W. Hunt
Charles W. and Kaloma K. Huntley
Thomas L. and Patty L. Huntzinger
William A. and Jean G. Hurt
Marvin E. and Doris A.* Jensen
Donald W. Killmore
Donald F. and Judy A. Kuntz
Allen F. and Patricia L.* Lewis
Stephen R. and Carolyn M. Light
Walter L. and Eileen E. Long
Joseph P. and Carolyn F. (Norris) Mathis
Edwin C. and Kay (Short) McDowell
James A. and Marilyn Michaud
Russell D. and Sandra L. Mowrer
Stanley R. and Janice E. Nau
Thomas E. Norton
Delbert G. Oliver
Bill and Becky Parryboek
Jayant P. and Pushpa J. Patel
Jon A. and Pamela J. Peterka
Roger R. and Leslie G. Piscitella
David L. and Nancy J. Potak
David S. Renne
Alan J. and LeAnn F. Richards
Charles R. Ries
Larry A. and Kathleen A. Roebner
Sigel L. and Beverly T. Ross
John W. and Pamela J. Sample
Robert K. and Nancy J. Scott
Donald C. and Caroline F. Signor
Harold D. Simpson
M. Dean and Judith A. Skalla
Jerry L. Sparks
Paul S. and Margaret A. Stephens
Paul and Arianthe C. Stettner
George O. and Sharyl J. Thomas
Y. G. and Judy Tuei
Dennis K. and Carla J. Wacker
Margaret R. Weiss
Thomas G. and Pamela J. Wills
Sharon L. Wilson
Glen C. and Janice A. Young

1970-1979
Steven R. and Phyllis J. Abt
Robert E. Adler
Barth H. Amend
Ronald L. and Shahid A. Arlian
Melvin R. Baer
Terry J. Barber and Sandie A. Winslow-Barber
C. Bruce Barbre
Joe A. and Carol D. Baxter
John R. and Brenda Beattie
John C. and Betty L. Becker
Charles W. Binder
James E. and Kathryn R. Blakeley
Kenneth L. Bolin
John W. Briggs
Rohn A. Brown and Kathryn Ried
Harley J. Bryant and Lauren Sufian
Joel W. and Linda Buck
Robert L. and Anne L. Cardenas
Douglas B. Chapman
Harold L. and Florence E. Cole
Paul R. and Catherine A. Dawson
William J. J., and Bonny Day
Ceri B. Dean
Gregory R. Enders
Donald F. Fagerstone
James A. and Linda B. Ferentchak
Phillip M. and Laura M. Finsterwald
Barney J. and Audrey M. Fix
David A. Frazier
Gary P. and Susan A. Ganong
Richard L. and Julie G. George
Paul T. and Karen M. Gilbert
Jerry A. and Pamela M. Gomez
James E. Graf
Benjamin C. Hablutzell
David V. and Mona Harmann
Gary A. Hayes
Shannon L. and Judith L. Hebb
David D. Hedstrom
Paul A. and Claudia L. Hindman
Keith D. and Helen I. Helfenstein
Frederic M. Hulett, III and Dianne M. Fishwild
Huakuo K. and Rebelkaw Hwang
Norman B. and Kristel L. Jansen
Robert D. Jarrett
Keith C. Kepler
Ronald K. and Judith E. Kerschner
Donald W. and Sue E. Kimball
Charles F. and Kathleen R. Kovac
Stuart C. and Edith C. Kramer
Wayne C. Kuse
Edward A. and Judy Lasnik
George T., II and Donna J. Laughlin
Steven P. Lautenschlager
Daniel L. and Renee R. Law
Donald J. and Susan C. (Gathers) Law
Jim C. Loftis and Judith A. Billica
Donald W. and Sue E. Kimball
Charles F. and Kathleen R. Kovac
Stuart C. and Edith C. Kramer
Wayne C. Kuse
Edward A. and Judy Lasnik
George T., II and Donna J. Laughlin
Steven P. Lautenschlager
Daniel L. and Renee R. Law
Donald J. and Susan C. (Gathers) Law
Jim C. Loftis and Judith A. Billica
Glen R. and Jean Longhurst
Scott S. Lynn
Roland A. and Mary A. Madden
Robert A. Maddox
Gary R. and Ellen M. Mader
Stephen J. Malyszko and Nancy A. Lange
Frederick L. and Sheliah C. Mann
Steven L. and B. Ann McCabe
Thomas B. and Lee H. McKee
Charles A. McKnight
James W. Mehring
David W. Morse
Philip M. and Kathryn R. Myers
Rodney A. Nielsen
James Russ Noblett
John E. and Linda K. Nydahl
James E. and Judith D. Pankonin
Dennis L. and Mary E. Peery
Greg G. and Patricia L. Peters
Ralph R. and Susan K. Peters
Richard D. and Caroline E. Pilgrim
Charles D. and Debra K. Pitman
Leslie W. Pittman
Robert L. and Debbi L. Powell
Douglas S. and Janet B. Reese
Robert K. Reich
J. Owen and Rosemary K. Rhea
Eugene J. Riordan
Ronald E. and Harriette M. Roadman
Dean C. and Patricia A. Rovang
Matthew S. and Susan H. Sakurada
Henry S. Santeford, Jr.
Michael C. Schleifer
Delbert E. and Marie J. Seaver
Axel O. and Myrlyne C. Sjogren
Loren E. and Deborah Snyder
George R. and Patricia V. Stoll
Gary K. and Gretchen L. Sutherland
Gregg S. Ten Eyck
Fred D. and Margaret Theurer
Robert W. and Jean Thresher
Albert C. and Marilyn S. Tuck
Samuel E. and Sharon L. VanZant
Jonathan H., IV and Jane A. Votel
Joseph S. Waterfield
Yaupon and Hsiu-Chen L. Wang
Eric R. and Dawn S. West
Sarah K. Wiant
F. C. and Rebecca E. Williams
Thomas W. Williams and Candace Merrill-Williams
Carla J. Worley
Raymond M. Zehr

1980-1989

Thomas J. and Kristina M. Abele
Thomas L. and Melissa S. Acker
Robert F. Anders
Russell M. and Dana S. Arakaki
Thomas C. Arndt
Gregory F. Ash and Susan E. Ash
Steven G. Baggs and Diana V. Paglia-Baggs
Gary S. and Lynn M. Barbary
Timothy A. Bartholome
Kevin H. and Leslie A. Blackman
Terry A. Bowl and Julie T. Bow
Aaron G. and Barbara K. Bren
John D. Byers
Gwendolyn A. Cadieux
Douglas E., Jr. and Caroline E. Carlile
Daniel B. and Pamela T. Carr
John C. Chapman
Ho-Chen and Kathy H. Chien
Michael P. and Whitney A. Clouthier
Peggy K. Coleman
M. Andrew and Kimberly H. (Hull) Crouch
Paul C. and Cheryl Currier
Henry H. Curtis, III
Kacey Cutler
Robert J. Dellicker
Stephen T. Dempsey
Richard J. and Michelle H. Detry
Charles J. Duey
Robert T. Edison and Jungsook Kim
Dean E. and Maria Eisenhauer
Omnia I. El Hakim
Riad H. Eljaia and Khierieh Lutfi
Dennis M. Elliott
Lawrence R. and Deborah A. Ellis
Kathy B. Emerson
Allen D. Emter
Gregory J. and Mary C. Esterl
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For information, please contact Mac McGoldrick at Mac.McGoldrick@colostate.edu.

2010 College of Engineering Alumni Award Winners

Each year, the College of Engineering recognizes former students whose career, service and/or volunteer efforts have brought honor to the individual, the College, and Colorado State University.

College of Engineering Award:
Stephen R. Light (’68, B.S.)
President and Chief Executive Officer, Xerium Technologies Inc.
Light serves as president and CEO of Xerium Technologies Inc., a global manufacturer of clothing and roll covers used primarily in the paper production process. Prior to this, Mr. Light completed the successful turnaround of Flow International Corp., the largest producer of industrial waterjet cutting and cleaning equipment. In management positions at General Electric, he was on the startup team for the computerized axial tomography (CAT scanner) business, the standard of diagnostic medical imaging. Mr. Light was invited to ring the closing bell at the New York Stock Exchange in 2009 and the NASDAQ Exchange in 2005.

Atmospheric Science:
Roland A. Madden (’78, Ph.D.)
Senior Research Scientist, National Center for Atmospheric Research
Madden is a senior research scientist at the National Center for Atmospheric Research in Boulder, Colo. Madden is a co-discoverer of the Madden-Julian Oscillation, a 30- to 50-day seesaw of easterly winds and pressure in the equatorial regions of the Indian and western Pacific oceans. The Madden-Julian Oscillation affects weather from eastern Africa to the central Pacific and may play a role in triggering El Niño episodes. Madden is well-known for his work in the field of tropical meteorology, long-range predictability, and large-scale traveling waves.

Civil and Environmental Engineering:
Narayanaswamy Krishnamurthi (’75, Ph.D.)
Co-Founder, Western Oil Sands
Krishnamurthi is a groundwater expert who specializes in the application of groundwater engineering to solve petroleum problems. He was an employee of Shell Oil Company and B.H.P. Billiton before co-founding Western Oil Sands. Headquartered in Calgary, Alberta, Western Oil Sands is a 20 percent partner in the Athabasca Oil Sands Project. With partners, the company mines and extracts recoverable bitumen reserves for upgrading into synthetic crude oil. Krishnamurthi retired in 2002.

Electrical and Computer Engineering:
Desi Rhoden (’83 B.S.; ’84, M.S.)
Executive Vice President, Montage Corporation
Rhoden is a veteran of the semiconductor industry, with more than 25 years’ experience in areas including memory and high-performance systems. He serves as executive vice president at Montage
Corporation, a Shanghai-based company focused on low-power/high-performance mixed-signal devices, including advanced memory buffers and DDR3 register buffers, as well as digital TV tuners, decoders, receivers, demodulators, and related DTV devices.

**Engineering Science:**
Kristin L. Wood ('85, B.S.)
Cullen Trust for Higher Education Endowed Professor, Mechanical Engineering, University of Texas at Austin

Wood is the Cullen Trust for Higher Education Endowed Professor in the Mechanical Systems division of Mechanical Engineering at The University of Texas at Austin. His research is in design theory and methodology, computer integrated engineering, design for manufacture (tolerance design and automation techniques), applied mechanics in the design of mechanical components and assemblies, and the design of micro-electromechanical systems.

**Mechanical Engineering:**
Charles F. Kovac ('79, B.S.)
Vice President and Group Executive, Wabtech Corporation

Kovac is vice president and group executive of Wabtech Corporation’s Freight Group. Wabtech is a leading supplier of highly engineered, value-added solutions for the freight, transit, and industrial transportation markets. Kovac has been with the company since 2007. From 2003 to 2007, Kovac was the vice president and general manager of AMETEK’s Global Household and Specialty Motors Division, a supplier of electric motors and air moving systems. In 2000, he co-founded the Teleios Group to pursue consulting and private equity projects. Prior to Teleios, Kovac spent 12 years with Woodward Governor Company.

**Graduate of the Last Decade Award:**
Jason T. Gentry ('00, B.S.)
Technical Lead, Avago Technologies

At Avago, Gentry is responsible for architecting the ASIC top-level floor planning methodologies and flows to be used by the worldwide ASIC design labs. He also co-led a team of engineers responsible for converting external customer’s RTL code to silicon. Gentry is considered the foremost expert in Tcl/Tk in worldwide Avago labs, and he advises script and algorithm solutions for the most difficult situations. He holds four patents and has been recognized for his design successes repeatedly by Avago.

For more information on the alumni awards program and a complete listing of past award winners, visit www.engr.colostate.edu, click on alumni/friends.