Student-Led Wastewater Design Strengthened by Professional Engineer Collaboration

Chincoteague Wastewater Treatment Plant Improvements

2026 NCEES Engineering Education Award

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Project Description

This submission demonstrates that professional engineering mentorship is most valuable when students are responsible for real decisions. Licensed P.E. review did not function as a courtesy check; it changed the team's process-selection rationale, construction-phasing strategy, geotechnical risk response, and public-welfare framing of the final wastewater solution. More importantly, the collaboration changed the students, not just the design: students began the project as capable classroom problem-solvers and left understanding how engineers defend decisions under client standards, permit requirements, constructability constraints, cost limitations, operational realities, and public-welfare obligations.

Chincoteague Island, Virginia, is a narrow barrier island whose wastewater infrastructure must serve both a year-round community and a large seasonal visitor population drawn to the Chincoteague National Wildlife Refuge and Assateague Island National Seashore. That seasonal surge more than doubles the island's effective population during peak periods, placing highly variable demand on infrastructure originally sized for a much smaller service condition. The Chincoteague Wastewater Treatment Plant (CTP) therefore presented the student team with a real coastal utility problem: increase capacity, maintain permit compliance, and design for resilience on a constrained site.

CTP operates under VPDES Permit No. VA0054003, issued by the Virginia Department of Environmental Quality (VDEQ), with a permitted capacity of 39,500 gallons per day (gpd). Owned and operated by the Hampton Roads Sanitation District (HRSD), the plant is an Extended Aeration Activated Sludge (EAAS) facility with two treatment trains, only one of which remains fully functional. Between December 2018 and August 2023, the plant averaged 10,370 gpd annually; during the summer season, the average influent flow increased to 19,810 gpd. Influent strength was also significant, with BOD averaging approximately 287 mg/L and peaking at 534 mg/L, and TSS averaging approximately 249 mg/L. Aging infrastructure compounded these pressures: corroded sludge holding tanks had been removed from service, influent and effluent pump stations were undersized, the existing 2-inch outfall passed beneath an inaccessible building, and the standby generator occupied the footprint needed for new treatment infrastructure.

HRSD invited the twelve-member student team to develop a Preliminary Engineering Report (PER) recommending a path forward. The team worked with licensed Professional Engineers, HRSD reviewers, construction professionals, and technical mentors, with HRSD staff acting as a real client. The project goal was to design an expanded facility capable of treating 130,000 gpd average daily flow and 260,000 gpd peak flow, while maintaining VPDES compliance during every phase of construction, accommodating future flow from the adjacent U.S. Coast Guard (USCG) facility, and improving long-term resilience in a coastal environment subject to flooding, corrosion, storm surge, and sea level rise.

Students analyzed five years of influent flow and water quality data, modeled four biological treatment alternatives in BioWin, completed hand calculations for SBR sizing, filtration, and pumping, performed structural and hydraulic design calculations, developed a geotechnically informed site plan, prepared RSMeans-based construction cost estimates, completed a 50-year life-cycle cost analysis, evaluated project delivery methods under the Virginia Public Procurement Act, prepared a permitting strategy covering local, state, and federal requirements, and assessed the project using the Institute for Sustainable Infrastructure (ISI) Envision framework. Professional engineers and industry mentors reviewed the students' assumptions and forced the team to defend the design as a client-ready recommendation, not simply a classroom exercise.

The four biological treatment technologies evaluated were Moving Bed Biofilm Reactor (MBBR), Membrane Bioreactor (MBR), Sequencing Batch Reactor (SBR), and Extended Aeration Activated Sludge (EAAS). Each was modeled in BioWin under existing and projected flow conditions and scored using a Multi-Attribute Decision Model (MADM) that considered maintenance complexity, energy efficiency, proven technology, sludge production, capital cost, flexibility under load variability, effluent quality, and operating cost. SBR ranked first, with a weighted score of 1.2 compared with MBBR at 2.0, EAAS at 3.3, and MBR at 3.4. SBR was selected because it consolidated biological treatment and clarification within a single reactor, reduced the need for separate secondary clarifiers, fit the constrained footprint, provided flexible cycle control for seasonal flow variability, avoided a return activated sludge pumping system, and offered a lower capital-cost alternative to membrane-based treatment.

The recommended design includes two SBR basins sized around the 130,000 gpd average daily flow and 260,000 gpd peak design flow. The student calculations used treatment objectives of approximately 10 mg/L BOD, 10 mg/L TSS, 3 mg/L TKN, and 0.5 mg/L TP to guide process sizing and polishing needs. Following the SBR system, a post-SBR equalization basin of approximately 0.024 MG stabilizes decant flow before cloth disc filtration. Upgraded tablet chlorination and dechlorination provide disinfection capacity for the increased flow. A new 4-inch Schedule 40 PVC effluent line, approximately 270 feet long, relocates the outfall from beneath the inaccessible building and improves maintainability before discharge to the Chincoteague Channel.

For structural and site design, the team addressed the challenges of building in a saline, high-groundwater coastal environment. The ECS geotechnical report identified groundwater approximately 3 to 4 feet below ground surface and recommended deep foundations for tank structures using 12-inch square prestressed precast concrete piles with an approximate tip elevation of EL. -51 feet. P.E. review helped students understand that a test-pile program was not excessive conservatism; it was a professional response to subsurface uncertainty. Critical mechanical and electrical equipment is elevated above flood elevations, and the design incorporates corrosion-resistant materials, cathodic protection where appropriate, buoyancy resistance, and a relocated standby generator above the flood-risk elevation. Two 12-foot by 20-foot precast concrete buildings replace deteriorated wooden sheds: an operator building with workstation, WiFi, restroom, and tool storage, and a mechanical building housing switchgear and aeration blowers.

One of the most complex parts of the project was the five-phase Maintenance of Plant Operations (MOPO) plan, which was developed to keep CTP in compliance while the existing facility is demolished and the new SBR system is constructed in the same constrained footprint. The plan sequences work around the seasonal flow cycle, targeting a November start when flows are lowest. Phase 1 establishes access and temporary facilities. Phase 2 uses temporary storage tanks and nighttime pump-and-haul operations to an HRSD receiving facility, with planning-level costs ranging from approximately $90,000 to $300,000 depending on hauling distance and receiving-facility assumptions. Phase 3 demolishes obsolete treatment infrastructure, salvaging reusable components and recycling debris where feasible. Phase 4 installs piles, SBR tanks, aeration, mixing, and SCADA systems. Phase 5 tests, commissions, trains operators, and transitions the plant into full operation before the summer flow season.

The construction cost estimate, developed using RSMeans data with a 25% base contingency and additional allowances for volatile materials such as steel and lumber, totals $2.41 million. The 50-year life-cycle cost, including operations, maintenance, staffing, periodic equipment replacement, and future demolition, is projected at $7.37 million. The Envision assessment earned a projected 255 out of 694 applicable points, or 37%, qualifying for a Silver level under the ISI framework. The permitting strategy reviewed Accomack County, Virginia DEQ, federal NEPA, floodplain, Chesapeake Bay Preservation Act, and endangered-species considerations. Design-Bid-Build was recommended because it aligns with HRSD standards, maintains public procurement transparency, and fits the project's scale under the Virginia Public Procurement Act.

Collaboration of Faculty, Students, and Licensed Professional Engineers

The structure of this project was designed from the start to function as a professional engineering engagement rather than a conventional academic exercise. Students worked alongside licensed Professional Engineers, HRSD reviewers, construction professionals, and technical mentors who reviewed calculations, challenged assumptions, questioned constructability, and held the team to standards expected of an engineering consultant preparing a PER for a public utility. The review was deliberately discipline-specific: process, operations, pumping, structural materials, owner standards, construction phasing, and public-welfare implications were each tested by practitioners with relevant experience.

How P.E. Collaboration Changed both the Students and the Design

The most important outcome of the collaboration was not simply a different recommended facility layout; it was a change in how students made engineering decisions. Students learned to move from "Does the calculation work?" to "Can this decision be defended to an owner, operated by staff, permitted by regulators, constructed safely, and relied upon by the public?"

Matt Doyle, P.E., served as both the course faculty advisor and primary professional mentor, but the project was intentionally not a single-mentor exercise. Doyle coordinated the educational framework, reviewed technical memoranda, pressed students to document assumptions, guided regulatory interpretation, and helped the team connect calculations to client communication and professional judgment. He also helped students understand why P.E. comments from multiple reviewers mattered: each comment represented a different dimension of professional responsibility, including process reliability, owner standards, constructability, pumping performance, materials selection, and public protection.

Ag Fallon, P.E., supported the alternative analysis by pushing students to evaluate process options beyond treatment performance alone. After that review, the MADM gave greater practical weight to footprint, maintainability, life-cycle value, operator burden, and reliability on a constrained coastal site.

Pete Loomis, P.E., provided detailed process knowledge surrounding the overall process flow diagram. His review helped students understand how each unit process had to connect hydraulically and operationally, and it forced the team to present the SBR basins, equalization, filtration, disinfection, dechlorination, and outfall as one integrated treatment train rather than as isolated design components.

David Binning, P.E., required the team to reconcile recommendations with specific HRSD owner standards. That review changed the students' mindset from "technically acceptable" to "owner-acceptable," including reliability expectations, maintainability, permitting obligations, standard materials, and documentation suitable for a public utility.

Kayla Stephens (Vendor) helped refine the SBR cycle strategy by challenging students to think through fill, react, settle, decant, wasting, equalization, and seasonal flow variability as an operating sequence. That review changed the students' understanding of SBR design from a tank-sizing exercise into an operations and controls problem.

Bob Fairweather (Pump Vendor) supported the students with pumping-system review, including the practical relationship among peak flow, pump capacity, headloss, redundancy, wet-well function, and

maintainability. That input helped students connect hydraulic calculations to actual equipment selection and long-term operator reliability.
Kevin Ritchie (Concrete Manufacturer) shifted the structural and constructability discussion from a primarily cast-in-place concept toward a more constructible precast and prefabricated concrete approach where appropriate. That input helped students understand how schedule, quality control, site constraints, labor availability, corrosion exposure, and construction sequencing can change a preferred structural solution.
Scott Crowder (General Contractor) changed the MOPO sequencing by pushing students to treat construction phasing as a public-protection strategy rather than a contractor detail. The resulting sequence placed greater emphasis on low-flow seasonal timing, temporary storage, nighttime pump-and-haul operations, demolition sequencing, startup, and maintaining VPDES compliance through transition.
Dan Hingley, P.E.; Lara Grotz, P.E.; Priyanka Mohandoss, P.E.; and Jim Pyne, P.E., provided final professional feedback on the integrated design package. Their review helped students test whether the final recommendation read as a coherent Preliminary Engineering Report rather than a collection of separate student assignments, with particular attention to owner expectations, clarity of engineering justification, constructability, operations, public welfare, and defensible documentation. That final review reinforced the central lesson of the project: professional practice requires not only selecting a technically sound alternative but also communicating the basis of design clearly enough for an owner, regulator, operator, and future engineer to understand and rely on it.

HRSD's involvement as an active client shaped the collaboration in ways that could not be replicated by a classroom problem. HRSD provided facility data, VPDES permit information, geotechnical reports, operating constraints, and Design and Construction Standards that governed the work. Students learned that every calculation, recommendation, and deliverable must fit within client standards, regulatory obligations, public procurement requirements, and operational realities. The named mentor comments reinforced that lesson: owner-standard review changed what counted as an acceptable recommendation; process review changed the treatment-train logic; pump review changed hydraulic and equipment assumptions; structural review changed the constructability strategy; and MOPO review changed phasing into a compliance and public-welfare problem.

Within the team, students held differentiated roles that mirrored the structure of a consulting team: Project Manager (Abdalla Abu-Khalifa), Project Technical Lead (David Prester), Structural Lead (Omar Abu-Khalifa), Water Lead (Phillip Vasilakopoulos), Environmental Lead (Bai Sesay), BioWin Modeler (Jack Tigani), Cost Estimation and CAD Design (Tyler Moskal), Structures and CAD Design (Michael Isabella and Manuel Matos), GIS and CAD Design (Matthew Cantos), Structures and Specifications (Rafferty Houghton), and Cost Control and Administration (Helron Zheng). This structure created real accountability. The project manager coordinated deliverable schedules and client communication, while each technical lead had to produce work that could withstand review by licensed engineers and be integrated into a coherent PER.

The clearest measure of the collaboration was not the number of deliverables produced or even the final SBR recommendation; <u>it was the change in student judgment</u>. The students learned that engineering is not a sequence of disconnected calculations. It is a disciplined process of making defensible decisions under uncertainty, explaining those decisions to an owner, revising them after professional review, and understanding that a licensed engineer's obligation is ultimately to the public. In that sense, P.E. collaboration changed the students, not just the design.

Protection of Health, Safety, and Welfare of the Public

The Chincoteague Channel receives the treated effluent from CTP and is connected to tidal waters that support shellfish harvesting, recreation, tourism, and the ecological health of Chincoteague and Assateague. The connection between the student design and protection of public health, safety, and welfare is therefore direct: inadequate treatment or construction-phase failure could affect swimmers, shellfish areas, aquatic habitat, local economic activity, and public confidence in essential wastewater infrastructure.

The CTP's VPDES permit establishes enforceable limits on biochemical oxygen demand, total suspended solids, total residual chlorine, fecal coliform, and enterococci. The student design was evaluated against the plant's ability to maintain those limits during normal operation, seasonal peak loading, and construction transition. The SBR system, cloth disc filtration, upgraded chlorination and dechlorination, and relocated outfall were not selected as isolated components; together they form the treatment barrier needed to protect the Chincoteague Channel and maintain compliance under variable hydraulic and organic loading.

The MOPO plan was the team's most direct encounter with public protection. Maintaining permit compliance during construction is an enforceable obligation, not a preference. The temporary bypass, storage, pump-and-haul sequence, demolition timing, and startup plan were developed specifically to avoid a lapse in treatment quality while the old plant is taken offline and the new SBR system is commissioned. Students learned that the public remains at risk during construction and that the engineer's obligation to protect public welfare does not pause because a project site is active.

The project's flood resilience measures address a public-welfare risk common to coastal wastewater facilities. The site is within a flood-prone coastal setting, and the student technical memorandum identified a Base Flood Elevation of 5.0 feet with an HRSD freeboard requirement that drives critical infrastructure toward an 8.0-foot design elevation. A treatment plant that loses power, floods controls, or suffers structural damage during a coastal storm can discharge partially treated or untreated wastewater when receiving waters are most vulnerable. Elevating critical equipment, relocating the generator, specifying corrosion-resistant materials, designing for buoyancy, and incorporating deep foundations are professional responses to that risk.

The project also showed students that community welfare extends beyond the treatment process itself. Revising the MOPO strategy to minimize reliance on the adjacent tennis-court property preserved community recreational space and reduced stakeholder disruption. Relocating the outfall removed a maintenance condition that could have concealed future pipe failure. Connecting the USCG facility improved collection-system reliability for a federal installation with public-safety functions. Sizing the disinfection and filtration systems for peak tourist flows connected students' calculations directly to water quality in a nationally significant coastal community.

Multidiscipline and Allied Profession Participation

The Chincoteague CTP project required integration across multiple branches of civil and environmental engineering and exposure to allied professional practice areas. Students did not complete isolated calculations; they had to coordinate process performance, hydraulics, structures, geotechnical conditions, construction phasing, cost, permitting, sustainability, and operations into a single recommendation.

Environmental engineering formed the core of the biological treatment work, including influent characterization, BOD and TSS removal, nutrient treatment, disinfection, VPDES compliance, BioWin modeling, and Envision sustainability assessment. Water resources engineering addressed hydraulic design, lift-station sizing, equalization volume, outfall hydraulics, and the 130,000 gpd design basis. Structural engineering covered water-retaining SBR basins, buoyancy resistance, concrete durability, prefabricated buildings, and equipment support. Geotechnical engineering informed the use of driven piles, shallow groundwater assumptions, pile-tip elevation, test-pile recommendations, and construction risk.

Financial analysis structured the economic evaluation of the project. Students developed construction cost estimates using RSMeans unit pricing, applied material-specific contingencies for volatile commodities like steel and lumber, and extended those estimates into a 50-year life cycle cost model that incorporated inflation-adjusted operations, maintenance, staffing, and demolition costs.

Construction and project management engineering structured the five-phase MOPO plan, Work Breakdown Structure, project schedule, demolition sequence, pump-and-haul logistics, and evaluation of Design-Bid-Build, CMAR, Design-Build, and JOC delivery methods under the Virginia Public Procurement Act. Mechanical, electrical, and controls considerations were also embedded in the work through pump selection, aeration blowers, mixers, emergency power, switchgear, SCADA integration, flood elevation of equipment, and operator access for long-term maintenance.

The project also engaged allied professional practice areas. Regulatory compliance required students to interpret the VPDES permit, Chesapeake Bay Preservation Act considerations, NEPA review, Accomack County local requirements, floodplain requirements, and federal endangered-species screening. The Envision assessment introduced sustainability as a measurable decision framework. Cost estimating and life-cycle analysis required students to think like public-sector financial stewards. Coordination with the USCG introduced interagency coordination, property-boundary constraints, and the importance of early stakeholder engagement.

Knowledge and Skills Gained

The knowledge and skills students developed through this project fall into two mutually reinforcing categories: technical engineering competency and professional practice capability. The most important learning was not simply how to calculate a tank volume; it was how to make defensible engineering decisions under client, regulatory, constructability, cost, schedule, and public-welfare constraints.

On the technical side, students developed working knowledge of biological wastewater treatment process design, including SBR basin sizing using actual influent data, hydraulic retention time and sludge retention time calculations, aeration oxygen demand, sludge production, post-treatment filtration, and disinfection. BioWin modeling bridged the gap between textbook process diagrams and variable influent streams at a real plant. Hydraulic calculations for pumps, equalization, and outfall sizing were performed using the proposed peak design flow. Structural and geotechnical work required students to think beyond strength alone and account for buoyancy, corrosion, settlement, shallow groundwater, flood exposure, and constructability.

Students learned to use RSMeans unit pricing, apply contingency methodology, account for volatile material risks, and extend a construction estimate into a 50-year life-cycle cost model. Those exercises showed students why public infrastructure decisions cannot be made on capital cost alone: operations, maintenance, staffing, equipment replacement, energy, sludge management, and end-of-life planning shape the true value of a treatment solution.

The permitting strategy introduced students to the institutional environment in which infrastructure projects are actually built. Navigating VPDES permit requirements, Chesapeake Bay Preservation Act considerations, NEPA review, local permitting, floodplain rules, and endangered-species screening taught students that permits are not paperwork at the end of design; they are design constraints that affect scope, cost, schedule, and risk from the beginning.

Professional practice skills developed alongside the technical work. Project management was embedded in the assignment: a twelve-person team had to organize workstreams, maintain schedules, coordinate deliverables, communicate with a client, respond to named P.E. and mentor comments, and integrate technical memoranda into a consistent PER. Students in leadership roles learned to manage accountability, and students in technical roles learned that their calculations and recommendations had to be clear enough for a licensed engineer to review, specific enough for an owner to evaluate, and practical enough for operators and contractors to use.

Engineering ethics was not presented as an abstract code; it appeared as operational constraints. Maintaining VPDES compliance during construction, preventing untreated discharge during plant transition, protecting operators and construction workers, and preserving treatment reliability during storms were ethical obligations expressed as engineering decisions. The MOPO plan made professional responsibility tangible because a construction failure would affect real people, real water quality, and a real public utility.

Students also developed engineering judgment: the ability to make reasoned decisions when data are incomplete and constraints compete. When the geotechnical report showed variable coastal soils and shallow groundwater, the team documented uncertainty and recommended an early test-pile program instead of pretending the foundation design was fully resolved. When BioWin and the MADM showed that alternatives differed not only by treatment performance but by footprint, maintenance, and constructability, the team used those findings to support the SBR recommendation. When the MOPO plan showed that construction phasing could affect compliance, the team treated phasing as part of the engineering solution rather than as a contractor detail.

The Chincoteague Wastewater Treatment Plant Improvements project gave twelve students the experience of practicing engineering before entering practice: a real client, real site constraints, real permit obligations, real public-welfare consequences, and licensed Professional Engineers and industry mentors who treated the work as worthy of serious review. The result was not only a credible wastewater solution for HRSD, but also a professional formation experience in which students learned that engineering judgment is developed through evidence, constraints, accountability, named technical review, and responsibility to the public. The design changed, but more importantly, the students changed.

Students and licensed Professional Engineers at the Chincoteague WWTP site, where classroom design became professional practice. Through direct P.E. mentorship, the team learned that engineering decisions are not just calculations on paper—they are commitments to public health, resilient infrastructure, and the communities engineers serve.