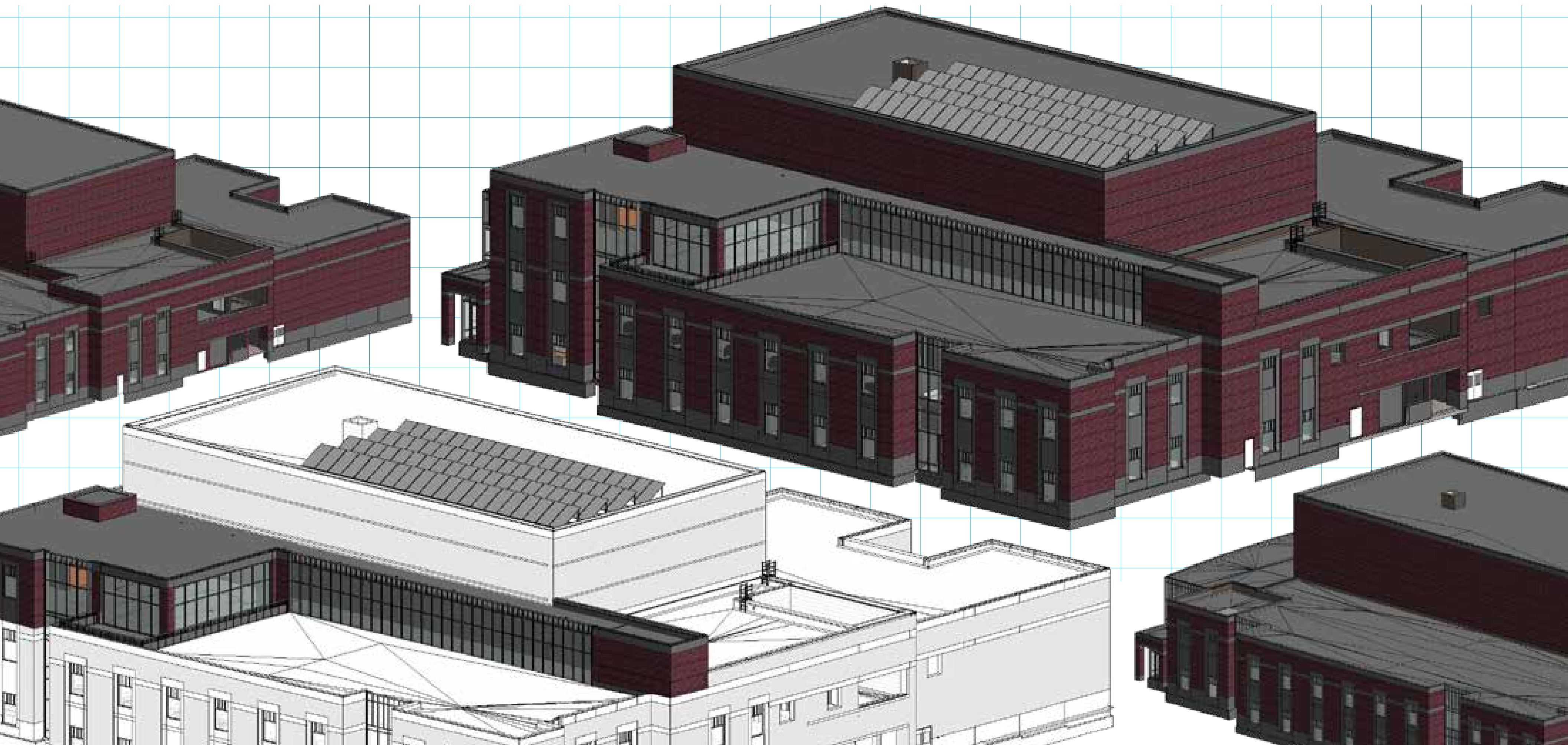
NCEES
advancing licensure for engineers and surveyors

2019 Engineering Education Award



2019
AWARD

Cover features renderings from the grand prize winner's model.

President's Message

NCEES celebrated its 11th year offering the Engineering Education Award in 2019. The award recognizes engineering programs that encourage collaboration between students and professional engineers (P.E.s). Advancing licensure for engineers is a top priority for NCEES, and the award program supports this by promoting understanding of the value of licensure and encouraging partnerships between the engineering profession and education.

The projects are a conduit for students to see first-hand how P.E.s safeguard the health, safety, and welfare of the public. Through these projects, lessons from the classroom can be applied to real-world issues, both domestic and international. This allows students to expand their knowledge of engineering principles and to work on skills like communication, teamwork, professional ethics, and social responsibility.

We at NCEES thank the students, faculty, and practitioners who participated in this year's competition. We applaud your efforts to connect professional practice and education and to inspire the next generation of professional engineers. We also thank the jury members for giving their time and expertise to evaluate each project and for continuing to support this initiative.

This book recognizes the 2019 winners, and our hope is that their projects will inspire other engineering programs to develop collaborative projects with licensed professional engineers.

Dean C. Ringle, P.E., P.S.
2019–20 NCEES President

ABOUT THE AWARD

The NCEES Engineering Education Award was established in 2009 to promote understanding of the value of licensure and to encourage collaboration between the engineering profession and education.

Academic programs accredited by EAC/ABET were invited to submit projects that demonstrate a meaningful partnership between professional practice and education. The competition was open to programs from all engineering disciplines.

Projects did not have to offer academic credit, but they were required to meet other eligibility requirements. The projects had to be in progress or completed by March 11, 2019. If a project had been entered in a previous award cycle, the engineering program was required to explain how the project had been further developed since the previous submission.

The NCEES Engineering Education Award jury met in Clemson, South Carolina, on June 4, 2019, to conduct a blind judging of the 51 entries. Each submission consisted of a display board, abstract, and project description. These materials were sent electronically to the jury for review prior to the judging and were also available at the judging.

The jury considered the following criteria in its deliberations:

- Successful collaboration of faculty, students, and licensed professional engineers
- Protection of public health, safety, and/or welfare
- Multidiscipline and/or allied profession participation
- Knowledge or skills gained
- Effectiveness of display board, abstract, and project description

The jury selected the University of Nebraska–Lincoln Charles W. Durham School of Architectural Engineering and Construction to receive the $25,000 grand prize. The jury chose seven additional winners to each receive a $10,000 award.

2019 NCEES Engineering Education Award **Jury**

Jury members from each of the four NCEES geographical zones were chosen to represent state licensing boards, academia, and professional engineering societies.

Nancy Gavlin, P.E., S.E., Jury Chair
Illinois Structural Engineering Board

Steven Barrett, Ph.D., P.E.
Wyoming Board of Professional Engineers and Professional Land Surveyors

Chimin (Jimmy) Chao, P.E.
South Carolina Board of Registration for Professional Engineers and Surveyors

Michael Kelly, P.E.
New Jersey State Board of Professional Engineers and Land Surveyors

Jean Andino, Ph.D., P.E.
Arizona State University

Martin Gordon, P.E.
Rochester Institute of Technology

Michelle Roddenberry, Ph.D., P.E.
Florida State University

John Wagner, Ph.D., P.E.
Trine University

Mark Golden, CAE, FASAE
National Society of Professional Engineers

Michael Smith, D.Eng.
DiscoverE Diversity Council

2019

NCEES Engineering
Education Award
$25,000 Grand Prize Winner

University of Nebraska–Lincoln

Charles W. Durham School of Architectural
Engineering and Construction
Jack H. Miller Center for Musical Arts

$25,000
GRAND
PRIZE

University of Nebraska–Lincoln

Charles W. Durham School of Architectural Engineering and Construction

Jack H. Miller Center for Musical Arts

Participants

Students

Hussam Albalushi
Aisha Alhashmi
Hamida Al Jabri
Rahil Al Jabri
Maythaa Al Nofli
Shamsa Al-Salami
Tyler Apgar
Kyle Boesch
Marijo Bosiljevac
Jack Buckley
Luke Dolezal
Sarah Drummey
Daniel Ewart
Monica Houck
Camden Johnson
Riley Johnson
Michael Krone
Gabriel Larsen
Zhangwei Liu
Connor Malnack
John Meyers
Brent Regier
Brooke Scherer
Austin Seagren
Michaela Sherer
Cody Starkey
Jeffrey Thompson
Chris Wozny
Kaleb Wulf

Faculty

Todd Feldman, P.E.

Professional Engineers

Denise Allacher, P.E.
Adam Brumbaugh, P.E.
Rebecca Cherney, P.E.
Kelley Clouse, S.E.
Nick Decker, P.E.
Don Foster, P.E.
Abby Goranson, P.E.
Sam Haberman, P.E.
Joe Hazel, P.E.
Brian Hoagland, S.E.
Trevor Hollins, P.E.
Brian Howell, P.E.
Kyle Kauzlarich, P.E.
Ken Kilzer, S.E.
Brian Kolm, P.E.
Nick Mandel, P.E.
David Manley, P.E.
Matt Morrissey, P.E.
Dick Netley, P.E.
Brian Nevole, P.E.
Doug Nelsen, P.E.
Ron Ostendorf, P.E.
Jenn Pohlman, P.E.
Beth Redding, P.E.
Brandon Rich, P.E.
Ben Ries, P.E.
Andrew Roche, P.E.
Nate Timm, P.E.
Pete Uhing, P.E.
Kyle Weber, P.E.
Kevin Wenninghoff, S.E.
Andy Wiese, P.E.
Andrew Wilson, P.E.
James Wingert, S.E.
Tyler Winnike, P.E.
Steve Yanke, P.E.
Jake Zach, S.E.

Additional Participants

Brenna Boyd, E.I.
Gary Cooper
Stacy Feit, A.I.A.
Erin Froschheiser, A.I.A.
Bernie Gehrki, A.I.A.
Tyler Hopson, E.I.
Jonathan Ingram, E.I.
Ben MacKenzie, E.I.
Andrew Portis, A.I.A.
Jake Pulfer, E.I.
Nate Ritta, E.I.
Adam Steinbach, E.I.
Brendan Walsh, E.I.
Geof Wright, E.I.

Jury Comments

"Great practical design solution"

"Nice job of integrating many aspects into a comprehensive design"

"Technically sound approach to the upgrade of a musical arts center"

Abstract

This project brought together master of architectural engineering students to create an interdisciplinary design team consisting of structural, mechanical, and electrical subdisciplines. Each team and each discipline was assisted by industry professional engineering mentors, and presentations of important milestone phases were evaluated by other professional volunteers. Three separate multidisciplinary teams of nine or 10 students each were challenged to design the structural, mechanical, and electrical systems for the new Jack H. Miller Center for Musical Arts on the Hope College campus in Holland, Michigan. This new 64,00-square-foot facility houses an 800-seat concert hall with main floor and balcony seating, as well as a 125-seat recital hall for small performances. Additional spaces include rehearsal and recording rooms, faculty studios, practice rooms, offices, and a large two-story atrium off the main concourse of the university. The center is to provide Hope College with a building that has superior acoustics, integrated timber or engineered wood throughout 25 percent of the building, and a rooftop amenity space that can be used year-round. Student teams were challenged to find integrative and innovative design solutions to meet these criteria. Emphasizing user experience, acoustic performance, and sustainability, the design scope included the entirety of the building, with special focus on the concert and recital spaces.

Over 50 professionals, consisting of 36 P.E.s, 10 E.I.s, four architects, and one other specialist, volunteered their time to mentor student teams or serve as evaluators for presentations of milestone deliverables. So the students could have a clear understanding and appreciation of the significance of input from industry mentors and evaluators, they estimated the monetary value of volunteers' time using an average standard hourly rate and determined professionals' contributions to this two-semester capstone experience was valued at over a half-million dollars! The overarching goal of this immersive activity was to develop excellence in architectural engineering students and prepare them for realistic career experiences by carrying out a fully integrated, multidisciplinary approach to the planning and design of cutting-edge, operational, high-quality building systems.

$25,000 GRAND PRIZE

University of Nebraska–Lincoln

Charles W. Durham School of Architectural Engineering and Construction

Jack H. Miller Center for Musical Arts

Perspectives On

Protection of public health, safety, and welfare

The safety and security measures necessary in this project made clear to students the weight that engineering decisions carry. Public safety is of utmost concern and must be considered in all design decisions. Since every design decision made impacts other facets of the project, interdisciplinary coordination is key. Layered safety and security design solutions provide a range of safety and security measures to allow for the variety of occupancies in a multi-use space.

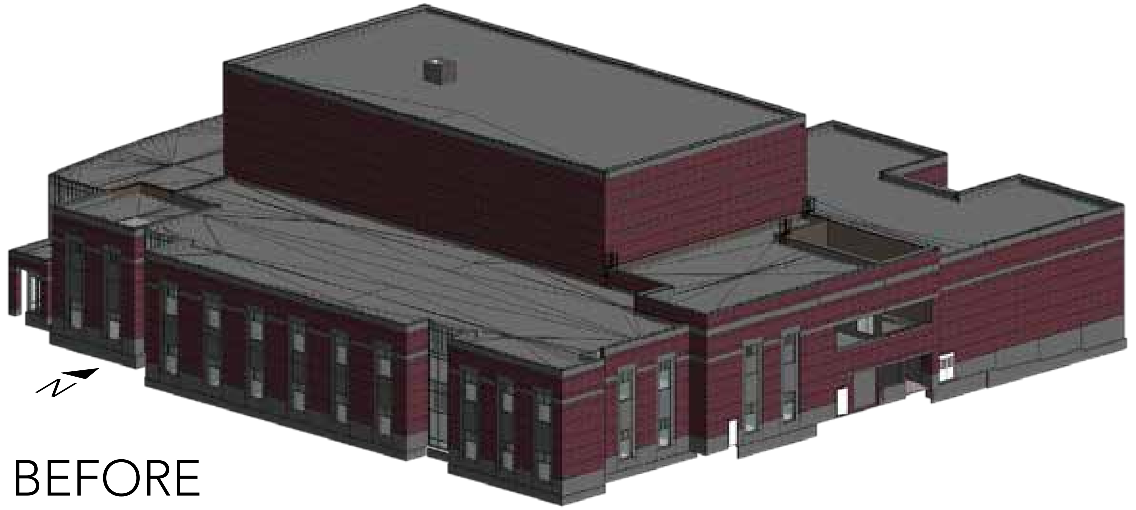
In order to protect occupants and the property, a fire sprinkler system was a high priority and was designed according to NFPA 13 2010 edition and adheres to local Authority Having Jurisdiction codes and standards. The fire alarm system utilizes a range of smoke, heat, and mechanical equipment fire detection devices that tie back into the fire alarm control panel for activating the notification and evacuation devices in the building in the case of an emergency evacuation procedure. Fire alarm systems were designed in conjunction with the university emergency communication system. The rooftop amenity space was designed to be accessible to students year-round as well as serving as an event space for community involvement. This posed a programmatic challenge when determining access points for both students and the public while keeping secured parts of the building inaccessible. An integrated network-based security system was designed. Access control, CCTV systems, and network connectivity allow for security monitoring and management of surveillance cameras, card readers, and other security equipment. Emergency lighting powered by an emergency inverter provides egress illumination.

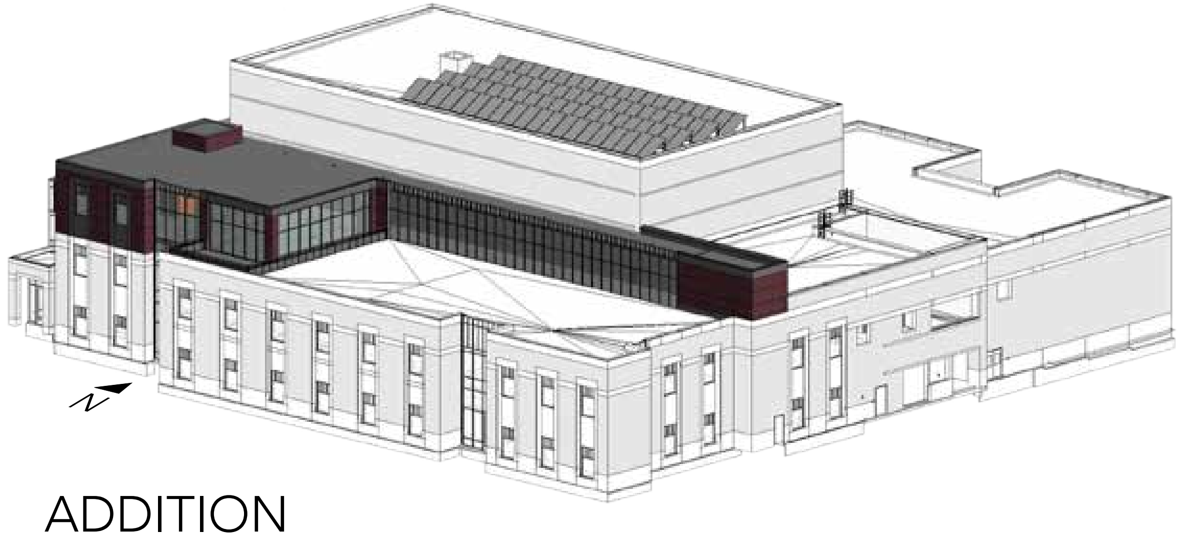
Conservative loading was used to size structural members. A minimal floor load of 100 psf was applied throughout the first and second floors, with 150 psf for mechanical spaces. Additionally, knee braces were added to timber frames to ensure each frame can resist wind loads, and an expansion joint was added to ensure the integrity of the first-floor diaphragm.

Public health and welfare were further addressed by designing for occupant health, productivity, and comfort through mechanical, acoustical, daylighting, and structural floor vibration design, pursuing WELL certification. Design features that incorporate indoor air quality standards were met for the mechanical system design with proper ventilation and exhaust movement. Daylighting also promotes occupant well-being, while decreasing energy use, which in turn decreases the potential public health effects due to energy production. Additionally, design decisions were made to present an attractive gateway to the Hope campus. The atrium design, which includes a large curtain wall, exposed timber, and accent lighting, was designed as a beacon to draw members of the public into the building and to encourage attendance at performances and events.

Knowledge and skills gained

The student participants gained real-world skills as a result of this collaborative effort. First, using an actual building design project provided an opportunity to consider synthesis and integration outside of theoretical parameters. It gave the students the opportunity not only to form their own interdisciplinary approach but to witness and learn



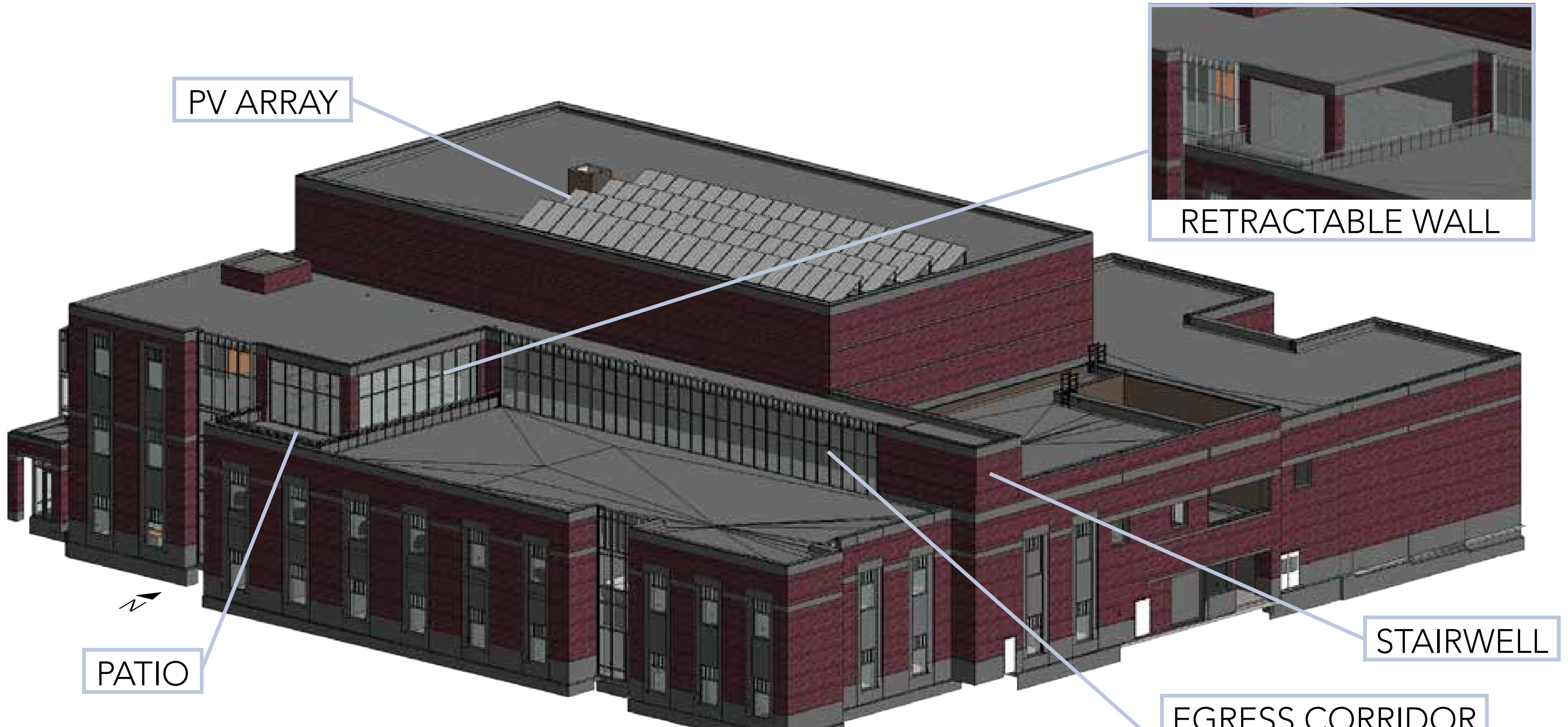


$25,000 GRAND PRIZE

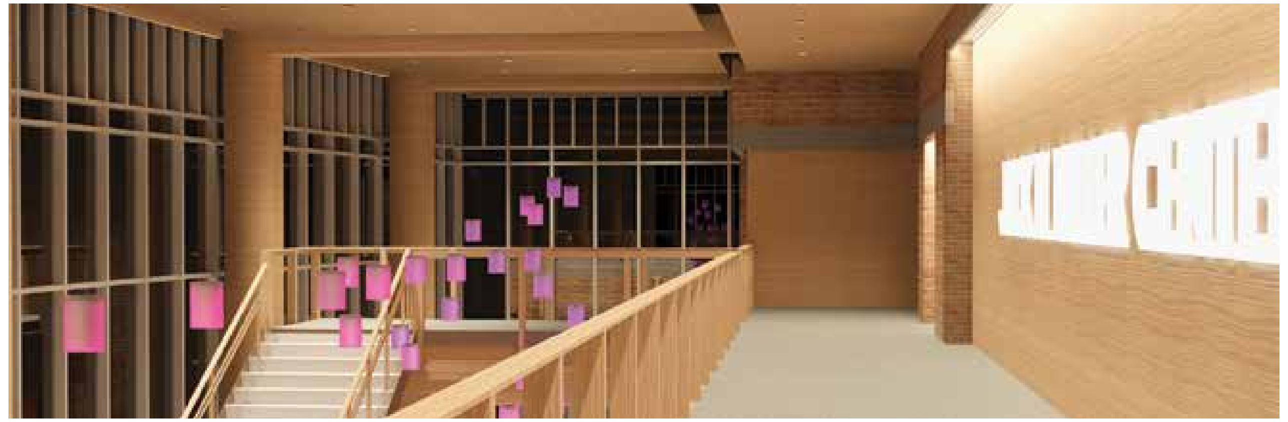
University of Nebraska–Lincoln

Charles W. Durham School of Architectural Engineering and Construction

Jack H. Miller Center for Musical Arts



FINAL DESIGN



from people who have made their life's work on this very basis. By having industry mentors, the students became better prepared to enter the profession with a clear understanding of the skills a complete engineer must develop and possess.

Further, professionals gave feedback at periodic phase presentations, which challenged the students to accept criticism, learn from it, and continue to fine-tune their projects for a wholly realistic design. Finally, this close relationship illuminated the different opportunities and specializations available to students to pursue as a career and created potential connections for future employment or collaboration when the students have transitioned into professional engineers themselves. The significant guidance and evaluation of over 50 experienced professionals raised the bar by having the expectation of real, workable solutions to inherent problems in design. The value of professional input was made clear from day one, which made students take this investment in their work very seriously.

Multidiscipline or allied profession participation

For this engineering capstone project, three student design teams, consisting of nine or 10 mechanical, structural, and electrical option students each, received support and constructive feedback from professional engineers, professional architects, acoustical consultants, and faculty advisors in architectural and construction engineering. Each team was assigned a full set of professional mentors, to include one or two architects, several engineers (structural, mechanical, and electrical), and an acoustical consultant. There were 28 non-faculty mentors in all—20 P.E.s or S.E.s, three E.I.s, four professional architects, and an acoustical consultant.

After each design milestone, teams were required to present a narrative showcasing the progress of their designs within each discipline. Another set of professionals participated as evaluators, providing feedback on presentation and document submissions. This group included 16 P.E.s or S.E.s and seven E.I.s, for a total of 23. They graded the presentations according to a competition rubric. Follow-up questions and comments were then discussed with the professionals. This allowed students the opportunity to defend and improve their design. The presentation and discussion process was designed to simulate a professional setting.

$25,000 GRAND PRIZE

University of Nebraska–Lincoln

Charles W. Durham School of Architectural Engineering and Construction

Jack H. Miller Center for Musical Arts

Points of View

Todd Feldman, P.E.
Faculty advisor

What value does a real-world project bring to the students?

In addition to allowing students to understand the constraints and requirements of the project stakeholders, working on a real-world project also gives the students the opportunity to work alongside potential future employers and colleagues. These experiences help the students by giving them the valuable resources of both on-the-job training and networking.

How do you decide which projects to work on?

Nebraska Architectural Engineering (AE) Interdisciplinary Team Design Project (AE8030-8040) participates in the Architectural Engineering Institute Student Design Competition (AEISDC). The project selected for the competition is used as the basis every year for the course. The project requires the design and integration of the mechanical, electrical, and structural systems in the building. The project varies from year to year, including everything from a hospital design to the renovation of a historical building announced for next year's competition, which provides new opportunities for industry involvement and student innovation. The AEISDC is the most highly regarded student design competition in AE and continues to raise the bar for quality, depth, and completeness of the student submissions and presentations.

How did this project prepare students for professional practice?

The vast majority of Nebraska AE alumni will be designing and specifying mechanical, electrical, and structural systems for buildings and working on design teams during their careers. Nebraska AE Interdisciplinary Team Design Project delivers the students these experiences through the mentorship and evaluation from industry professionals. The students gain valuable practical insight before entering the workforce as the project and relationships develop, which makes them competitive candidates for employment. The course content and its industry immersion provides excellent preparation for future professional practice.

What advice do you have for other programs wanting to add similar collaborative projects to their curriculum?

Industry relations are critical to the Durham School of Architectural Engineering and Construction, yet mutually beneficial to all stakeholders. The students gain from the practical experience of the professionals, the professionals gain a deeper understanding of their practice from student questions, and the involved firms gain from early exposure to talented students. Our industry partners mentor and evaluate our students in addition to partnering on research opportunities. In return, the Durham School provides an excellent pool of interns and graduates, as well as research to transform their business practices. I highly encourage all engineering programs to develop these strong, mutual-benefit relationships.

Sarah Drummey
Student

What did you like best about participating in this project?

I enjoyed working and collaborating with the other disciplines. This is something I had minimal experience with prior to the project, so it was a great experience finding a collaborative solution for some of the challenges we faced. Also, working on a musical arts facility was enjoyable, given it is a project type that I had no experience with.

What did you learn?

I learned the value of diversity, which helped our design's unique solutions. I also learned the value of communication, which was pertinent in the success of our team.

How did the participation of professional engineers improve the experience?

The professional engineers were a valuable resource when facing some of the interdisciplinary challenges we had. They helped a lot with understanding the feasibility of the solutions we designed.

What do you think the engineers learned from working with students on this project?

Our team consisted of a diverse group of people. I think the professional engineers saw how this helped our design process and learned how diversity often results in unique, innovative designs.

Douglas W. Nelsen, P.E., L.C., Assoc. IALD
Practitioner

Why did you get involved with the University of Nebraska–Lincoln's project?

As a 2006 graduate of the UNL Architectural Engineering program, I know the importance of this project as it relates to the real-world success of the student. This project is often the first and certainly the most realistic experience of working on an actual project. It requires proper planning, communication, and coordination with each member of the team—all important components of what is expected of them when they enter the industry.

How did you assist the students in the project?

I was an industry mentor for the team and mainly assisted the students by providing them guidance, references, and resources but not the direct answer. I am a firm believer that the answers should be researched and determined by the students. I made myself available for any questions that the students had and performed quality assurance/quality control of the required submittals.

What did you learn from working with the students?

I have been both an industry mentor and an evaluator for more than 10 years, and over those years, I have learned that technology and the design tools available are always evolving. The students have great access to the latest software programs and the best resources necessary to be successful with this project. They strive to learn and use these tools to produce a better result.

What did you want students to take away from working with you?

As architectural engineering students, they need to be aware of all aspects of the building design. They need to know that a specific discipline can't work alone and that their design can and will impact others. It is critical to communicate and coordinate with other members of the team because the most well-designed buildings are ones that clearly show the seamless integration of all disciplines.

2019

NCEES Engineering Education Award $10,000 Winners

Lipscomb University | Raymond B. Jones College of Engineering | *Sustainable Water Treatment Prototype System for a Ghanaian Orphanage, School, and Hospital Campus*

Seattle University | Department of Civil and Environmental Engineering | *Infrastructure Improvement of a County Road*

Seattle University | Department of Civil and Environmental Engineering | *Seismic Assessment and Retrofit of a County Pump Station*

Smith College | Picker Engineering Program | *Development of a Culvert Evaluation Program*

University of Cincinnati | Department of Civil and Architectural Engineering and Construction Management | *Hoyes Field Elementary—A Net-Zero Energy School*

University of Wisconsin–Madison | Department of Civil and Environmental Engineering | *Alternative Energy Generation at School A*

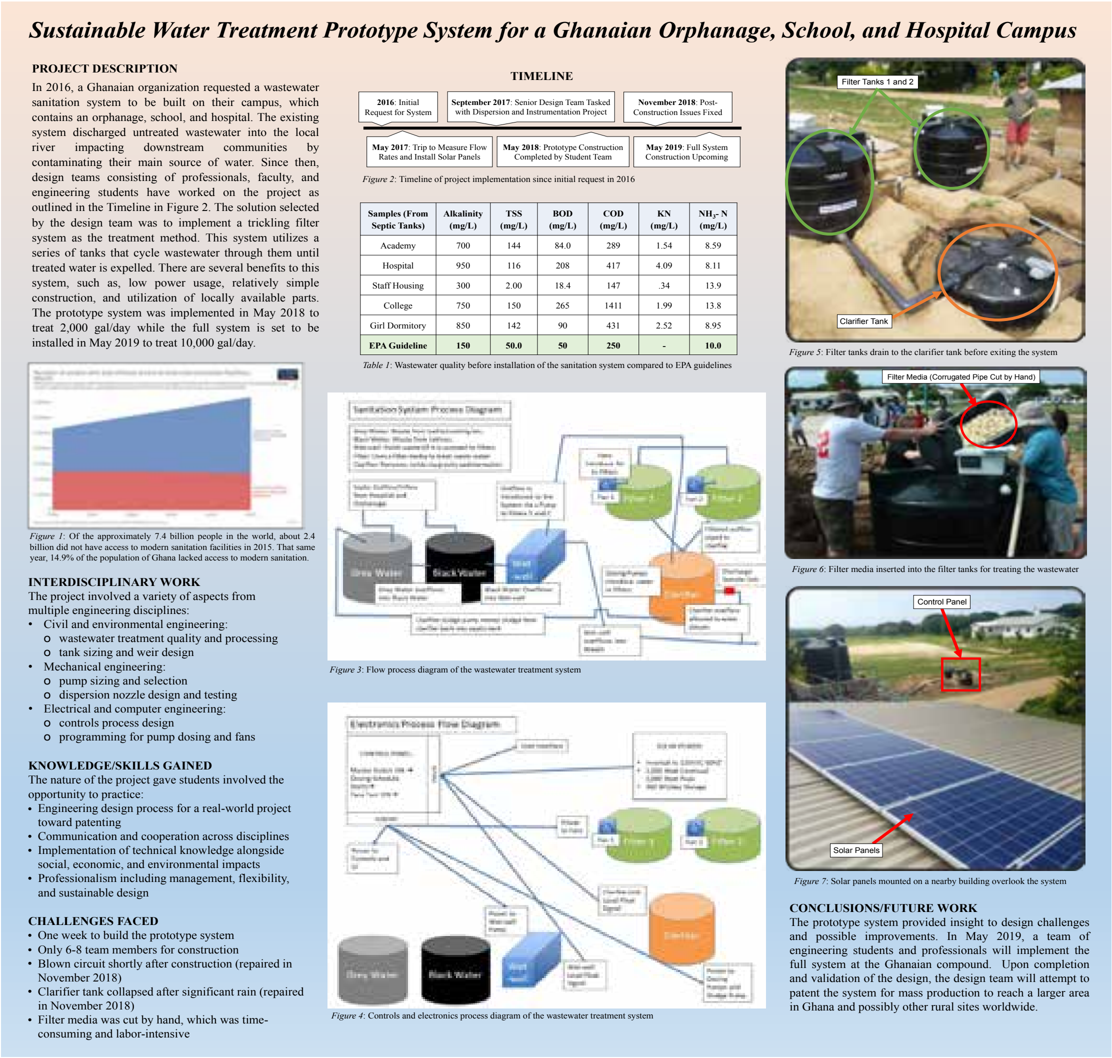
University of Wisconsin–Madison | Department of Civil and Environmental Engineering | *Design for Removal of VOCs at Drinking Water Well 18*

$10,000 AWARD

Lipscomb University

Raymond B. Jones College of Engineering

Sustainable Water Treatment Prototype System for a Ghanaian Orphanage, School, and Hospital Campus



Sustainable Water Treatment Prototype System for a Ghanaian Orphanage, School, and Hospital Campus

PROJECT DESCRIPTION

In 2016, a Ghanaian organization requested a wastewater sanitation system to be built on their campus, which contains an orphanage, school, and hospital. The existing system discharged untreated wastewater into the local river impacting downstream communities by contaminating their main source of water. Since then, design teams consisting of professionals, faculty, and engineering students have worked on the project as outlined in the Timeline in Figure 2. The solution selected by the design team was to implement a trickling filter system as the treatment method. This system utilizes a series of tanks that cycle wastewater through them until treated water is expelled. There are several benefits to this system, such as, low power usage, relatively simple construction, and utilization of locally available parts. The prototype system was implemented in May 2018 to treat 2,000 gal/day while the full system is set to be installed in May 2019 to treat 10,000 gal/day.

Figure 1: Of the approximately 7.4 billion people in the world, about 2.4 billion did not have access to modern sanitation facilities in 2015. That same year, 14.9% of the population of Ghana lacked access to modern sanitation.

TIMELINE

2016: Initial Request for System

May 2017: Trip to Measure Flow Rates and Install Solar Panels

September 2017: Senior Design Team Tasked with Dispersion and Instrumentation Project

May 2018: Prototype Construction Completed by Student Team

November 2018: Post-Construction Issues Fixed

May 2019: Full System Construction Upcoming

Figure 2: Timeline of project implementation since initial request in 2016

Samples (From Septic Tanks)	Alkalinity (mg/L)	TSS (mg/L)	BOD (mg/L)	COD (mg/L)	KN (mg/L)	NH_3- N (mg/L)
Academy	700	144	84.0	289	1.54	8.59
Hospital	950	116	208	417	4.09	8.11
Staff Housing	300	2.00	18.4	147	.34	13.9
College	750	150	265	1411	1.99	13.8
Girl Dormitory	850	142	90	431	2.52	8.95
EPA Guideline	**150**	**50.0**	**50**	**250**	**-**	**10.0**

Table 1: Wastewater quality before installation of the sanitation system compared to EPA guidelines

Filter Tanks 1 and 2

Clarifier Tank

Figure 5: Filter tanks drain to the clarifier tank before exiting the system

Filter Media (Corrugated Pipe Cut by Hand)

Figure 6: Filter media inserted into the filter tanks for treating the wastewater

Figure 3: Flow process diagram of the wastewater treatment system

Control Panel

Solar Panels

Figure 7: Solar panels mounted on a nearby building overlook the system

INTERDISCIPLINARY WORK

The project involved a variety of aspects from multiple engineering disciplines:

- Civil and environmental engineering:
  - wastewater treatment quality and processing
  - tank sizing and weir design
- Mechanical engineering:
  - pump sizing and selection
  - dispersion nozzle design and testing
- Electrical and computer engineering:
  - controls process design
  - programming for pump dosing and fans

KNOWLEDGE/SKILLS GAINED

The nature of the project gave students involved the opportunity to practice:

- Engineering design process for a real-world project toward patenting
- Communication and cooperation across disciplines
- Implementation of technical knowledge alongside social, economic, and environmental impacts
- Professionalism including management, flexibility, and sustainable design

CHALLENGES FACED

- One week to build the prototype system
- Only 6-8 team members for construction
- Blown circuit shortly after construction (repaired in November 2018)
- Clarifier tank collapsed after significant rain (repaired in November 2018)
- Filter media was cut by hand, which was time-consuming and labor-intensive

Figure 4: Controls and electronics process diagram of the wastewater treatment system

CONCLUSIONS/FUTURE WORK

The prototype system provided insight to design challenges and possible improvements. In May 2019, a team of engineering students and professionals will implement the full system at the Ghanaian compound. Upon completion and validation of the design, the design team will attempt to patent the system for mass production to reach a larger area in Ghana and possibly other rural sites worldwide.

Participants

Students

Trent Beacham
Davy Black
Carson Chaffin
Austin Cunningham
Nathan Foote
Jase George
Leah Hampton
Hanleigh Heinzmann
Billy Ivy
Joe Kerridge
Noah Kimbrough
McKenzie Lawry
Bryant Loesch
Danny Marsh
Emily Morgan
Joey Olson
SeungJin Park
John Ray
Nial Redha
Hope Reed
Salah Salman
Hayden Sears
Taylor Settle
Kyle Smith
Sam Webb

Faculty

Kirsten Dodson
Stephen Dodson
Caleb Meeks
Stephanie Weeden-Wright

Professional Engineer

George Garden, P.E.

Additional Participants

Camden Gilliam
Caleb Janelle
Glenn Marcum

Jury Comments

"Creative engineering solution"

"Great job at testing a design on a prototype scale before final implementation"

"Most extensively built water project among the submissions"

Abstract

A sustainable water treatment prototype system was designed and implemented by an interdisciplinary group of engineering students and professionals to serve a Ghanaian organization. The organization hosts a campus that includes an orphanage, school, and hospital. The project was initiated by a request made by the administration of the campus in 2016. The existing sanitation system was flawed and placed children at the orphanage, patients at the hospital, and the communities downstream at risk of contracting diseases or illnesses from the untreated water.

To improve the system and protect these populations, professional engineers, faculty, and students have worked hard on designing a solution. The objective of the system is to treat all of the wastewater from the campus to EPA guidelines before dispelling it into the nearby river. Based on design constraints, the team selected a trickling filter treatment system as the possible solution.

The design team has iterated through the engineering design process by completing initial assessments at the site, including quality testing and flow rate measurements, developing a prototype design and testing it, and using the mistakes and flaws from the prototype to design the full system. The assessment of the existing system was completed in May 2017 at the same time solar panels were installed to power the system. During the following academic year, the design team developed various parts of the system, including a dispersion nozzle, a measurement box, pump sizing and selection, control panel, and general assembly of the system. The prototype system including these components was constructed in May 2018 to handle 2,000 gal/day, only a portion of the total wastewater from the campus. The construction of the prototype system posed many obstacles for the design team, and two major systems failed within a couple of months. These challenges were addressed during the following academic year when the design team worked toward improvements and changes to the system. The full system capable of handling 10,000 gal/day is set to be implemented in May 2019 by a team of students and engineering professionals. Pending validation of the design, the team plans to patent the system for future expansion to other rural communities that lack access to modern sanitation facilities.

Going into this project, the team of engineering professionals and students had to account for several key design considerations. For instance, the system needed to be easy to construct and sustainable, while also using locally sourced parts. Due to the lack of reliable electricity, the system was designed to be powered using solar panels, placing a limit on the overall power draw. These factors and several others made this design a unique challenge for the team. In addition to the technical challenges, the team faced numerous other obstacles throughout the project. Because the project relied on civil, mechanical, and electrical/computer engineering concepts, students and professionals from each discipline were required to work hand-in-hand with one another to complete the design. This cross-disciplinary nature of the project required effective communication by all team members.

Additionally, many of the design decisions made by the teams were not solely technical in nature. As a system to be built in a developing country on a school and hospital campus, the students were required to think outside the technical design to understand social, cultural, economic, and environmental impacts. In order to strategically consider the impacts of design decisions, students employed concepts like ethics, sustainability, and environmental effects. The team decided to treat the water to EPA guidelines, utilize solar power as the energy source, and employ local companies where possible. Looking forward, the team will implement the sustainable water treatment system in May 2019 with the hopes of patenting the design.

$10,000 AWARD

Lipscomb University

Raymond B. Jones College of Engineering

Sustainable Water Treatment Prototype System for a Ghanaian Orphanage, School, and Hospital Campus

Perspectives On

Protection of public health, safety, and welfare

In the modern world, access to sanitation facilities is a major concern that must be addressed in order to improve public health. One major factor contributing to public health quality is the problem of sanitation and the discharge of wastewater into community water supplies. High population density cities suffer widespread disease primarily due to the lack of proper waste collection and treatment. Due to this, strides were taken to improve living conditions by improving public sanitation in an effort to promote proper hygiene. The United Nations, a leader in world development, has set a goal of ensuring availability to adequate sanitation and hygiene for all by 2030. According to the World Bank, around 5 billion people have access to modern sanitation as of 2015, while 2.4 billion are without access. This is great progress; however, there are still many who live in poor conditions and suffer from poor hygiene due to the lack of proper waste treatment. In Ghana alone, 14.9 percent of the population were estimated to still lack access to improved sanitation facilities in 2015. The lack of sanitation facilities or treatment means waste eventually finds its way into the public water supply, which causes the spread of sickness. By addressing access to sanitation, this project will have a long-term positive impact on the public health of those at the orphanage, school, and hospital campus as well as the communities downstream.

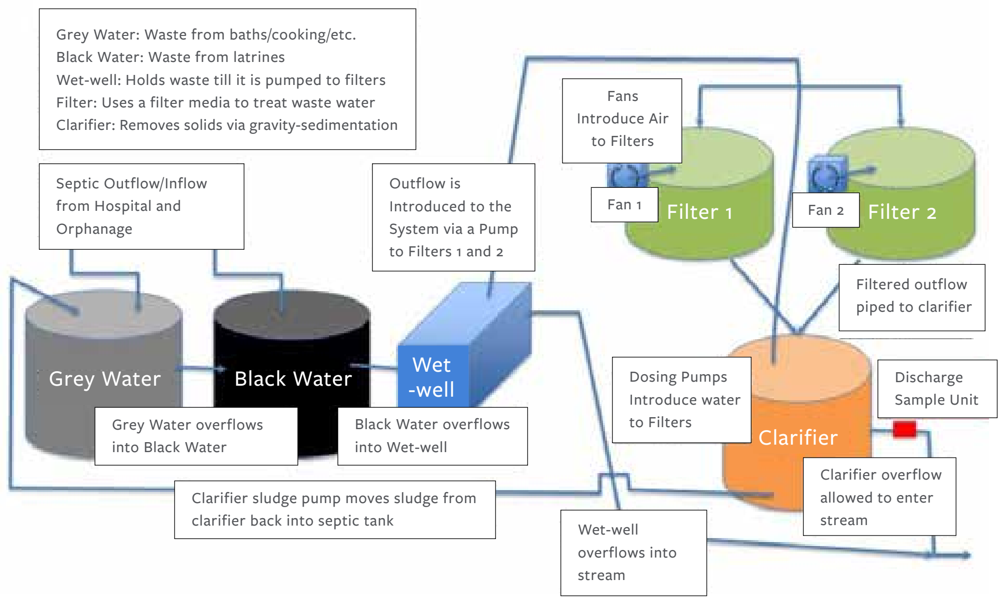
Knowledge and skills gained

By working on a real-world project, students gained valuable technical knowledge as well as professional skills. Much of the technical knowledge gained was highly dependent on the part of the system the student worked on and the related discipline. Overall, all of the students learned about the real-world function of the design process. Because the design and implementation of the system was completed in parts, the students experienced important steps of the engineering design process. Early in the process, students measured parameters like flow rate and quality to create constraints for the system. From those constraints, students examined design considerations and began building a prototype system with guidance from the lead P.E. Then, the students installed and tested their prototype design onsite. Learning from the failures of the prototype, the students and P.E.s worked to improve the design and make strategic changes. Finally, the students will implement the new design and any changes in May 2019 for completion of the full system. Also, due to the nature of the project for possible expansion to other communities, the team is developing a patent for the system. Though the product development is still in the initial phases, the students have been learning about the patenting process from the P.E. who is guiding the development of the design.

With respect to professional skills, the demand of the project created a wide variety of opportunities for developing practical proficiency. Because the project involved multiple disciplines of engineering, sufficient and effective communication was a major obstacle. The students involved learned that more communication is always better than less and that even small adjustments to the design should be communicated to all parties. Managing tasks and responsibilities as an interdisciplinary team was also a challenge for the students. At times, the students found difficulty in communicating expectations or design constraints across the disciplines. In order to understand the cause and effect of design decisions, students were required to use critical thinking to view the project holistically throughout development. Many of the design decisions made by the teams were not solely technical in nature. As a system to be built in a developing country on a school and hospital campus, the students were required to think outside the technical design to understand social, cultural, economic, and environmental impacts.

In order to strategically consider the impacts of design decisions, students employed concepts like ethics, sustainability, and environmental effects. Though the primary client was the school/hospital campus, communities downstream of the system would be largely affected by the sanitation system. With this understanding, the teams decided that the system should treat the water to EPA guidelines as mentioned above to protect the health of the communities downstream. This decision was supported by the team's development of a wastewater quality measurement box that tests the quality of the water before leaving the campus. In addition to the health of the communities downstream, the teams sought to design a sustainable system in a variety of ways. By utilizing solar power as the primary energy source, the system was not only environmentally friendly but also not reliant on the unpredictable electrical power at the campus. The solar panels were bought from and installed by a local company, thus further supporting the community and providing sustainable options for maintenance in the future. As the system was developed, the long-term success of the design was considered. The installation of the prototype system revealed opportunities for major improvements toward this goal. For example, after a heavy rain, the plastic clarifier tank which had originally been buried floated out of its hole due to the lack of permeability of the soil to absorb the excess water. Though this region in Ghana rarely experiences that heavy of rainfall, the floating tank provided clear indication of a need to improve to accommodate unexpected weather. In response to this, the team decided to replace the plastic tank with a concrete tank poured on site, which will be completed during the upcoming trip in May 2019.

Sanitation System Process Diagram

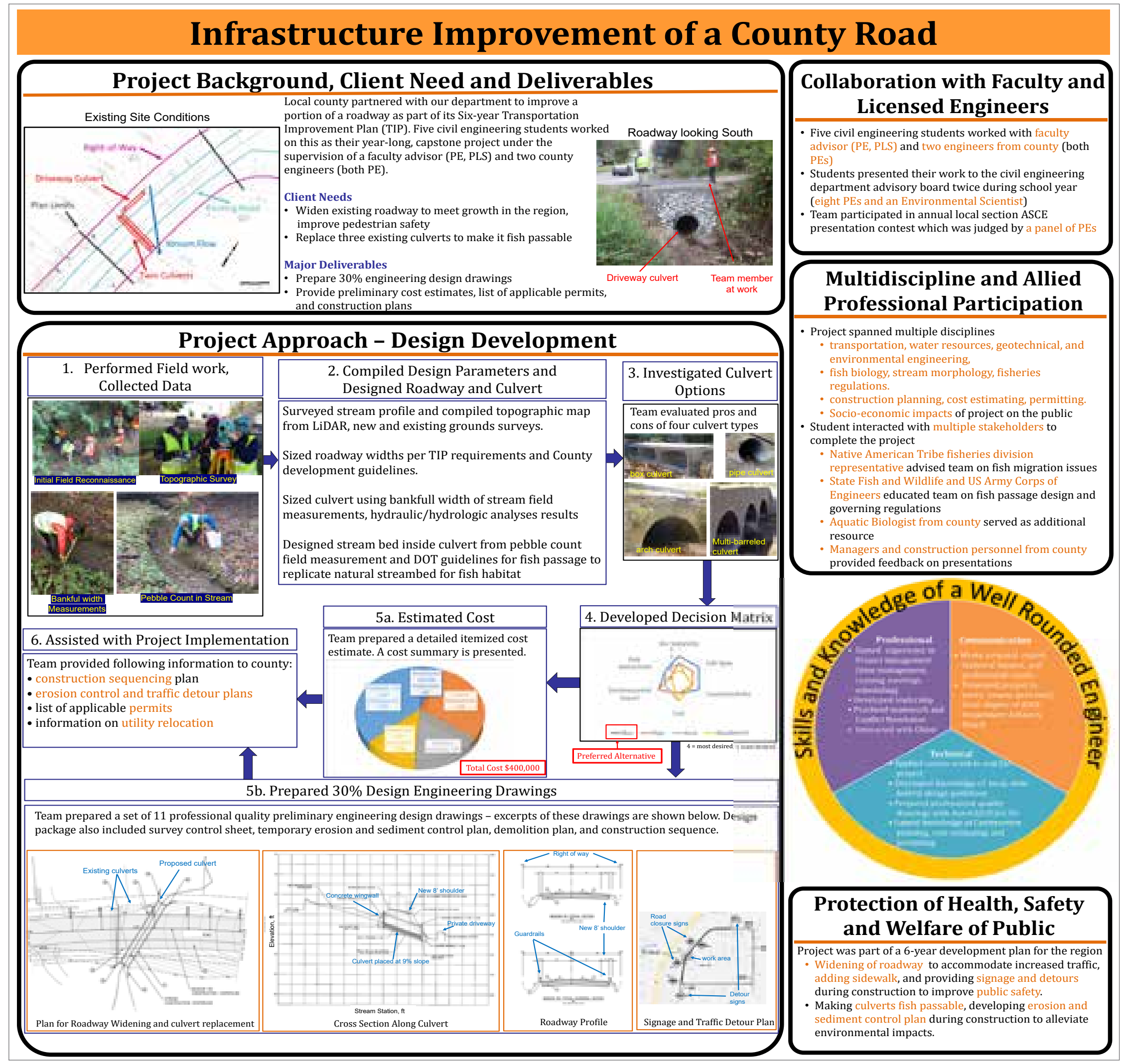


$10,000 AWARD

Seattle University

Department of Civil and Environmental Engineering

Infrastructure Improvement of a County Road



Participants

Students

Sam Birginal-Garcia, E.I.T.
Jackie Hempstead
Pavel Moskvitin, E.I.T.
Elizabeth Simon, E.I.T.
Caroline Umukobwa, E.I.T., ENV.SP.

Faculty

Nirmala Gnanapragasam, Ph.D., P.E.
Mark Siegenthaler, P.E., P.L.S.

Professional Engineers

Matthew Ojala, P.E. *(Snohomish County Public Works)*
Max Phan, P.E. *(Snohomish County Public Works)*
Michael Randall, P.E. *(Snohomish County Public Works)*

Additional Participants

Jane Atha *(Washington State Department of Fish and Wildlife)*
Casey Costello *(Washington State Department of Fish and Wildlife)*
Martin Fox *(Muckleshoot Indian Tribe, Fisheries Division)*
Patrick Klavas *(Washington State Department of Fish and Wildlife)*
Ted Parker *(Aquatic Biologist, Snohomish County Public Works)*
Jacalen Printz *(U.S. Army Corps of Engineers)*
Rob Schurman *(Snohomish County Surface Water Management)*

Jury Comments

"Very relevant project"

"Multiplicity of stakeholders and multidisciplinary advisors involved"

"Good concise summary with various roles clearly defined"

Abstract

A local county requested our engineering program to assist with a roadway enhancement project which was part of their six-year transportation improvement plan (TIP). Specifically, the project involved a) widening a stretch of road to accommodate the rapid growth in the region and to improve pedestrian access and safety, and b) replacing three culverts in the project area, making them fish passable. This was a capstone project to a student team.

The team performed a site reconnaissance to understand the client needs and project constraints. Following that, they surveyed the land to develop a topographic map of the project site, took relevant measurements of the stream, and studied the stream bed characteristics. The team researched the relevant design codes, compiled the necessary design parameters, developed a hydraulic/hydrologic model for the site, and based on the findings, designed the roadway alignment and replaced the three-culvert system with the single culvert underneath the roadway.

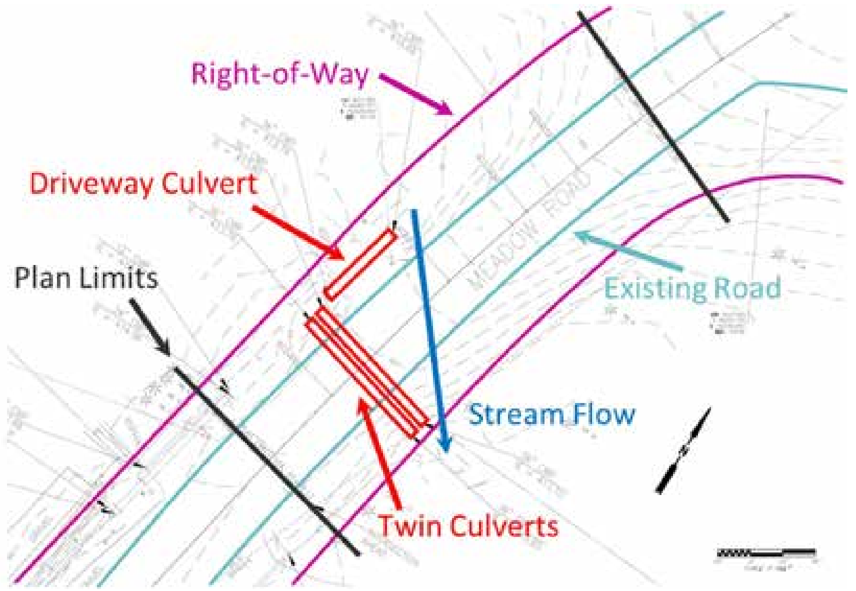
Furthermore, the team took the project to a 30 percent design, prepared an 11-page professional quality engineering drawing set using AutoCAD-Civil 3D, carried out a cost estimate, and identified eight county/state/federal permits applicable for the project.

A diverse group of five students worked on this project for a whole academic year under the supervision of two faculty members (one a P.E. and the other a P.E./P.L.S.) and three staff members from the county, two of them professional engineers (P.E.s) and one a fish biologist. The students also presented their project twice to the civil engineering department advisory board and once to the local section of the American Society of Civil Engineers (ASCE). Several P.E.s attended these two events and provided feedback to the team. Because the project had multiple stakeholders, the students interacted with a representative from a Native American tribe fisheries division, staff from the State Department of Fish and Wildlife, and the U.S. Army Corps of Engineers. The team also presented their work to county engineers, managers, and construction personnel.

The project encompassed a wide range of disciplines; transportation, geotechnical, and environmental subdisciplines within civil engineering; fish biology; environmental science; permitting; and cost estimating.

The students developed several skills useful to entry-level engineers. They learned how to apply the technical knowledge gained in the classroom to a real-life project. They practiced the basics of project management, leadership, team management, and client interaction. They honed their communication skills through presentations to a range of audience and preparation of memos, proposal, and report to the county.

The primary goal of the six-year TIP is to improve traffic flow and pedestrian safety in the region. In addition to striving for this in their design, the team planned signage and detours to be used during the construction phase of the project to improve public safety. Making the culverts fish passable and developing an erosion and sediment control plan during construction improve public welfare.



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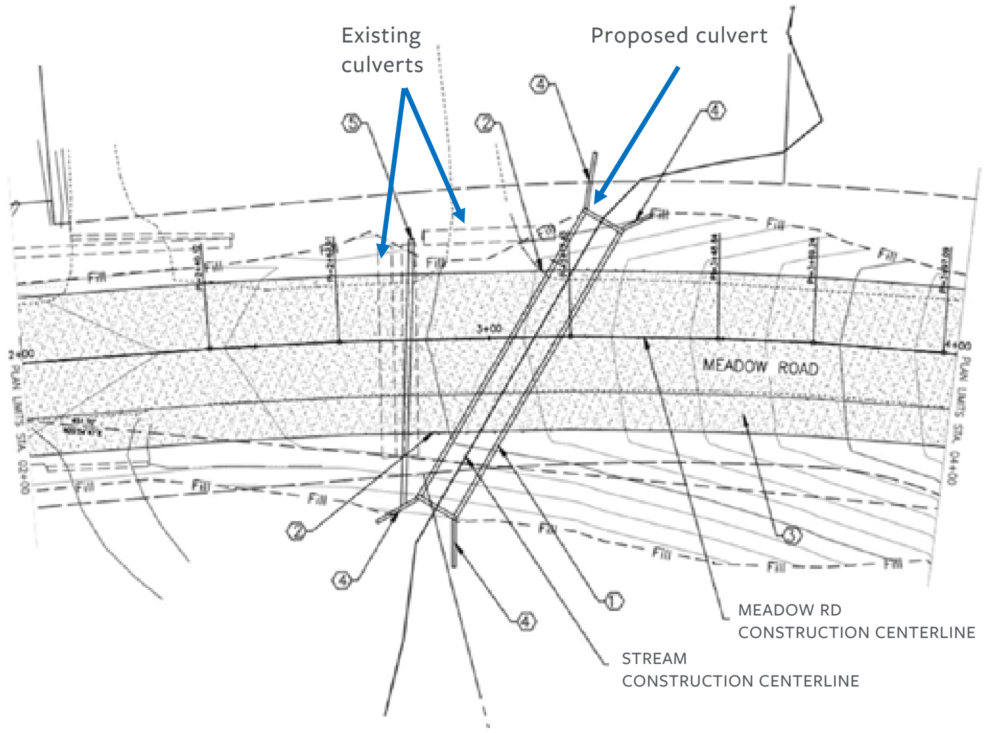
Seattle University

Department of Civil and Environmental Engineering

Infrastructure Improvement of a County Road



Perspectives On

Collaboration of faculty, students, and licensed professional engineers

A diverse group of five students worked on this project throughout the academic year. They were mentored and supervised by two engineers and a fish biologist from the county and two faculty members from the university, all holding active P.E. licenses. In addition, one of the faculty members is also a professional land surveyor (P.L.S.).

Our department has an advisory board consisting of a dozen practitioners from various subdisciplines related to civil engineering. All are P.E.s except for one who is an environmental scientist. The student team presented their project to the advisory board twice during the academic year—once in the early part of the year of their project understanding and plan of implementation, and the other at the end of the academic year when the project was completed.

The students also participated in the annual local section ASCE student presentation competition. Five P.E.s from various subdisciplines within civil engineering served as judges. Although the team did not win an award, the event gave them an additional opportunity to present their work to a group of licensed engineers and to answer questions.

Protection of public health, safety, and welfare

The project is part of a six-year development plan for the region. It involves widening the roadway to alleviate traffic congestion and improving pedestrian safety. The team planned signage and detours during construction to improve public safety. Making the culverts fish passable and developing an erosion and sediment control plan to alleviate the environmental impacts improve public welfare.

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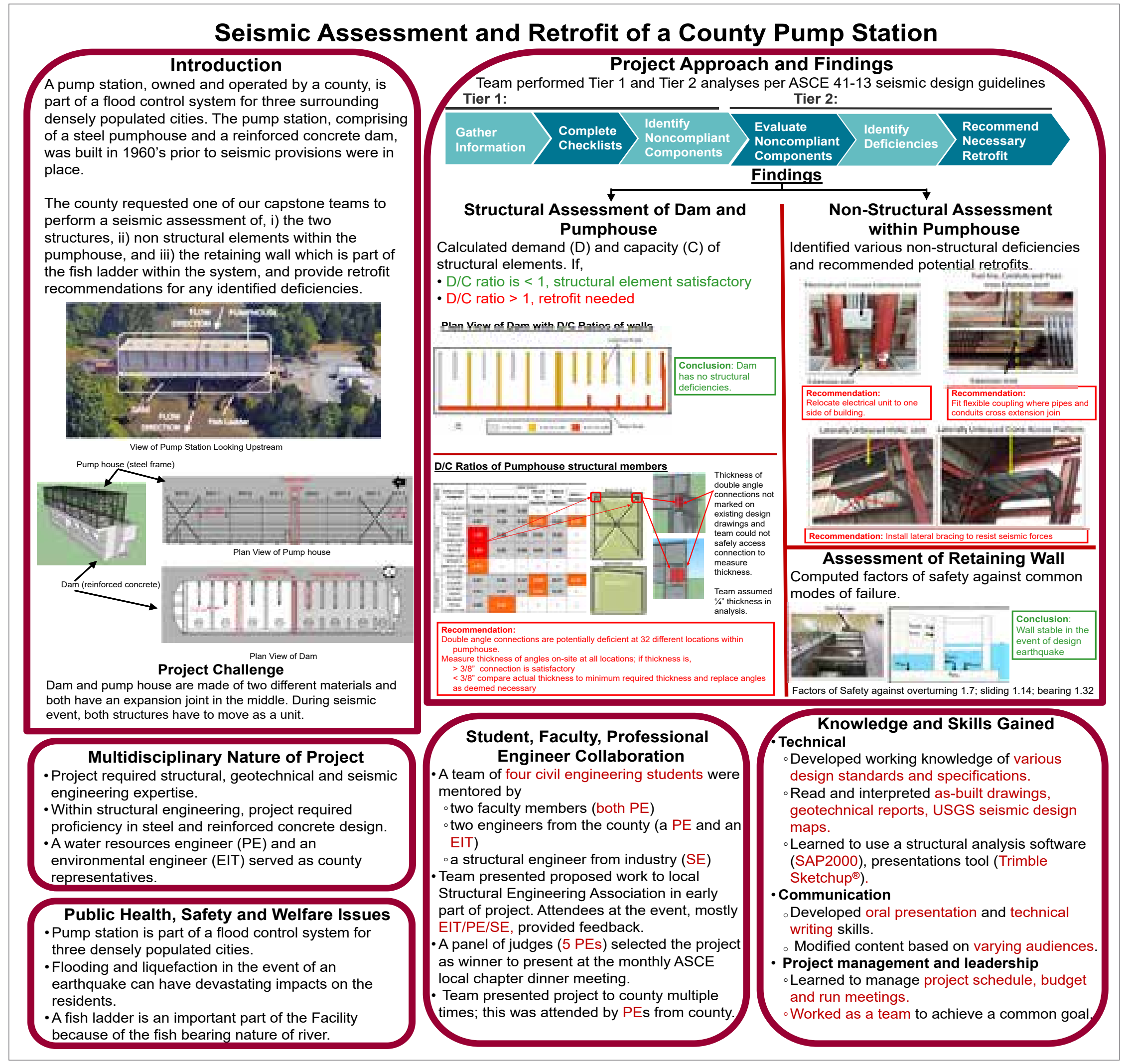
Seattle University

Department of Civil and Environmental Engineering

Seismic Assessment and Retrofit of a County Pump Station



Participants

Students

Angelica de Jesus
Austin Dennis, E.I.T.
Mashayla Combs
Ellen Fisher, E.I.T.
Moussa Tunkara, E.I.T.

Faculty

Nirmala Gnanapragasam, Ph.D., P.E.
Josh Pugh, Ph.D., P.E.

Professional Engineers and Engineers in Training

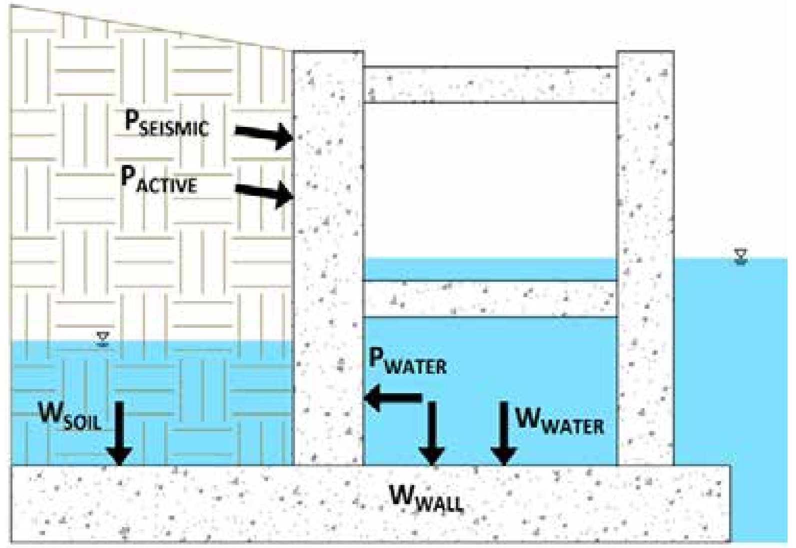
Thomas Bean, P.E. (*King County*)
Jessy Hardy, E.I.T. (*King County*)
David Webster, S.E. (*Thornton Tomasetti*)

Jury Comments

"Nice job with engineering analysis on preventative measure"

"Unique and beneficial to the community"

"Very important project for the protection of health and safety of the public"



Abstract

A team of four civil engineering seniors carried out seismic assessment of a pump station owned and operated by a county as part of their capstone project. The pump station is part of a flood control system for the region and came into operation in the early 1970s before seismic provisions existed. The pump station consists of a reinforced concrete dam and a steel pump house constructed on top of the dam. The county also requested the team to evaluate the functionality of non-structural elements housed within the pump house and an adjacent fish ladder in the event of an earthquake. Furthermore, the team was asked to research the liquefaction potential of the surrounding soil.

Assessment using the ASCE seismic design guidelines showed that the dam satisfied all seismic criteria with no deficiency. In the case of the pump house, double angle connections that fasten the beams to columns at 32 different locations within the structure were found to be potentially deficient. The team recommended that the county measure the thicknesses of the connections to ensure they met the minimum requirement or replace them with thicker angles. The team found several non-structural deficiencies of the pumphouse equipment and recommended suitable retrofits. The retaining wall forming the fish passage was found to be stable.

The students collaborated with several professional engineers (P.E.s) during the year. They worked under the guidance of two faculty members, both P.E.s. Two county staff members, one a water resources engineer (P.E.) and another an environmental engineer (E.I.T.), were the clients. Because the county did not have an in-house structural engineer, a structural engineer (S.E.) from a private company served as the county representative and subject-matter expert and mentored the team. The team presented their project to two professional organizations during the year: the Structural Engineering Association (SEA) and American Society of Civil Engineers (ASCE). Several E.I.T.s, P.E.s, and S.E.s attended these events and provided valuable feedback to the team.

The county initiated the project because of its concern for the public health, safety, and welfare

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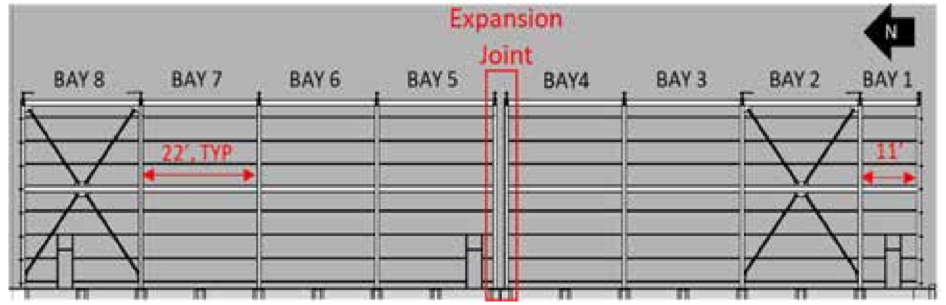
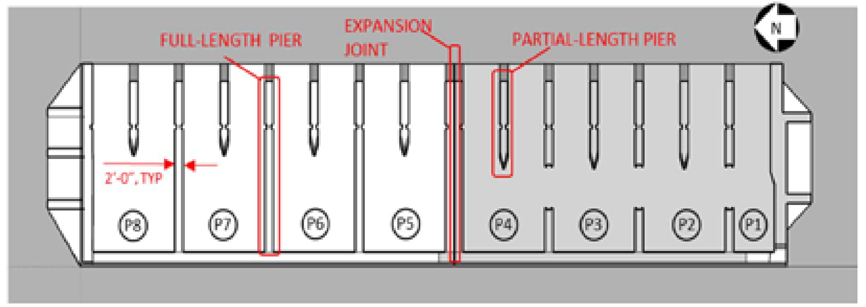
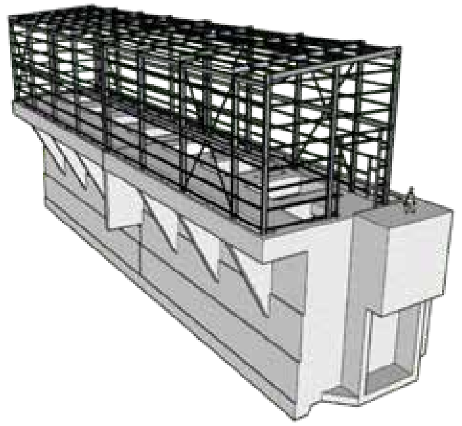
Seattle University

Department of Civil and Environmental Engineering

Seismic Assessment and Retrofit of a County Pump Station



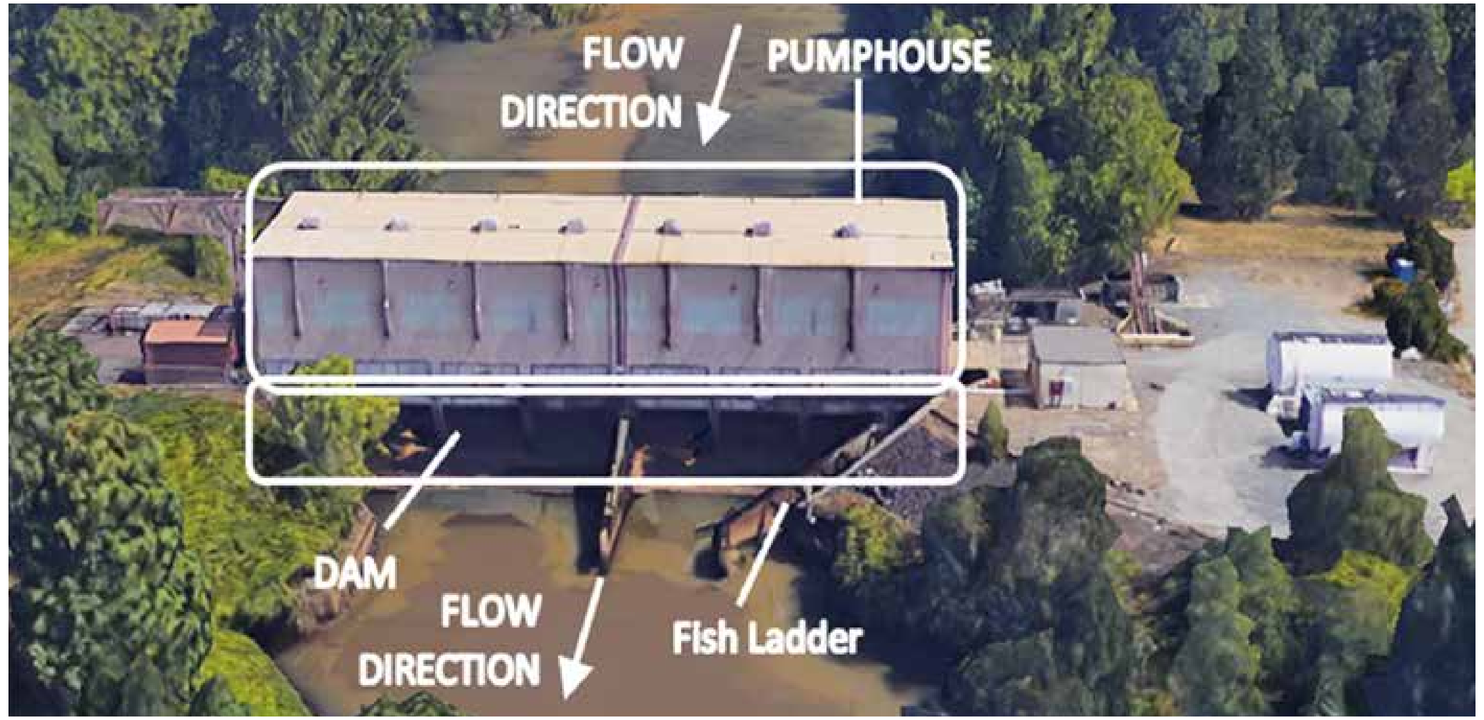




should the pump station fail during a seismic event. Flooding and liquefaction after an earthquake can have devastating impacts on the residents in the three surrounding cities.

This project required knowledge of multiple disciplines: structural, seismic, and geotechnical engineering. The pump station is constructed of reinforced concrete and steel. Therefore, students had to be familiar with construction materials, relevant design principles, and codes. Our undergraduate curriculum does not cover seismic engineering. Thus, the advisor and the structural engineer educated the team of the seismic engineering fundamentals necessary for the project. The students had to learn the rest on an as-needed basis with the help of the S.E. Stability analysis of the fish ladder required knowledge of geotechnical engineering and seismic engineering.

During the year, the students gained various knowledge and skills outside their regular coursework. The students used various building standards, design specifications, and a structural engineering software and developed familiarity reading as-built drawings, geotechnical reports, and seismic design maps. In addition to the technical skills listed above, they improved their communication skills through presenting to varying audiences and writing memos, proposals, and reports to the county. The students also honed their project management and leadership skills through team work, time management, scheduling, and the art of running professional meetings.



Perspectives On

Multidiscipline or allied profession participation

The project encompassed multiple disciplines within civil engineering: structural engineering for the assessment of the pump station (and within that subdiscipline, students had to analyze two different material types, steel and reinforced concrete) and geotechnical engineering for the stability analysis of the retaining walls. Our undergraduate curriculum does not cover seismic engineering. The faculty advisor and the structural engineer from the industry taught the team the fundamentals of seismic engineering, and the team had to learn more during the course of the project. The county personnel team consisting of a water resources engineer (P.E.) and an environmental engineer (E.I.T.) served as owner representatives.

Protection of public health, safety, and welfare

The project was initiated by the county because it was concerned that public health, safety, and welfare would be compromised if the facility failed during a seismic event. Flooding and liquefaction in the event of an earthquake can have devastating impacts on the residents in the three cities surrounding the project site. Therefore, the county required the assessment to be performed at the level of immediate occupancy of the facility after an earthquake. The proper performance of the fish passage after a seismic event is an environmental and public welfare concern.

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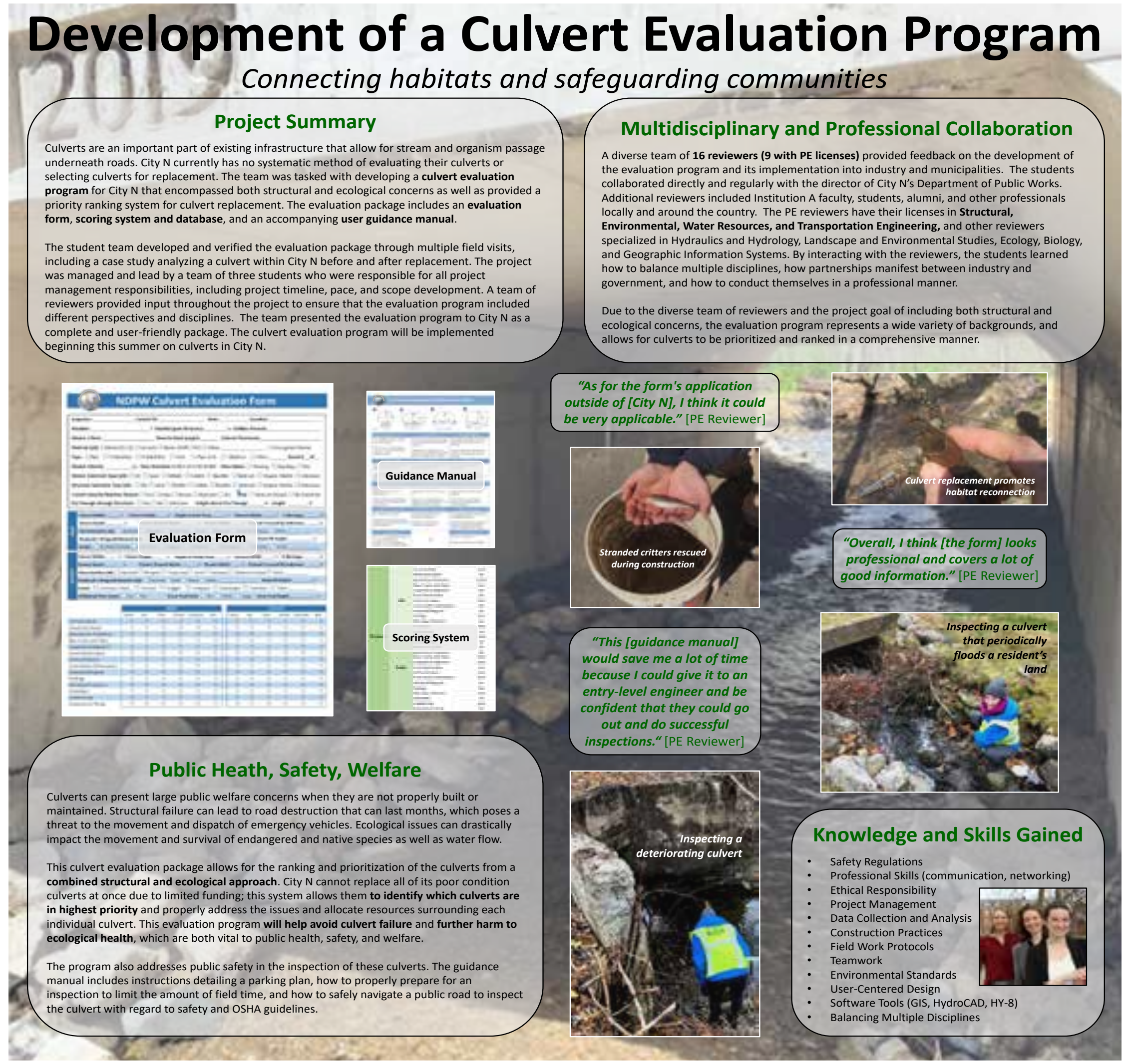
Smith College

Picker Engineering Program

Development of a Culvert Evaluation Program



Participants

Students

Molly Day
Tyler Feeney
Maia Tooley

Faculty

Andrew Guswa, Ph.D.
Susannah Howe, Ph.D.
Scott Jackson
Reid-Bertone Johnson, MLA, Ed.M.
Paul Wetzel, Ph.D.

Professional Engineers

Kristine Baker, P.E.
Liz Bartell, P.E.
Joyce Cheung, P.E.
Zachariah Chornyak, P.E.
Katy Kaproth-Gerecht, P.E.
Kim Reinauer, P.E.
Brett Towler, P.E.
David Veleta, P.E.
June Yeung, P.E.

Additional Participants

Karyn Nelson
Johanna Stacey

Jury Comments

"Very practical application and big impact on the community"

"Practical solution that can be immediately applied for the community's benefit"

"This is a novel project that helps to showcase how data analysis is helpful in engineering design and decision making."

Abstract

Culverts are a vital part of existing infrastructure that allow for stream and organism passage underneath roads. City N currently has no systematic method of evaluating their culverts or selecting culverts for replacement; information collection and replacement prioritization is challenging. The scope of this project was to develop a culvert evaluation program that would (1) address the lack of integration of ecological and structural concerns within existing culvert evaluations and (2) provide an objective method for prioritizing culverts for replacement. The evaluation program includes an evaluation form, a scoring system and database, and an accompanying user guidance manual.

The project was managed and led by a team of three female engineering students who were responsible for all project management responsibilities, including project timeline, pace, and scope development. Over the course of two semesters, the student team worked closely with their P.E. liaison from City N's Department of Public Works (DPW) and met weekly with a faculty liaison from Institution A and multiple times a week independently. By coordinating and scheduling all communication themselves, the student team learned the importance of both flexibility and accountability. The team developed a two-sided culvert evaluation form, an accompanying guidance manual, a condensed reference sheet for field work, ecological priority area shapefiles in GIS, and a culvert scoring system and database.

The students developed and refined the form through multiple field visits and input from four employees from City N's DPW (two P.E.s), five faculty from Institutions A and B in both engineering and environmental science, and seven P.E.s who work at civil engineering and water resource firms both locally and nationally. This team of mentors and reviewers involved throughout the project provided a range of perspectives and disciplines, supporting the team in creating a comprehensive product and in gaining a deeper understanding about the work of multidisciplinary professional engineers. The students verified that their evaluation program met all the project requirements: fast and easy deployment, integration of ecological and structural considerations, differentiation between culverts, and inter-rater reliability. The students also completed a verification case study of a culvert in City N directly before and after replacement, demonstrating that the scoring system provides sufficient distinction for City N's DPW to prioritize culverts for both structural and ecological health.

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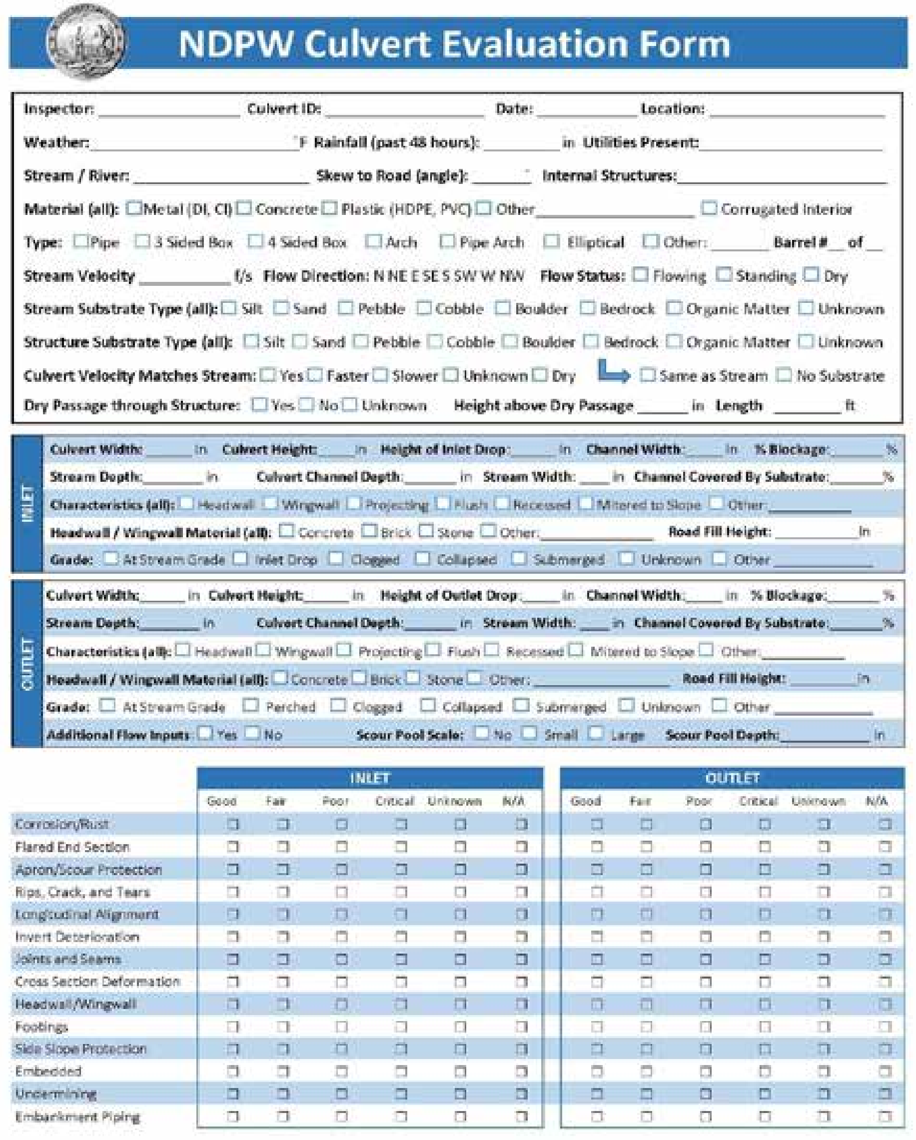
Picker Engineering Program

Development of a Culvert Evaluation Program



NDPW Culvert Evaluation Form

Inspector: ______ Culvert ID: ______ Date: ______ Location: ______

Weather: ______ °F Rainfall (past 48 hours): ______ in Utilities Present: ______

Stream / River: ______ Skew to Road (angle): ______ ° Internal Structures: ______

Material (all): ☐ Metal (DI, CI) ☐ Concrete ☐ Plastic (HDPE, PVC) ☐ Other ______ ☐ Corrugated Interior

Type: ☐ Pipe ☐ 3 Sided Box ☐ 4 Sided Box ☐ Arch ☐ Pipe Arch ☐ Elliptical ☐ Other: ______ Barrel # __ of __

Stream Velocity ______ f/s Flow Direction: N NE E SE S SW W NW Flow Status: ☐ Flowing ☐ Standing ☐ Dry

Stream Substrate Type (all): ☐ Silt ☐ Sand ☐ Pebble ☐ Cobble ☐ Boulder ☐ Bedrock ☐ Organic Matter ☐ Unknown

Structure Substrate Type (all): ☐ Silt ☐ Sand ☐ Pebble ☐ Cobble ☐ Boulder ☐ Bedrock ☐ Organic Matter ☐ Unknown

Culvert Velocity Matches Stream: ☐ Yes ☐ Faster ☐ Slower ☐ Unknown ☐ Dry ☐ Same as Stream ☐ No Substrate

Dry Passage through Structure: ☐ Yes ☐ No ☐ Unknown Height above Dry Passage ______ in Length ______ ft

INLET

Culvert Width: ______ in Culvert Height: ______ in Height of Inlet Drop: ______ in Channel Width: ______ in % Blockage: ______ %

Stream Depth: ______ in Culvert Channel Depth: ______ in Stream Width: ______ in Channel Covered By Substrate: ______ %

Characteristics (all): ☐ Headwall ☐ Wingwall ☐ Projecting ☐ Flush ☐ Recessed ☐ Mitered to Slope ☐ Other: ______

Headwall / Wingwall Material (all): ☐ Concrete ☐ Brick ☐ Stone ☐ Other: ______ Road Fill Height: ______ in

Grade: ☐ At Stream Grade ☐ Inlet Drop ☐ Clogged ☐ Collapsed ☐ Submerged ☐ Unknown ☐ Other ______

OUTLET

Culvert Width: ______ in Culvert Height: ______ in Height of Outlet Drop: ______ in Channel Width: ______ in % Blockage: ______ %

Stream Depth: ______ in Culvert Channel Depth: ______ in Stream Width: ______ in Channel Covered By Substrate: ______ %

Characteristics (all): ☐ Headwall ☐ Wingwall ☐ Projecting ☐ Flush ☐ Recessed ☐ Mitered to Slope ☐ Other: ______

Headwall / Wingwall Material (all): ☐ Concrete ☐ Brick ☐ Stone ☐ Other: ______ Road Fill Height: ______ in

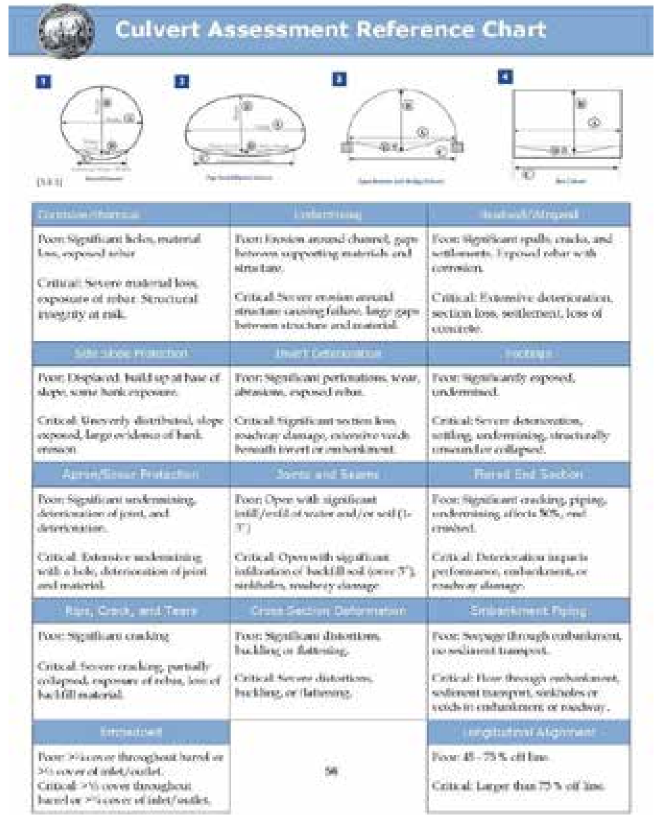
Grade: ☐ At Stream Grade ☐ Perched ☐ Clogged ☐ Collapsed ☐ Submerged ☐ Unknown ☐ Other ______

Additional Flow Inputs: ☐ Yes ☐ No Scour Pool Scale: ☐ No ☐ Small ☐ Large Scour Pool Depth: ______ in

	INLET						OUTLET					
	Good	Fair	Poor	Critical	Unknown	N/A	Good	Fair	Poor	Critical	Unknown	N/A
Corrosion/Rust	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Flared End Section	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Apron/Scour Protection	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Rips, Crack, and Tears	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Longitudinal Alignment	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Invert Deterioration	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Joints and Seams	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Cross Section Deformation	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Headwall/Wingwall	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Footings	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Side Slope Protection	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Embedded	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Undermining	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Embankment Piping	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

The team presented the culvert evaluation program to City N as a complete and user-friendly package; implementation will begin summer 2019 in City N. Although the culvert evaluation program was developed for City N, it is applicable to municipalities around the country, as confirmed by the feedback from the seven P.E.s outside of City N. A fundamental lesson the students learned during this project was the immense importance of culverts to public health and safety and to ecological health and habitat connectivity.

All three students involved in this project plan to take the Fundamentals of Engineering (FE) exam by the beginning of summer 2019, and all three will also be completing an ABET-accredited engineering degree. Two of the students have already accepted jobs working under licensed female engineers, and all three plan to continue to pursue licensure and careers in engineering.



Scoring System

Structural	Inlet	Corrosion/Rust	Good
		Flared end section	Fair
		Apron/Scour Protection	Critical
		Rips, Cracks, and Tears	Poor
		Longitudinal Alignment	Fair
		Invert Deterioration	Fair
		Joints and seams	Good
		Cross Section Deformation	Fair
		Headwall/Wingwall	Fair
		Footings	Poor
		Side Slope Protection	Fair
		Embedded	Good
		Undermining	Poor
		Embankment Piping	Good
	Outlet	Corrosion/Rust	Fair
		Flared end section	Fair
		Apron/Scour Protection	Fair
		Rips, Cracks, and Tears	Good
		Longitudinal Alignment	Good
		Invert Deterioration	Poor
		Joints and seams	Good
		Cross Section Deformation	Good
		Headwall/Wingwall	Fair
		Footings	Poor
		Side Slope Protection	Good
		Embedded	Fair
		Undermining	Good
		Embankment Piping	Fair

Perspectives On

Collaboration of faculty, students, and licensed professional engineers

This project involved a student team of three engineering seniors, coached by an engineering faculty member. The team collaborated closely with a professional engineer at City N's Department of Public Works (DPW), who served as both liaison and mentor. The team submitted weekly progress reports and had regular meetings with both the coach and the liaison. The team worked closely with each other, meeting several times each week for the duration of the eight-month project. They were in charge of coordinating the project throughout the duration, scheduling meetings, organizing work sessions, holding design reviews, and identifying and reaching out to collaborators for feedback and advice. Through this management process, the team learned the importance of self-accountability and scheduling. They also collaborated with four fellow senior engineering students who served as shadows to the project, testing the evaluation form and participating in design reviews. The team also received feedback on the evaluation materials from four other faculty members at Institution A, two within the engineering department and two from landscape and environmental studies, plus six P.E.s working in civil engineering and water resources firms regionally and nationally.

The team gained valuable input on their design work from multiple professional engineers and, in turn, used the input to improve the clarity and quality of every part of the evaluation program: the form, the guidance manual, and the scoring system. Many P.E. comments reinforced the importance of the components of the evaluation program that the team had already developed. The team's initial scope of work was to develop a culvert evaluation program specifically for City N, but the team gained insight about adapting the evaluation program and form through their interaction with P.E.s around the county; the form could easily be applicable for use in other municipalities and states.

The team learned many lessons through collaboration that

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Smith College

Picker Engineering Program

Development of a Culvert Evaluation Program

they would not have learned in a classroom setting. They experienced professional networking directly and through observation. They learned about how industry and government partner on projects through the case study of a culvert replacement. Since City N's engineers do not have time to undertake the design work needed for culvert replacement, they bid out the project to local consulting firms. The team also learned about how government engineering organizations and the public interact, in particular about how city governments communicate with the public and those affected by public works projects, as well as the influence the public has over these processes. In the case study of culvert replacement, the city had to push back the timeline for the replacement process due to public pressure, because the traffic detour required by the project was substantial. The team learned about the construction process through a visit to the culvert replacement site, gaining a more thorough understanding of the coordination it takes to complete a project in a residential area.

This project connected directly to many issues and ideas that professional engineers grapple with every day. At the center of the project was the process of balancing the need for both structural safety and ecological health while minimizing cost. The team learned

about which culverts get funded for replacement, which do not, and how this process happens. This knowledge came directly from the collaboration with professional engineers.

Protection of public health, safety, and welfare

Culvert condition has great impacts on the health, safety, and welfare of the public. The main goal of this project is to bring culverts with certain structural or ecological issues to the forefront of the DPW's attention so they can be properly targeted and prioritized in respect to other culverts in the city that may not have pressing needs. The primary benefit of a culvert priority ranking system to the greater public is that it can help prevent larger problems from occurring. From a structural view, if a culvert were to washout or fail, the roads over these culverts can be out for months at a time. From a public safety standpoint, a collapsed road can prevent the proper movement and dispatch of emergency vehicles, which can have great impacts on a community. Along with these issues, a failed culvert puts a large financial burden on the city at hand to rush through a design process and replacement. With culvert replacements costing hundreds of thousands of dollars, finding out which culverts are close to failure and replacing them before they do fail is in the best interest of the DPW and the public.

On the other hand, ecological issues can also present unique challenges. Culverts that limit aquatic and terrestrial organism passage can bring about the death of native and endangered species, which in turn can impact the ecological and public health of the surrounding area. For example, there is a culvert in City N that does not allow for proper terrestrial organism passage from downstream to an upstream pond and breeding ground. Due to the physical barrier, the terrestrial animals, such as turtles, have to cross the road in order to reach their destination. When they attempt to cross the road, they are killed by passing cars. A citizen in City N routinely brings posters of the dead turtles to City N City Council meetings to try to bring awareness to this issue.

After developing the evaluation package and researching other packages in use around the country, the team clearly recognized that the impacts of poorly designed culverts extend far beyond water overtopping roads. The greater structural and ecological implications that culverts can have are often hidden from the public until it is too late. By developing a culvert priority ranking system that brings the problematic structures to the forefront of the DPW, the city can tackle issues in a timely manner and address previously invisible problems before they devastate infrastructure and residents' lives.

Along with the prioritization scoring, the team also addressed public safety in the inspection of these culverts. For example, the guidance manual includes instructions detailing how to inspect culverts with regards to OSHA and other safety guidelines. The instructions include a detailed parking plan, how to properly prepare for an inspection to limit the amount of field time, and how to safely navigate a public road to inspect the culvert.

While this project was initially intended specifically for City N's DPW, there are many themes that ring true to communities nationally. Most importantly, the project's key value is that it takes two traditionally separated culvert concerns—structural and ecological—and considers both on the same scale. Traditionally, city DPWs care primarily about a culvert's structural condition, and environmental advocacy groups focus on the ecological angle. This new integrated framework enables DPWs to more actively and systematically include ecological perspectives as well as properly allocate resources for culvert replacement, which will allow for a more sustainable future for the culverts and city infrastructure. There are tens of millions of culverts across the United States. If more DPWs could implement clearer culvert ranking systems that encourage interdisciplinary thinking like City N, the impact on the health, safety, and well-being of the nation would be immense.

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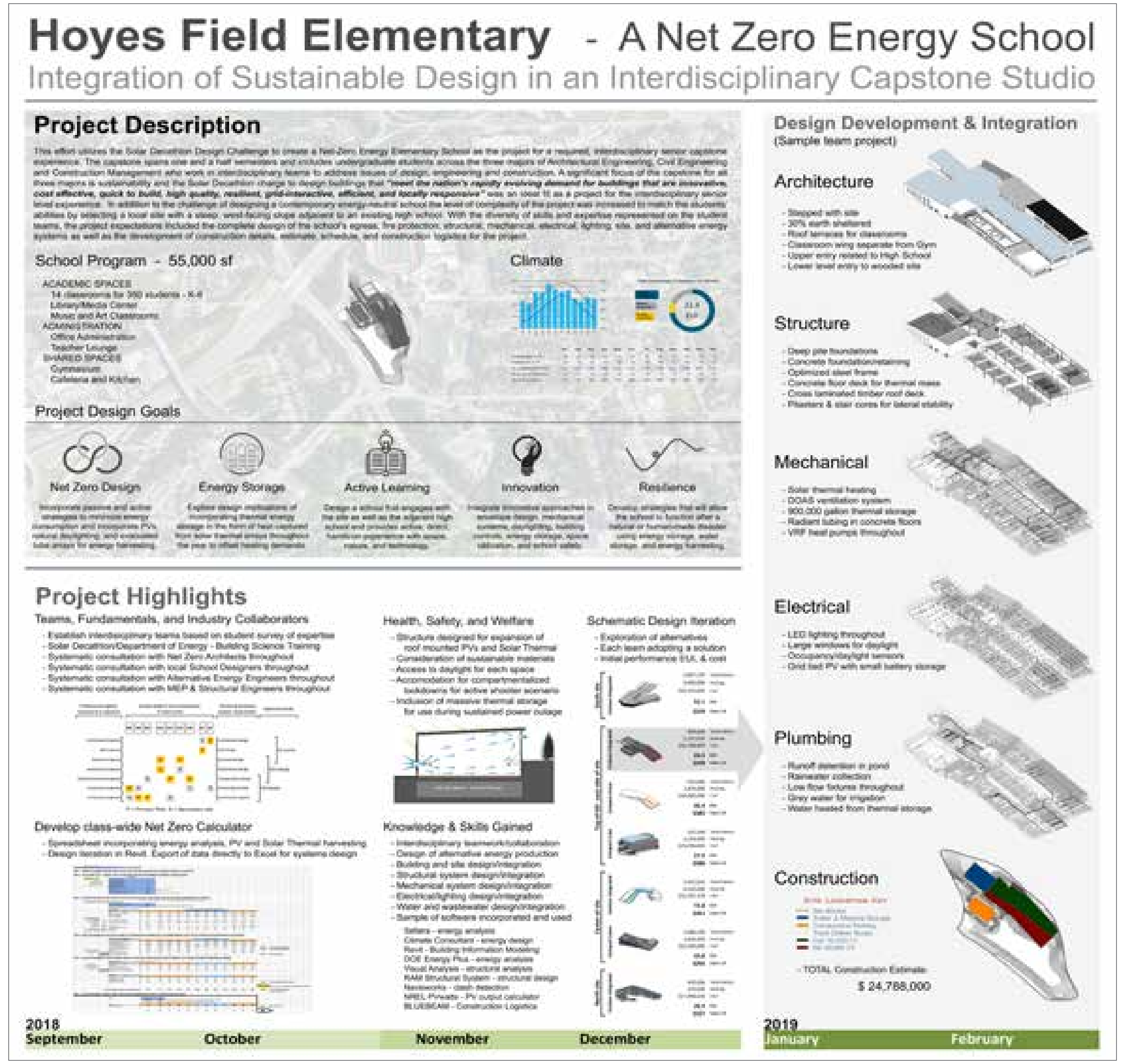
University of Cincinnati

Department of Civil and Architectural Engineering and Construction Management

Hoyes Field Elementary—A Net-Zero Energy School



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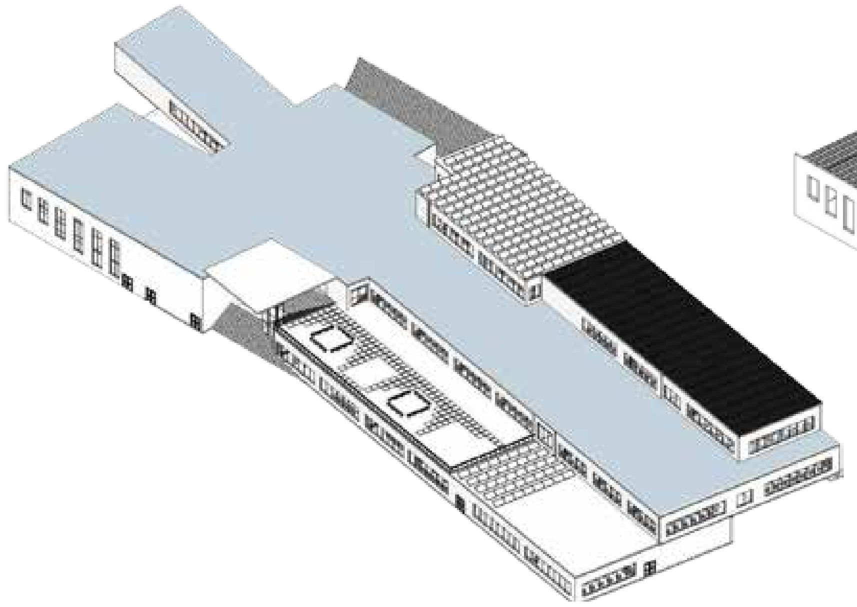

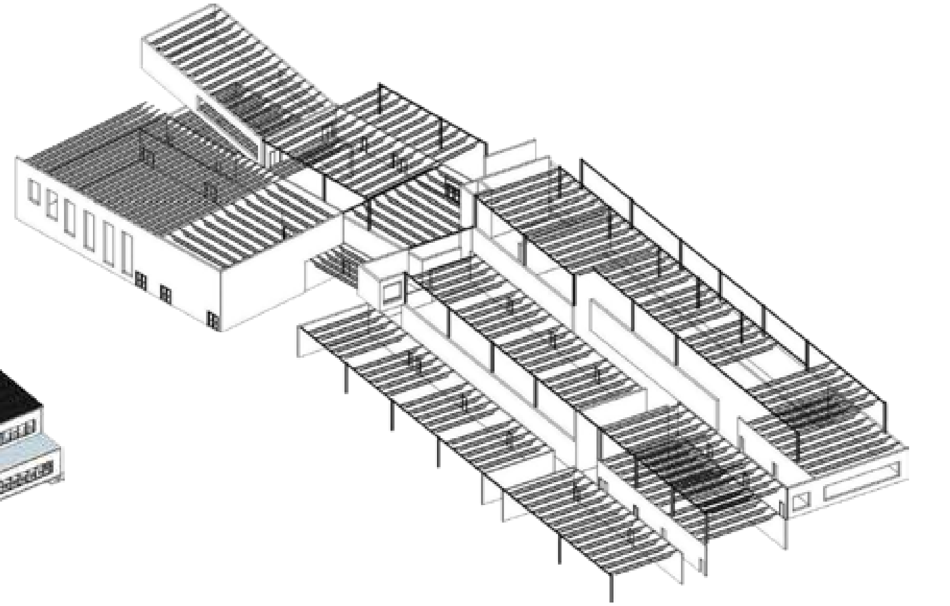

Professional Engineers

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Nabil Nassif, P.E.
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John Noble, A.I.A.
Jeff Parker, A.I.A.
Jasmine Whitfield, E.I.T.
Emma Wilhelmus, E.I.T.

Jury Comments

"Good cross-discipline collaboration"

"Showed clearly the relationship between the P.E. consultants and the students"

"Substantial involvement of P.E.s across multiple disciplines"

Abstract

This effort utilizes the Solar Decathlon Design Challenge to create a Net-Zero Energy Elementary School as the project for a required, interdisciplinary senior capstone experience. The capstone spans one and a half semesters and includes undergraduate students across the three majors of architectural engineering, civil engineering and construction management, who work in interdisciplinary teams to address issues of design, engineering, and construction. A significant focus of the capstone for all three majors is sustainability, and the Solar Decathlon charge to design buildings that "meet the nation's rapidly evolving demand for buildings that are innovative, cost effective, quick to build, high-quality, resilient, grid-interactive, efficient, and locally responsive" was an ideal fit as a project for the interdisciplinary senior-level experience. In addition to the challenge of designing a contemporary energy-neutral school, the level of complexity of the project was increased to match the students' abilities by selecting a local site with a steep, west-facing slope adjacent to an existing high school. With the diversity of

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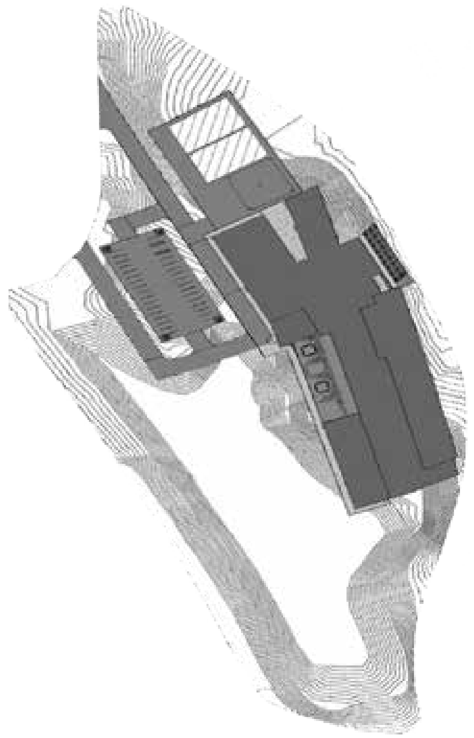
Hoyes Field Elementary—A Net-Zero Energy School



skills and expertise represented on the student teams, the project expectations included the complete design of the school's egress, fire protection, structural, mechanical, electrical, lighting, site, and alternative energy systems as well as the development of construction details, estimate, schedule, and construction logistics for the project.

A unique aspect of the required capstone year is the creation of teams incorporating students from all three majors that work collaboratively in a studio environment to solve a complex design problem. Teams are formed in a "blind" process according to student responses to a survey in which they identify their area of focus and expertise and every effort is made to balance each team so that primary and secondary levels of interest and expertise yields at least one and ideally two individuals on each team who have sufficient depth of knowledge in their sub-discipline. Areas of student expertise include building design, building systems engineering (MEP,) structural engineering, geotechnical engineering, transportation engineering, construction engineering, and construction management.

Local consulting engineers and architects were identified early on in the Fall term, matching their expertise with the project chosen for the capstone, and then were invited on a regular basis to provide individual feedback to teams as the projects progressed as well as feedback during formal presentations at midterm and final design stages. Several individuals from the firms participated as well, enriching the feedback by bringing alternative perspectives for the teams to consider. The focus on holistic building design and integration of the various systems, including alternative energy production, resulted in the innovative proposal to include massive thermal energy storage in the designs by incorporating evacuated tube solar thermal collectors and harvesting the heat all summer long when school is not in session and storing it for the winter months.

By default, the students on each team from the different disciplines experienced significant cross-over of knowledge and skills on a routine basis. For example, structural engineering students learned about HVAC design from the AE students, and the AE students learned about construction scheduling from the construction engineering students. Furthermore, since alternative energy production and net-zero design is not currently a part of the curriculum leading up to the capstone studio for any of the three majors in the department, the knowledge learned and skills gained in design, engineering, and the use of software, such as Enscape, Navisworks, Revit, Sefaira, RAM structural, Energy Plus, Bluebeam, were profound across all disciplines.

Perspectives On

Protection of public health, safety, and welfare

The protection of public health, safety, and welfare was a primary focus of the studio in several respects. During the design process, students considered each design decision with respect to these issues. The elementary school project raised the level of engagement with health, safety, and welfare issues to the foreground throughout the design process.

An aspect of sustainable design is to minimize impacts on the environment by incorporating materials that have low or no VOCs, have high recycled content or can be easily recycled, and minimize the use of carbon in their manufacturing, delivery, and installation processes. This led most teams to consider the use of heavy timber and cross laminated timber as a viable alternative for portions of their buildings, as the wood was both a natural material with no volatile organic compounds and could also sequester carbon within the building at the same time. Maximizing natural daylight in all spaces also has direct benefits to the health of faculty, staff, and students.

At early stages, safety of the children during drop-off and pick-up forced students to consider several iterations that avoided dangerous interactions between school bus access and vehicular access by parents. These transportation and site issues had profound impacts on every team's design. Once designs began to emerge, local architects and fire protection professionals provided feedback about emergency egress and fire protection. These issues also impacted designs in terms of circulation within the building and exiting from the building during a fire that were complicated by the steep, sloped site. One consideration brought up by the school design expert, which students were wholly unprepared to cope with, was to divide the school into "lockdown compartments" to minimize access by an active shooter. This safety issue left an indelible mark on both the students and their designs.

Since taxpayer money is used to fund operations and utilities in public schools, by default, a net-zero energy building addresses the issue of public welfare by reducing the ongoing tax burden associated with utility bills. Typically, total cost of building construction and operating costs are calculated over a 20-year period in order to justify the initial investment of higher-quality materials and alternative energy installations. However, with many of the warrantees and life expectancies expiring at 20 years, our students calculated the life cycle cost for a 30-year period when pumps, PV panels, roofing, etc., expire or need to be replaced. This extended life cycle analysis provided further verification that investment in higher quality construction and net-zero energy production would actually make economic sense. Depending on the specific team design, this analysis revealed overwhelming support for the initial and ongoing investments, while in other designs, it was more difficult to justify.

The students in the construction engineering and management area of focus provided constructability reviews during the process as well as value engineering reviews at major stages of design. These efforts helped the teams make informed and wise choices about form, site integration, materials, etc. For example, during initial architectural design, the designers chose to step the foundations on the sloping site; the value engineering review suggested that one larger excavation would reduce cost significantly. This suggestion resulted in several thousand square feet of unneeded space buried deep within the building that then was put to good use by serving as the large volume required for the storage of thermal energy collected during the summer months.

Knowledge and skills gained

As mentioned previously, the capstone students in civil engineering and construction management had little to no experience in holistic design and building systems integration, pushing them even further to the edge of their comfort zone. To address this, the capstone faculty developed a systematic methodology for the generation and evaluation of alternatives as a way to accelerate the schematic design and site integration process. This was a new concept for all students and added a powerful approach to

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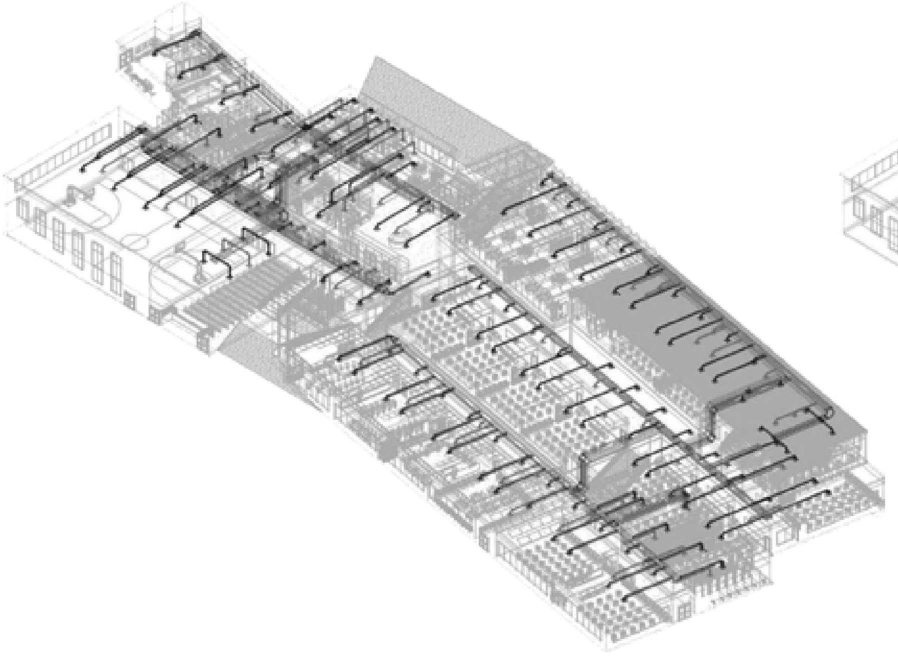
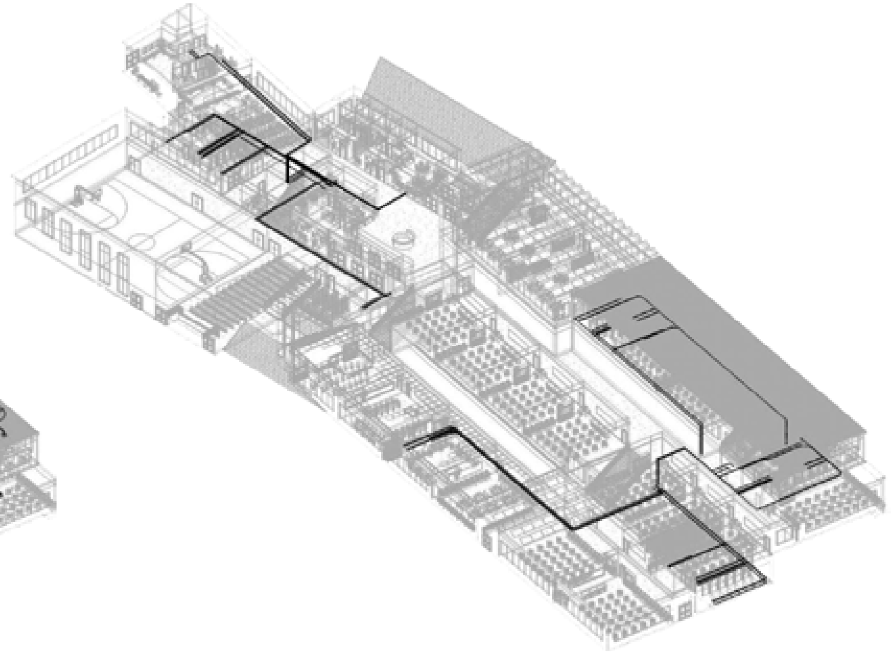
Hoyes Field Elementary—A Net-Zero Energy School

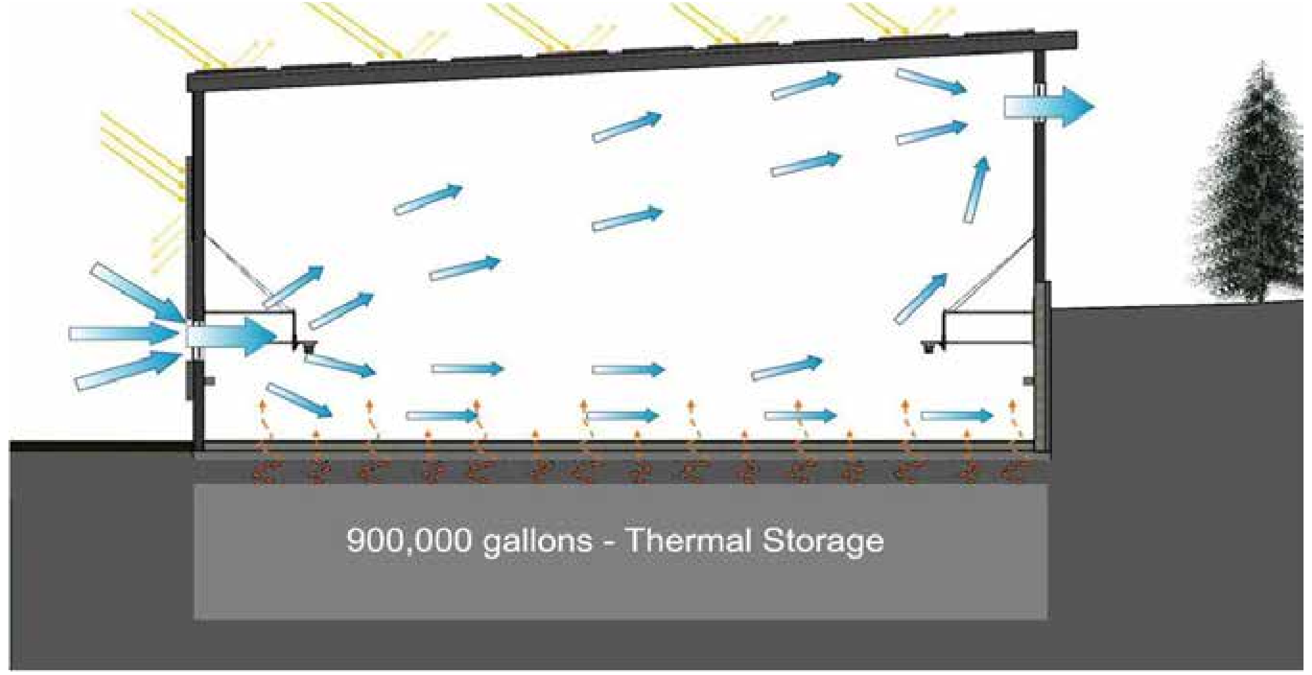




their arsenal of engineering and design strategies.

The capstone effort also represents the first time most of the students actively worked on a multidisciplinary team to solve a comprehensive and complex design problem. The students quickly resolved to use Revit to create a single model for collaboration and integration of structural, mechanical, electrical, plumbing, and alternative energy systems. To help facilitate the collaboration of the team members, Autodesk donated licenses of BIM 360 to the capstone teams, exposing the students to this powerful collaboration tool as well. For many of the civil engineering and CM students, this was the first significant effort in the use of Revit and for students in all three majors, this was the first time using BIM 360 as a collaboration tool. Introduction to other new software such as Enscape, Navisworks, and Bluebeam provided additional opportunities for students to exercise or gain new experience with advanced tools. The lessons learned about collaboration, communication, presentation, compromise, integration, and design throughout the process was invaluable.

Since none of the capstone students had experience in the design and



integration of alternative energy strategies, the learning curve here was equally steep and intense. Students were exposed to new concepts and tools for designing and integrating Photovoltaic systems and Solar thermal collection into their buildings. All students in all three majors on the Solar Decathlon design teams were required to complete 10 hours of online training in building science offered by the National Renewable Energy Laboratory (NREL) Students also developed new skills and knowledge in this area by learning and using software such as NREL's PVwatts calculator, Solar Thermal Output calculator developed by XXX Mechanical Engineer, Trimble-Sefaira for early stage analysis of building design performance, and lighting simulation and other energy modeling and simulation tools. From these various tools and the building science training, students (one from each team) collaboratively developed a single spreadsheet tool to help them determine net zero demands for their emerging designs. The spreadsheet incorporates and links data exported from Revit, HVAC, lighting and electric loads, and output from PVs and Solar thermal to calculate the number of PV panels, the number of Evacuated tube arrays, and the gallons of thermal storage required for an iteration of their design to reach net-zero.

The lessons learned by the three faculty mimics what the students learned, since none of three are necessarily "experts" in alternative energy design, BIM collaboration, or in the use of the software introduced. Of greater importance, the lessons learned that we will carry to the delivery of the capstone next year can be summarized in the following bullet points.

- To combat "senioritis," institute more deadlines throughout the process. Students work better if there is a specific deadline to respond to.
- To minimize the time "floundering" during schematic design, begin the senior year with the building science training in parallel with a series of specific lectures on alternative and energy training sessions in the use of new software.
- To help with communication and to accelerate the schematic design phase, expand the teams to include one to two architecture majors.
- To increase direct communication with and input from consulting engineers, create a mechanism that allows our partners to collaborate with teams on a much more regular and intimate basis.

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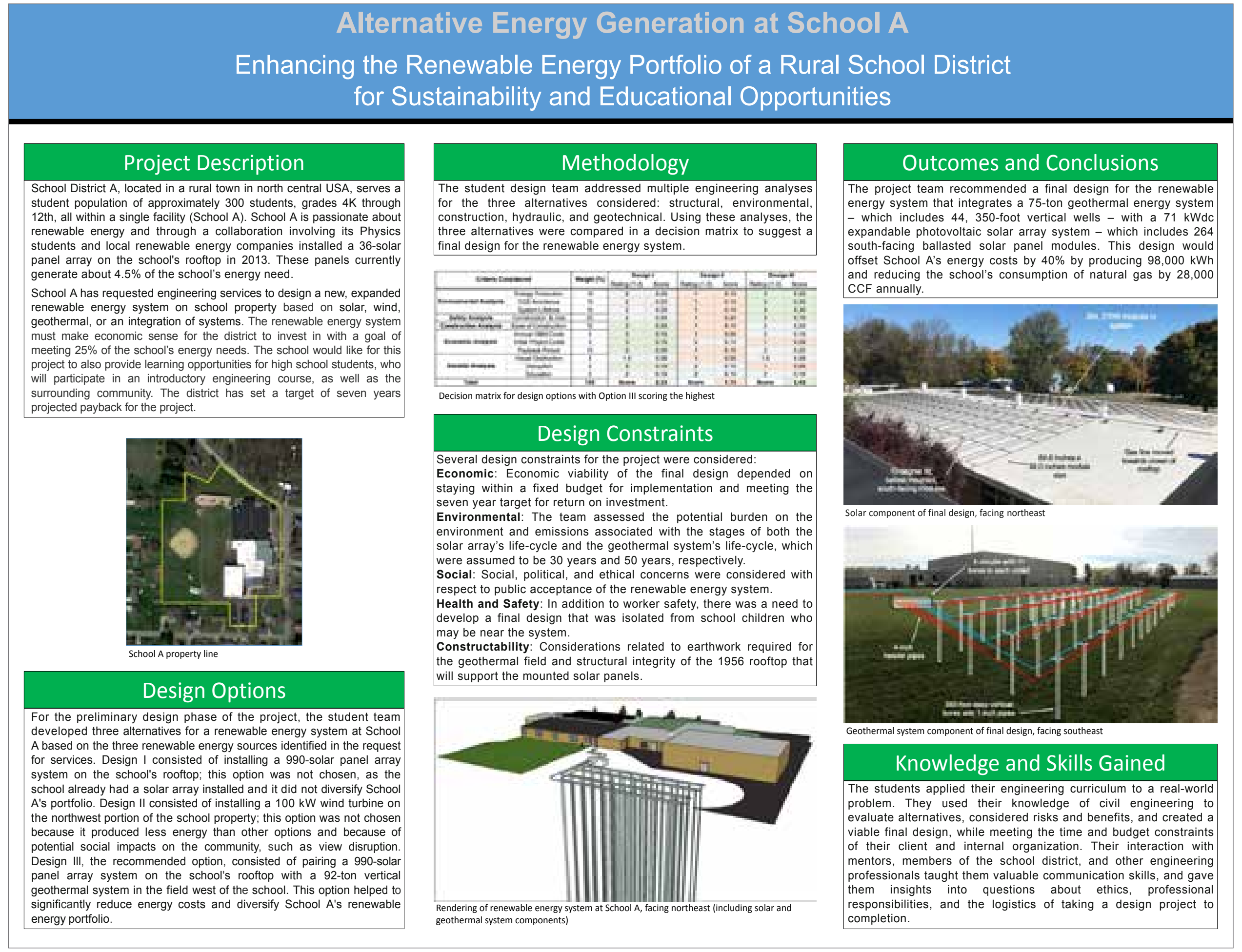
University of Wisconsin–Madison
Department of Civil and Environmental Engineering
Alternative Energy Generation School A



Participants

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Faculty

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Jan Kucher, P.E.
Mark Oleinik, P.E.
Charles Quagliana

Professional Engineers

Jim Ternus, P.E.

Additional Participants

Ian Berg
Joyce Casey
Rex Loker, A.I.A.

Jury Comments

"Practical engineering problem-solving process"

"Nice job with the evaluation of different alternatives"

"Pragmatic and real"

Abstract

School District A, located in a rural town in central USA, serves a student population of approximately 300 students, grades 4K through 12, all within a single facility (School A). School A is passionate about renewable energy and, through a collaboration involving its Physics students and local renewable energy companies, installed a 36-solar panel array on the school's rooftop in 2013. These panels currently generate about 4.5 percent of the school's energy need. School A has requested engineering services to design a new, expanded renewable energy system on school property based on solar, wind, geothermal, or an integration of systems. The goals of the renewable energy system are to help subsidize energy costs by meeting 2 percent of the school's energy needs and provide educational opportunities for its students.

In collaboration with P.E.s and two School A project leaders, a team of five undergraduate civil and environmental engineering students worked to evaluate the costs and output of the solar, wind, and/or geothermal deployment and their associated budget ranges, cost/benefit analysis, and lifetime sustainability in order to recommend a final design that met the school's goals for energy output, environmental sustainability, and education opportunities.

The students developed three design alternatives, preparing a concept design for each by applying engineering analyses for the three alternatives with structural, environmental, construction, hydraulic, and geotechnical engineering considerations. Then having achieved an understanding of the primary design constraints of the project, they prepared an evaluation matrix in which weighted decision criteria were applied to each concept design. Based on input from their collaborators, including the School A renewable energy system project leaders, the team made a recommendation to proceed with a final design that integrates geothermal and photovoltaic solar components. This design was shown to diversify School A's renewable energy portfolio while reducing annual energy costs by 40 percent.

As noted, several design constraints for the project were considered. Economic viability of the final design depended on staying within a fixed budget for implementation and meeting a target of seven years' projected payback. As a sustainability project, the team assessed the potential burden on the environment and emissions associated with the stages of both the solar array's life cycle and the geothermal system's life cycle, which northeast (including solar and geothermal system components) were assumed to be 30 years and 50 years, respectively. Social, political, and ethical concerns were considered with respect to public acceptance of the renewable energy system. In addition to worker safety, there was an important need to develop a final design that was isolated from school children who may have been near the system. Finally, constructability considerations related to earthwork required for the geothermal field and structural integrity of the 1956 rooftop that will support the mounted solar panels.

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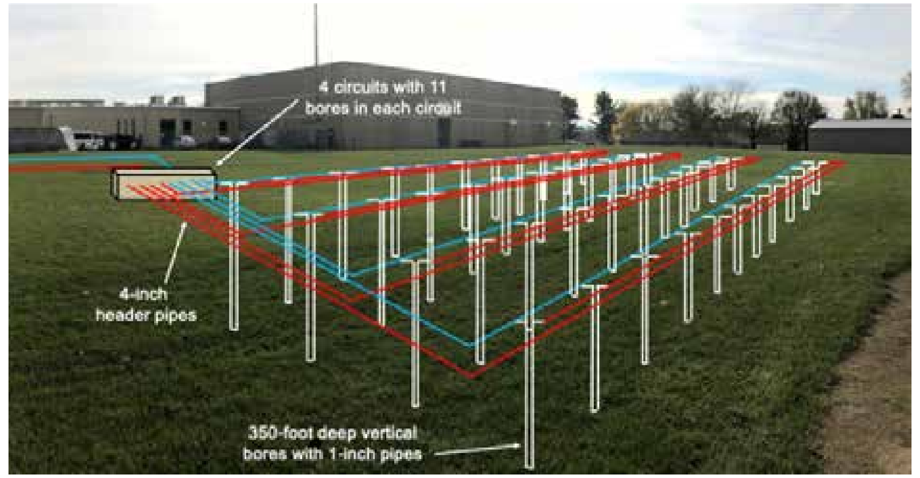
Department of Civil and Environmental Engineering

Alternative Energy Generation School A



Perspectives On

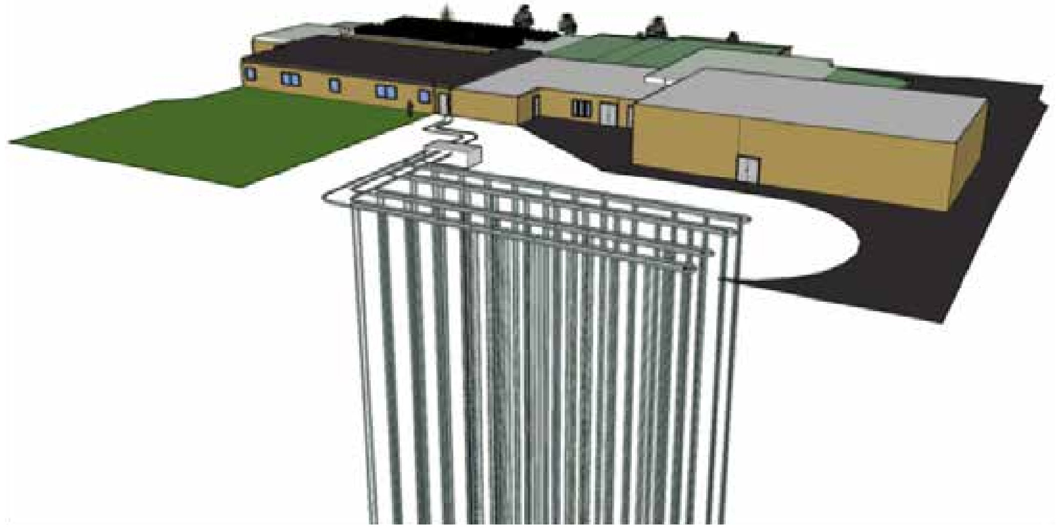
Protection of public health, safety, and welfare

The student team was challenged to evaluate the three design alternatives based on environmental, safety, and societal considerations. Constructability and economic viability were also considered. Economic viability of the final design depended on staying within a fixed budget for implementation and meeting a target of seven years' projected payback. As a sustainability project, the team assessed the potential burden on the environment and emissions associated with the stages of both the solar array's life-cycle and the geothermal system's life cycle, which were assumed to be 30 years and 50 years, respectively. Social, political, and ethical concerns were considered with respect to public acceptance of the renewable energy system. In addition to worker safety, there was an important need to develop a final design that was isolated from school children who may be near the system. Finally, constructability considerations related to earthwork is required for the geothermal field and structural integrity of the 1956 rooftop that will support the mounted solar panels. The selected design scored highest with respect to environmental and safety considerations and very well with respect to societal considerations.

As noted, the student team assessed the potential burden on the environment and emissions associated with the stages of both the solar array's life cycle and the geothermal system's life cycle. A cradle-to-grave assessment was completed, and the amount of energy required for the whole life cycle of the solar system and geothermal system were found to be approximately 280,000 MJ and 110,000 MJ, respectively. The student team also found that this design would reduce the school's emissions by approximately 8,200 tons of carbon dioxide annually.

Multidiscipline or allied profession participation

During this project, the work by the student team included structural, geotechnical, environmental, hydraulic, and construction engineering, drafting, estimating, scheduling, client and community interaction, review of regulatory requirements and professional standards, and preparation of written reports and construction documents. The five civil and environmental engineering students logged approximately 1,200 hours of design work, including team meetings and meetings with mentors and faculty.



Examples of the multidisciplinary engineering analysis performed by the student team follow:

Structural Engineering. The structure that will support the solar array was built in 1956, a time when structures were built to support a snow load of 30 pounds per square foot (psf). Current codes only require 20 psf for snow load. Therefore, the solar panels can weigh up to 10 psf, but the proposed system would only add approximately 5.2 psf of load. The structural analysis of the roof-mounted array also accounted for loading due to wind. The proposed solar array will be installed using a ballast mounting technique, which is ideal because it eliminates rooftop penetration.

Construction Engineering. The site staging and sequence of construction was established for the proposed design. The vertical well geothermal system will be installed in the field west of the school, which is easily accessible.

Hydraulic Engineering. To appropriately size the geothermal system, an analysis of the system's flow rates was conducted acknowledging anticipated head losses. This allowed the student team to correctly size all pipes in the system and determine the most appropriate pump for the system flow. The total flow rate required for the 75-ton system is 225 gallons per minute (gpm). Header pipes (HDPE DR-11, 4-inch diameter) will route water to and from the four circuits of 11 geothermal wells each. The header pipes merge in a vault located below the ground surface. From the vault, the heated water is routed into the school and to the mechanical room in the basement where heat pumps will be located. The recommended heat pump can accommodate a flow rate of 57 gpm, and a total of four heat pumps will be needed.

Geotechnical Engineering. The student team utilized three Wisconsin DNR well logs to estimate subsurface conditions at School A. These well logs—all located within 1,300 feet of School A—showed a clay layer overlaying a clay with sand and gravel layer overlaying a sandstone layer. Furthermore, the water table was observed at a depth between 25 and 30 feet. A complete geotechnical analysis is still necessary for a more thorough, accurate design.

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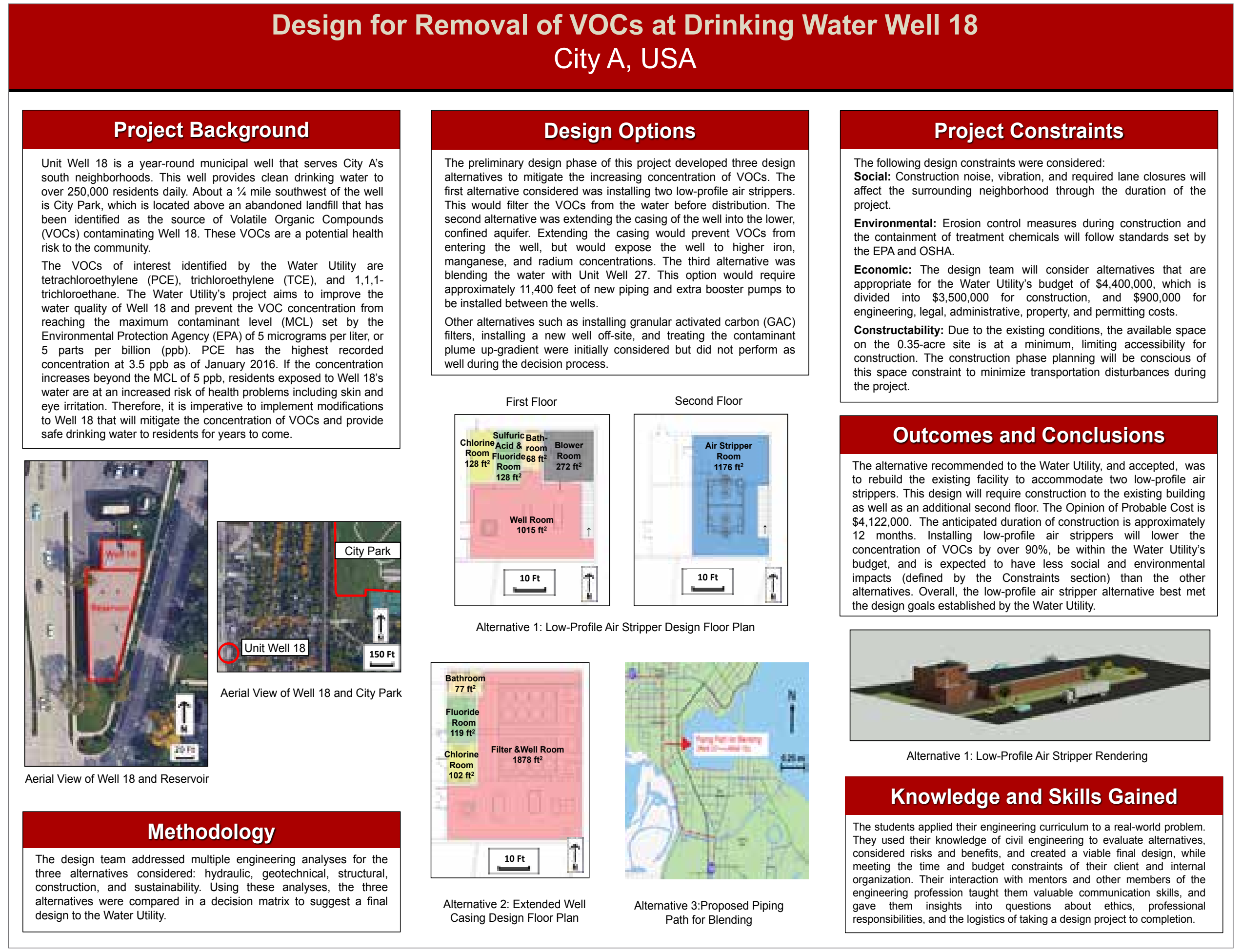
University of Wisconsin–Madison
Department of Civil and Environmental Engineering
Design for Removal of VOCs at Drinking Water Well 18



Participants

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Charles Quagliana

Professional Engineers

Keith Behrend, P.E.
Al Larson, P.E.

Jury Comments

"Practial solution to improve the safety of drinking water that affects a large population"

"Nice job on a project that has very real improvement in the public health"

"Well researched, and students acknowledged there were many solutions"

Abstract

City A in the USA obtains municipal drinking water from wells screened in the underlying sandstone aquifer. Well 18 is a year-round municipal well that serves several neighborhoods in City A, providing clean drinking water to over 250,000 residents daily. Well 18 is surrounded by residential and commercial land uses but is located 1,500 feet southwest of an abandoned landfill, now City Park. City A's Water Utility has identified the abandoned landfill as the source of volatile organic chemicals (VOCs) that are leaking into the groundwater and have put the drinking water at risk of exceeding federal and state regulatory limits. VOCs are classified as primary contaminants by the Environmental Protection Agency (EPA) and pose a risk to human health, including an increased risk of cancer and problems with the liver, nervous system, and circulatory system. The VOCs present at Well 18 include tetrachloroethylene (PCE), trichloroethylene (TCE), and 1,1,1 trichloroethane. The top priority of this project was continuing the distribution of clean and safe drinking water to the City A community by preventing the VOC concentration from reaching the maximum contaminant level (MCL) set by the EPA of 5 micrograms per liter, or 5 parts per billion (ppb).

In collaboration with two P.E.s and city officials, a team of five undergraduate civil and environmental engineering students worked to develop a design for removing VOCs from groundwater so that Well 18 provides safe drinking water for City A neighborhoods. Social, environmental, economic, and spatial constraints were some of the major issues considered for this project. The opinions and concerns of the City A community were very important for the final design. Available space was limited at the approximately 0.35-acre site, and construction noise, vibrations, and lane closures were concerns for the adjacent neighborhoods. In addition, the Water Utility established budget goals for the project.

During the preliminary design stage, the students considered six design options. Three of the options—including low-profile air stripping, blending water from multiple wells, and extending the well casing—were considered feasible for a secondary analysis. The team further developed these three design alternatives, preparing a concept design for each. Construction, environmental, geotechnical, and hydraulic engineering analyses were performed for the three alternatives to understand the technical implications.

The effect on the water supply was considered for all alternatives as well as the implications of all chemicals, waste, and emissions. Each alternative was evaluated through a life cycle cost analysis that incorporated initial construction and maintenance costs. Spatial constraints were important because the existing Well 18 facility occupies most of the property. Adding on-site treatment requires existing building demolition and reconstruction of a larger building with foundations capable of handling larger loads, as well as a more complex hydraulic system.

Having achieved an understanding of the engineering, environmental, and public constraints, the team prepared an evaluation matrix in which weighted decision criteria were applied to each concept design. Based on input from their collaborators and an expert panel, the team made a recommendation to modify the existing facility to construct two low-profile air strippers, thereby removing VOCs from the water before distribution.

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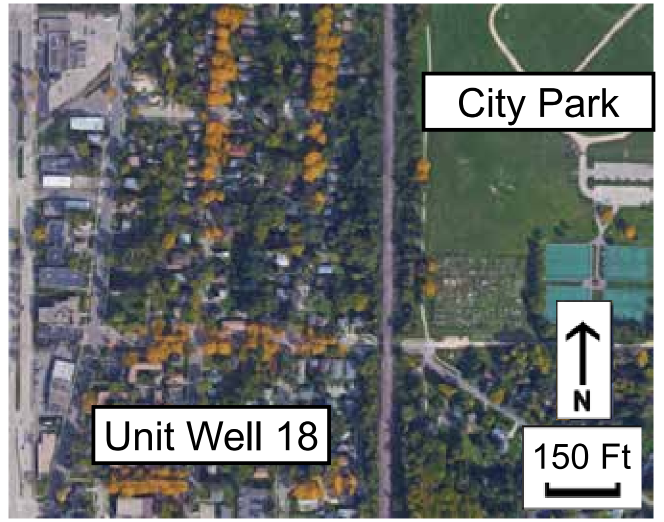
University of Wisconsin–Madison
Department of Civil and Environmental Engineering
Design for Removal of VOCs at Drinking Water Well 18



Perspectives On

Collaboration of faculty, students, and licensed professional engineers

Two P.E.s from the local community served as mentors throughout the semester, meeting weekly with the student team. The mentors provided design supervision, lessons-learned experiences, critique and oversight for presentations and reports, and advice for client relationships and public meetings. In addition, overall instruction for the course was provided weekly by a P.E. Two student team presentations (at the preliminary and final design stages) were made to a panel of judges from the local P.E. community, thereby widening the students' exposure to other professionals and affording opportunities for additional critique of their work.

The weekly contact between mentors and students allowed the students to benefit from the P.E.s' many years of experience. At the same time, the mentors and faculty expected the student team to retain responsibility for its own performance to the pre-established goals for time management, presentations, design components, deliverables, and schedules. Both mentors and faculty made themselves available for phone or email discussions as necessary and provided review of the student deliverables.

The students learned the following through the collaboration that would not have been learned in the classroom.

Communication and Collaboration as Components of Design: Collaboration between engineers, stakeholders, regulatory agencies, and the public is difficult if not impossible to teach in the classroom. In this project, the student team spoke directly to the city Water Utility and the public, learning to listen and balance the needs and requirements of various entities. The project constraints and needs then became critical elements of the three concept designs.

Multiple Right Answers: Most classroom activities and problems are designed to promote an understanding of the theory by having a single "correct" answer. In this project, having achieved an understanding of the engineering, environmental, and public constraints, the students prepared an evaluation matrix in which weighted decision criteria were applied to three concept designs, all of which can be considered "right answers." The team and client made a recommendation to proceed with two low-profile air strippers, a design that effectively utilized the small site, provided long-term treatment for the drinking water, was within the established project budget, and met environmental, economic, and social sustainability goals.

Application/Integration of Multiple Disciplines: In this project, it was necessary for the student team to combine their individual skills for successful performance of the work yet complete tasks in several disciplines of civil and environmental engineering. To do this, they identified the skill sets of each team member, assigned themselves tasks accordingly, and sought outside advice from mentors, faculty, and other students in areas where needs remained.

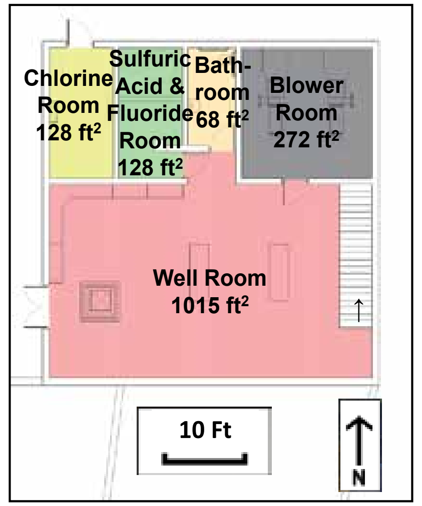
Learn to Identify the Uncertainties: Engineering projects have uncertainties, and awareness of the uncertainties informs the designers and user of related risks. Many classroom activities present the student with data and/or a set of assumptions upon which analyses are to be based. In this project, students were challenged to identify areas where they did not have or find pertinent information, or where certain information was not knowable prior to performing analyses. They correctly identified several items (geotechnical conditions, media head losses, contaminant concentrations over time, etc.) as items that should be noted and considered.

Knowledge and skills gained

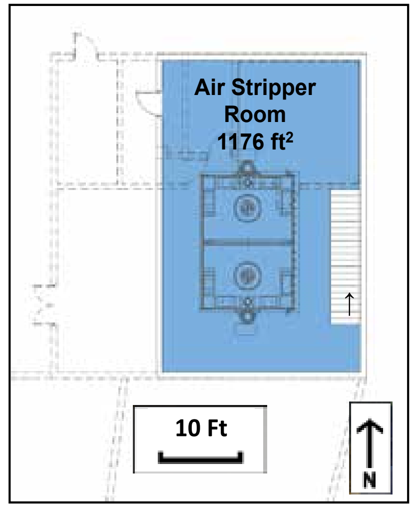
The students applied their engineering curriculum to a real-world problem. They used their knowledge of civil engineering to evaluate alternatives, considered risks and benefits, and created a viable final design, while managing themselves to meet the time and budget constraints of their client and internal organization.

Their interaction with mentors and other members of the engineering profession taught them valuable communication skills and gave them insights into questions about ethics, professional responsibilities, and the logistics of taking a design project to completion.

First Floor



Second Floor



Previous Winners

2018

Grand Prize

North Carolina State University
UNC/NCSU Joint Department of Biomedical Engineering
Enabling Pediatric Brain Surgery through Head Stabilization

Additional Awards

Miami University
Department of Chemical, Paper, and Biomedical Engineering
Design and Implementation of a Community-Driven Water System in a Rural African Village

Seattle University
Department of Civil and Environmental Engineering
Load Rating and Repair Options for Bridge Connecting Dam and Intake Structure

Seattle University
Department of Civil and Environmental Engineering
Replacement Design of a Culvert to Allow for Fish Passage

University of Minnesota Twin Cities
Department of Civil, Environmental, and Geo-Engineering
Multistage Drip Irrigation System in Ethiopia

University of Nebraska–Lincoln
Charles W. Durham School of Architectural Engineering and Construction
Children's Hospital and Medical Center Expansion

University of Wisconsin–Madison
Department of Civil and Environmental Engineering
Interlake Lock and Boat Transfer

University of Wisconsin–Madison
Department of Civil and Environmental Engineering
Law Park Revitalization

2017

Grand Prize

Dordt College
Engineering Department
Liberia Farm Bridge

Additional Awards

George Mason University
Sid and Reva Dewberry Department of Civil, Environmental, and Infrastructure Engineering
Design and Construction of a Reliable Drinking Water System for an Orphanage in Central America

Marquette University
Department of Civil, Construction, and Environmental Engineering
El Bosque Pedestrian Bridge

North Carolina State University
UNC/NCSU Joint Department of Biomedical Engineering
Belltower Medical—Urinary Catheter Solutions

Seattle University
Department of Civil and Environmental Engineering
Design of a Care Facility for Young Mothers in Uganda

Seattle University
Department of Civil and Environmental Engineering
Restoration and Replacement Options for Utility Company Bridge

2016

Grand Prize

University of Nebraska–Lincoln
Charles W. Durham School of Architectural Engineering and Construction
888 Boylston Street—Interdisciplinary Team Design

Additional Awards

George Mason University
Sid and Reva Dewberry Department of Civil, Environmental, and Infrastructure Engineering
New Drinking Water and Sewer System for an Elementary School for Orphans—Bilwi, Nicaragua

George Mason University
Sid and Reva Dewberry Department of Civil, Environmental, and Infrastructure Engineering
Water and Sanitation Project—Children's Feeding Center—Puerto Cabezas, Nicaragua

Seattle University
Department of Civil and Environmental Engineering
Design Development of a Cultural Village for Migrant Workers

Seattle University
Department of Civil and Environmental Engineering
Design of Habitat-Sensitive Erosion Hazard Mitigation Near a Bridge

Seattle University
Department of Civil and Environmental Engineering
Solar Microgrid in Rural Zambia with Real-Time Cloud-Based Monitoring

2015

Grand Prize

Marquette University
Department of Civil, Construction, and Environmental Engineering
Sechum Vehicle Bridge

Additional Awards

The Citadel
Department of Civil and Environmental Engineering
Multidisciplinary Evaluation and Rehabilitation Design of Sacred Heart Catholic Church

George Mason University
Sid and Reva Dewberry Department of Civil, Environmental, and Infrastructure Engineering
Water Supply, Distribution, and Storage Sabana Grande, Nicaragua

Seattle University
Department of Civil and Environmental Engineering
Seismic Analysis and Retrofit Design of a Historic Substation Control Building

University of Arkansas at Little Rock
Department of Construction Management and Civil and Construction Engineering
American Red Cross of Greater Arkansas Seismic Retrofit Feasibility Study

University of Nebraska–Lincoln
Charles W. Durham School of Architectural Engineering and Construction
Multidisciplinary Vertical Farm Design

Previous Winners

2014

Grand Prize

Seattle University
Department of Electrical and Computer Engineering
Microgrid System for a Wind and Solar Farm Located in Rural Kenya

Additional Awards

The Citadel
Department of Civil and Environmental Engineering
Wave Dissipation System

North Carolina State University
UNC/NCSU Joint Department of Biomedical Engineering
Creating a Better Way to Locate Vasculature for Intravenous Therapy

Seattle University
Department of Civil and Environmental Engineering
Historic Landmark Incline Lift Structural Evaluation and Retrofit

University of Evansville
College of Engineering and Computer Science
Fairfield Reservoir and Dam

University of Notre Dame
Department of Civil and Environmental Engineering and Earth Sciences
Innovative Housing Solutions for Post-Quake Haiti

2013

Grand Prize

Cleveland State University
Civil and Environmental Engineering Department
Design, Funding, and Construction of the August Pine Ridge School/Hurricane Shelter in Belize

Additional Awards

Northern Arizona University
Department of Civil Engineering, Construction Management, and Environmental Engineering
Paper Pulp Sludge Characteristics and Applications

Seattle University
Department of Civil and Environmental Engineering
Design Options for a Creek Crossing for a Utility Company

Seattle University
Department of Civil and Environmental Engineering
Structural Evaluation and Retrofit of a Warehouse

University of Nevada, Reno
Department of Civil and Environmental Engineering
Capstone Design Project—SouthEast Connector

University of Texas at El Paso
Department of Civil Engineering
Multidisciplinary Design of a Sustainable, Environmentally Friendly, and Affordable House

2012

Grand Prize

Florida Atlantic University
Department of Civil, Environmental, and Geomatics Engineering
Dania Beach Nanofiltration Plant Expansion

Additional Awards

Oklahoma State University
School of Civil and Environmental Engineering
Roadway and Water Feature Design at the Botanic Garden

Seattle University
Department of Civil and Environmental Engineering
Design of an Orphanage, Learning and Community Center in Ethiopia

Seattle University
Department of Civil and Environmental Engineering
Historic Dam Guard Rail and Vehicle Barrier Retrofit for Public Safety

University of Texas at El Paso
Department of Civil Engineering
Multidisciplinary SMART Design of Fire Station 513

Valparaiso University
College of Engineering
Maji for Masaera—Rehabilitation of a Man-Made Irrigation Canal

Previous Winners

2011

Grand Prize

University of New Mexico
Department of Civil Engineering
Integrated Infrastructure Improvements for a Youth Scout Ranch

Additional Awards

California State University, Los Angeles
Department of Civil Engineering
Connecting Professional Practice and Education through a Civil Engineering Capstone Project: Mud Flow Barrier

Lawrence Technological University
Department of Civil Engineering
Civil Engineering Capstone Project Recovery Park

Seattle University
Department of Civil and Environmental Engineering
Flood Control Channel Design for a River in Northwest Haiti

Seattle University
Department of Civil and Environmental Engineering
Structural Design of Dam Sluice Gate Walkway Slabs: Retrofit and Replacement Options

University of Texas at El Paso
Department of Civil Engineering
Development of a Sustainable Infrastructure Management System for a City

2010

Grand Prize

University of Delaware
Department of Civil and Environmental Engineering
Pomeroy Trail East Annex

Additional Awards

California Polytechnic State University, San Luis Obispo
Civil and Environmental Engineering Department
Bridging the Gap between Theory and Practice through Capstone Design

California State University, Los Angeles
Department of Civil Engineering
Connecting Practice with Education through Civil Engineering Capstone Experience: Puddingstone Reservoir Operations Level Study

Clemson University
Holcombe Department of Electrical and Computer Engineering
Engineering Haptic Virtual Manipulatives to Enhance K–12 Math and Science Education

University of Maryland
Department of Civil and Environmental Engineering
Engineers Without Borders: Solar Recharge Project in Burkina Faso, Africa

University of New Mexico
Department of Civil Engineering
Integration of Civil Engineering and Construction Management Education: A Multidisciplinary, Mentor-Led Capstone Experience

2009

Grand Prize

Florida A&M University–Florida State University
Department of Civil and Environmental Engineering
Senior Design Capstone Course: Collection of Projects with Featured Everglades Restoration Project

Additional Awards

Seattle University
Department of Civil and Environmental Engineering
Structural Design Package for the Replacement of a County Bridge

University of Arizona
Department of Civil Engineering and Engineering Mechanics
Practitioner-Led Engineering Experiences

University of Missouri–Kansas City
Department of Civil and Mechanical Engineering
Redcone Civil Design Group: A Practitioner-Centric Capstone Experience

University of Tennessee at Chattanooga
Department of Civil Engineering
Intermodal Transit Center

Virginia Polytechnic Institute and State University
Charles E. Via Jr. Department of Civil and Environmental Engineering
Land Development Design Initiative

Honorable Mention

University of Iowa
Department of Civil and Environmental Engineering
Pilot Program for Expanding Connections between Professional Practice and Education

EDUCATION

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NCEES Engineering Education Award

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- Energy and Sustainability
- Device/Design/Prototype
- Freshman/Sophomore Design
- Innovation

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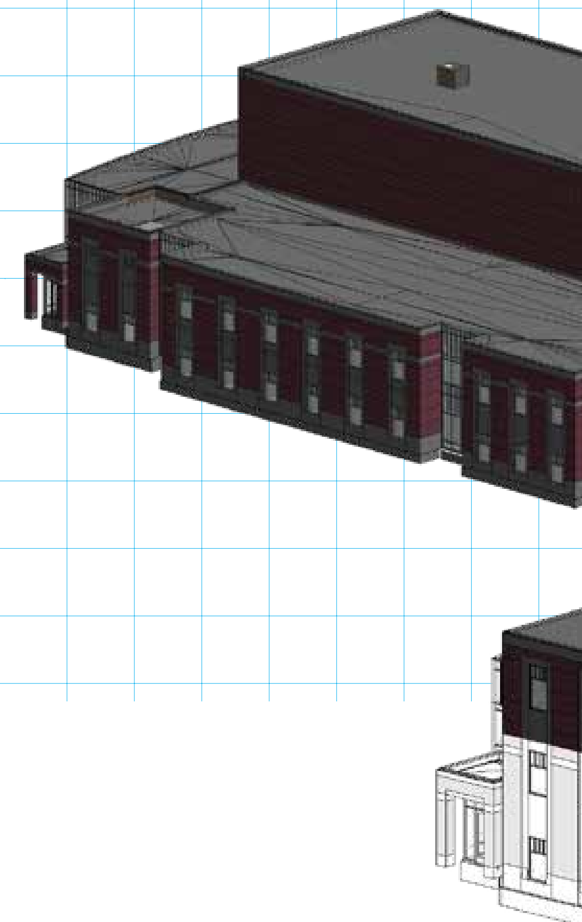

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