Ph.D. Transportation and Environmental Engineering

Board of Governors, State University System of Florida
Request to Offer a New Degree Program

(Please do not revise this proposal format without prior approval from Board staff)

Florida Atlantic University	**Fall 2020**
University Submitting Proposal	**Proposed Implementation Term**
College of Engineering and Computer Science	**Civil, Environmental & Geomatics Engineering (CEGE)**
Name of College(s) or School(s)	**Name of Department(s)/ Division(s)**
Engineering, Other	**Ph.D. in Transportation and Environmental Engineering**
Academic Specialty or Field	**Complete Name of Degree**
14.9999	
Proposed CIP Code	

The submission of this proposal constitutes a commitment by the university that, if the proposal is approved, the necessary financial resources and the criteria for establishing new programs have been met prior to the initiation of the program.

2/11/20			2/11/20
Date Approved by the University Board of Trustees		**President**	**Date**
	2/11/20		2/12/20
Signature of Chair, Board of Trustees	**Date**	**Vice President for Academic Affairs**	**Date**

Provide headcount (HC) and full-time equivalent (FTE) student estimates of majors for Years 1 through 5. HC and FTE estimates should be identical to those in Table 1 in Appendix A. Indicate the program costs for the first and the fifth years of implementation as shown in the appropriate columns in Table 2 in Appendix A. Calculate an Educational and General (E&G) cost per FTE for Years 1 and 5 (Total E&G divided by FTE).

Implementation Timeframe	Projected Enrollment (From Table 1)	
	HC	FTE
Year 1	14	10
Year 2	18	13
Year 3	23	17
Year 4	29	22
Year 5	35	26

Projected Program Costs (From Table 2)				
E&G Cost per FTE	E&G Funds	Contract & Grants Funds	Auxiliary Funds	Total Cost
$22,592	$225,916	$68,000	$0	$293,916
$19,860	$516,370	$170,000	$0	$686,370

Note: This outline and the questions pertaining to each section must be reproduced within the body of the proposal to ensure that all sections have been satisfactorily addressed. Tables 1 through 4 are to be included as Appendix A and not reproduced within the body of the proposals because this often causes errors in the automatic calculations.

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	HC	FTE	E&G Cost per FTE	E&G Funds	Contract & Grants Funds	Auxiliary Funds	Total Cost
Year 1	14	10	$22,592	$225,916	$68,000	$0	$293,916
Year 2	18	13					
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Year 4	29	22					
Year 5	35	26	$19,860	$516,370	$170,000	$0	$686,370

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INTRODUCTION

I. Program Description and Relationship to System-Level Goals

A. Briefly describe within a few paragraphs the degree program under consideration, including (a) level; (b) emphases, including majors, concentrations, tracks, or specializations; (c) total number of credit hours; and (d) overall purpose, including examples of employment or education opportunities that may be available to program graduates.

The proposed new Ph.D. degree program responds to the critical emerging need to address two major, interlinked and interdependent systems (i.e., transportation and environmental systems) that impact the reliability, resiliency and sustainability of our current and future built and natural environments. Also, these two systems are most prone to anthropogenic influences that significantly affect regional scale economic conditions. Transportation networks combined with proper infrastructure convey socioeconomic benefits, yet they impact the environment and human health in direct and indirect ways. Conversely, environmental factors and conditions can also control how transportation systems are implemented. The major link between these two competing systems and their contributions to the economy is dependent on a sustainable, robust, safe, secure, energy-efficient, and economically viable built infrastructure. The proposed combined Transportation and Environmental Engineering Ph.D. program aims to seamlessly blend the interdependency of transportation and environmental system linkages to address critical challenges that enable the well-being of one or both systems through multidimensional research that merges traditional transportation and environmental engineering together as a single system.

(a) Level: Florida Atlantic University (FAU) proposes to offer a Ph.D. in Transportation and Environmental Engineering. This program will build upon and expand the success of the current sustainable infrastructure track offered within the Ph.D. in Ocean Engineering, making it a broader combined program that integrates transportation engineering and environmental engineering issues.

(b) Emphases: FAU has strategic pillars that are institutional unit-engaged activities that create new knowledge to benefit society. Two of the pillars of the university are directly aligned to this proposed doctoral degree program. I-SENSE, which is the Institute for Sensing and Embedded Network Systems Engineering that supports advancements in computing and sensing technologies targeted toward infrastructure systems, marine and environmental systems, and human health/behavior. The other pillar is the Harbor Branch pillar for ocean science and engineering/environmental sciences research effort. The Department created two strategic focus groups for strengthening emerging research and better engage with the university pillars: 1) urban mobility and 2) environmental sustainability.

(c) Total number of credit hours: There are two paths proposed to achieve the Ph.D. degree. The first is the traditional path, which requires both a B.S. and M.S. degree, and the second path is the direct BS to Ph.D. The program requires a minimum of 72 post baccalaureate credits hours including 21 credit hours of specialized coursework, 21 credit hours of dissertation research, and up to 30 credit hours from a master's degree in a closely related field that is consistent with the admission requirements. There is currently no Ph.D. program with the CIP code 14.9999 in the SUS.

(d) Overall purpose: The degree program engages a diverse group of faculty from engineering, science, urban planning and management disciplines to address issues aligned with the FAU's research pillars. This Ph.D. program will supplement and support the research efforts at FAU in the fields of urban mobility and water resources/environmental sustainability, as well as ongoing activities at the Harbor Branch and I-SENSE pillars. The primary goal of the Ph.D. in Transportation and Environmental Engineering program is to allow students to perform

specialized training and research, resulting in a degree that recognizes the student's scholarly competence and their ability to practice, conduct and report original and significant transportation and environmental engineering research. This Ph.D. program will serve Florida's needs by enabling the state to advance, via research and creation of new information and technology, a knowledge-based economy to manage the many environmental stressors on its water, land, air resources and transportation infrastructure, which impacts social and economic opportunities for current and future generations. The proposed Ph.D. program will encompass the fields of transportation engineering and environmental engineering, which is consistent with pressing needs of the state of Florida and the nation. The Department of Civil, Environmental and Geomatics Engineering (CEGE) at FAU is a research and teaching unit created in 2009 as a result of merging the Civil Engineering and Geomatics Engineering programs. The Department consists of nationally and internationally well-known faculty members with diverse and extensive experience in research, teaching, and graduate student education and mentoring. This new Ph.D. program in Transportation and Environmental Engineering is specifically tailored to meet the changing needs of the university's service region as well as the State and national priorities as identified by federal and state agencies and industry. Graduates will be rigorously prepared for careers in professional practice, regulatory agencies, research laboratories, academia, and specialized job functions in engineering, management, government, and consulting. CEGE faculty are responsible for $2.6 million in external research funding (FY2017-18), providing a solid base for student support, and the proposed doctoral program will provide significant leverage to help double research expenditures by bringing more national/state research centers like our Tier 1 University Transportation Center supported by USDOT, as well as our other research labs and centers: Freight Mobility Research Institute (FMRI), Laboratory for Adaptive Traffic Operations and Management (LATOM) at the Transportation Engineering Research Hub, Hydrosystems Research Laboratory (HRL), and the Laboratories for Engineered Environmental Solutions (Lab.EES).

B. Please provide the date when the pre-proposal was presented to CAVP (Council of Academic Vice Presidents) Academic Program Coordination review group. Identify any concerns that the CAVP review group raised with the pre-proposed program and provide a brief narrative explaining how each of these concerns has been or is being addressed.

The pre-proposal was presented to CAVP on February 22, 2019. No concerns were raised at the meeting.

C. If this is a doctoral level program please include the external consultant's report at the end of the proposal as Appendix D. Please provide a few highlights from the report and describe ways in which the report affected the approval process at the university.

As indicated in Appendix D, Hanover Research, an independent external consultant firm, provided a comprehensive report of the market analysis for civil and environmental engineering graduate programs in March 2018. Hanover's report took a broad view of civil, environmental, construction and infrastructure related doctoral programs, which led to the following key conclusions:

- Job opportunities related to civil-transportation and environmental engineering in Southeast Florida are plentiful and expected to grow by 2025. Above average job growth is projected for Postsecondary Engineering Teachers, Environmental Engineers, and Civil Engineers in Workforce Regions 20 through 23. Across these key occupations, total annual job openings are expected to average 6892 – 8085.

- Combined civil-transportation and environmental engineering programs have expanded rapidly, with more than five times as many students enrolled in 2015 as in 2006. However, this is still a relatively small field, with approximately 1,200 Ph.D. enrollments nationwide in 2015. Enrollment trends for civil and environmental engineering Ph.D. programs in Florida suggest that student

demand has been steady over the past five years, with most programs enrolling between 30 and 60 students in 2017. In sum, these trends suggest that FAU's goals of enrolling 7 to 10 new students in the first year and five students per year thereafter would be feasible. However, a prospective student survey is recommended to ensure sufficient student interest. *This survey was completed and is discussed in Section II.B*.

- FAU's proposed program would be the first of its kind in Florida and among the first nationwide. At the moment, in Florida, students with a transportation or environmental engineering interest must choose between a Ph.D. in Civil Engineering (offered by six universities) or a Ph.D. in Environmental Engineering (offered by three universities). Likewise, no Florida competitors offer online or hybrid options for coursework, like FAU has proposed. FAU's closest competitors would likely be Florida International University, University of Miami, and Florida State University-FAMU, which all offer Ph.D. programs in Civil Engineering with concentrations in Environmental Engineering. A review of combined Civil-Transportation and Environmental Engineering programs nationally only identified one institution that formally offers a hybrid Ph.D. program did not reveal any similar hybrid Ph.D. program.

- FAU's proposed credit requirements are slightly lower than those of competitor programs, but its curriculum requirements are similar. FAU's proposed total credits beyond the bachelor's degree (72 credits) are slightly lower than the competitor average (76.5 credits) but similar to UCF and more than FSU/FAMU and University of Miami. Like FAU's proposal, nearly all competitor programs require a qualifying exam, dissertation proposal defense, and dissertation defense. However, unlike FAU, most competitor programs do not include a publication requirement.

In addition, an external consultant report was requested by the FAU Provost's office. Two highly qualified professors in civil, environmental and transportation engineering were contacted to conduct a review of the proposal documents and conduct a site visit. The consultants were:

- Shahram Pezeshk, Ph.D., Chair and Professor, Department of Civil Engineering, University of Memphis
- Ashok Kumar, Ph.D., Chair and Distinguished University Professor, Department of Civil and Environmental Engineering, The University of Toledo

The final report is found in Appendix H. The findings of the report were as follows:

- They perceived the student demand, local market demand, and ability of CEGE faculty to attract Ph.D. level funding and students to be high for the proposed program
- They found the proposed curriculum to be appropriate to fill unmet workforce needs
- They perceived the administration to be fully supportive of the proposal
- They found that the proposed program has an adequate number of research active faculty with the right expertise/credentials to successfully implement the proposed program
- They found the facilities more than adequate to sustain the proposed program
- They found it difficult to find any major challenges in offering the proposed degree program, but did recommend that CEGE pursue hiring dedicated laboratory technicians

The report concluded that FAU is ready to implement the proposed Ph.D. program in transportation and environmental engineering, which will produce engineers to help in the economic development of the state and to improve the quality of life of Floridians.

The FAU Provost's office has reviewed the above findings of the external consultant reports and approved the Department's request to propose a new Ph.D. program in Transportation and Environmental Engineering.

D. Describe how the proposed program is consistent with the current State University System (SUS) Strategic Planning Goals. Identify which specific goals the program will directly support and which goals the program will indirectly support (see link to the SUS Strategic Plan on the resource page for new program proposal).

This proposed program is consistent with the Florida Board of Governor's Strategic Plan (2012-2025), specifically:

Excellence: By providing a new academic program in the area of transportation engineering and environmental engineering, FAU will contribute to strengthen the quality and reputation of academic programs, scholarship, research, innovation, and community and business engagement. This new program will improve the quality and relevance of FAU's two research pillars (I-SENSE and Harbor Branch) with world-class consequential research that actively engages the community and businesses in a meaningful, measurable way. It will increase externally funded research and patents, leading to broad external recognition of our academic and research programs. Also, it will help to meet the community needs and fulfill unique institutional responsibilities by promoting the FAU mission statement of academic and personal development, discovery, and lifelong learning through excellence and innovation in teaching, outstanding research and creative activities, public engagement and distinctive scientific and cultural alliances, all within an environment that fosters inclusiveness. Furthermore, the program will address the community's acute need for transportation and environmental engineering graduates and professionals.

Productivity: By providing a new academic program in the area of transportation and environmental engineering, FAU will be increasing the degree productivity in the needed focus area of STEM in the high demand disciplines of transportation and environmental engineering. FAU will be increasing the research and commercialization activities, and increasing the level of community and business engagement. The new program will increase access and production of professional degrees in the state of Florida, while including students from traditionally underrepresented groups, returning non-traditional students (which is a strength of FAU), and distance learning students since the program will be delivered in online and hybrid formats. The new program will also increase externally funded research and patents, while fostering a culture of entrepreneurship. Also, the proposed program will help to meet the community's need for transportation and environmental engineering graduates and professionals trained in a culture of academic and personal development, discovery, lifelong learning, and public engagement. Finally, students and faculty will engage in Florida's growing industry and the business community that is focused on mobility and the environment – both big parts of Florida's economic engine.

Strategic Priorities for a Knowledge Economy: By providing a new academic program in the area of transportation and environmental engineering, FAU will be directly increasing student access and success in degree programs in the STEM fields and other areas of strategic emphasis that respond to existing, evolving, and emerging critical needs and opportunities. Also, faculty and student researchers will be better able to attract more research funding from external sources and promote more collaboration with private industry on research projects. Finally, this new program should directly increase the number of highly trained STEM graduates who will join the transportation and environmental engineering related workforce in Florida.

STATE UNIVERSITY SYSTEM GOALS	EXCELLENCE	PRODUCTIVITY	STRATEGIC PRIORITIES FOR A KNOWLEDGE ECONOMY
TEACHING AND LEARNING	DIRECT Strengthen Quality and Reputation of Academic Programs and Universities	DIRECT Increase Degree Productivity and Program Efficiency	DIRECT Increase the Number of Degrees Awarded in STEM and Other Areas of Strategic Emphasis
SCHOLARSHIP, RESEARCH AND INNOVATION	DIRECT Strengthen Quality & Reputation of Scholarship, Research, and Innovation	DIRECT Increase Research and Commercialization Activity	DIRECT Increase Collaboration and External Support for Research Activity
COMMUNITY AND BUSINESS ENGAGEMENT	DIRECT Strengthen Quality & Recognition of Commitment to Community and Business Engagement	DIRECT Increase Levels of Community and Business Engagement	DIRECT Increase Community and Business Workforce

E. If the program is to be included in a category within the Programs of Strategic Emphasis as described in the SUS Strategic Plan, please indicate the category and the justification for inclusion.

The Programs of Strategic Emphasis Categories:

1. Critical Workforce:
   - Education
   - Health
   - Gap Analysis
2. Economic Development:
   - Global Competitiveness
3. **Science, Technology, Engineering and Math (STEM)**

Please see the Programs of Strategic Emphasis (PSE) methodology for additional explanations on program inclusion criteria at the resource page for new program proposal.

This proposed program is included in **Category 3. Science, Technology, Engineering, and Math (STEM)**. It is an engineering discipline (CIP code 14.9999) with emphasis on natural science, technology, engineering, mathematics, and design and construction.

F. Identify any established or planned educational sites at which the program is expected to be offered and indicate whether it will be offered only at sites other than the main campus.

The proposed program is expected to be offered at the main Boca Raton campus, with satellite research facilities and centers at the Davie campus, the Sea Tech campus, the Harbor Branch campus, and Jupiter campus with online, mostly online, and hybrid eLearning content.

II. Need and Demand

A. Need: Describe national, state, and/or local data that support the need for more people to be prepared in this program at this level. Reference national, state, and/or local plans or reports that support the need for this program and requests for the proposed program which have emanated from a perceived need by agencies or industries in your service area. Cite any specific need for research and service that the program would fulfill.

Demonstrating job demand for doctoral programs that are interdisciplinary in nature (hence our choice of CIP 14.9999 Engineering, Other), and grounded in fields where the growing complexity of what is demanded from graduates on the job is changing rapidly, is best demonstrated by a package approach. In this section, we will first (Part 1) use the more traditional CIP-SOC analysis to show general demand in the field itself at the national and state level and make projections about doctoral graduate demand based on national trends. This section continues with a discussion of the demand for training in related fields in South Florida and concludes with findings from a report that identifies entities that regularly hire graduates trained in transportation and environmental engineering at all levels. Sources for the analyses in this first section are the Bureau of Labor Statistics, the Florida Department of Economic Opportunity, and information from a market study conducted for FAU by an outside consultant (Hanover Research).

Part 2 of the discussion will tackle the growing complexity of this field that now requires an analytical and research-based approach to solving transportation and environmental challenges, and particularly challenges in the intersection of those two areas, that are certainly beyond the skill set garnered by an undergraduate program curriculum and also beyond the skill set obtained from a master's program graduate. Doctoral students are trained to synthesize, analyze, design and manage teams of scientists and engineers to solve complex problems that must be approached from a multi-disciplinary and multi-methodological approach. This will be illustrated by a discussion of agencies in the South Florida region that demonstrate a need for this higher level of training in the field. Part 2 should help address and augment the limitations of the traditional CIP-SOC analysis for doctoral programs in emerging STEM fields. Existing CIP codes are not always appropriate for interdisciplinary programs and job data utilized in the CIP-SOC approach is not always current enough to catch trends for emerging fields. The section concludes with testimonial excerpts of support letters from potential employers of these graduates in South Florida, as well as current job postings that demonstrate the need for higher level education in transport and environmental engineering and related areas.

Part 3 concludes this discussion with a presentation of key findings and conclusions from the Hanover Research report as well as examples of recent real world events where graduates from this program could take a leadership role in being part of the solution to environmental challenges that intersect with transportation. The full Hanover report is provided in Appendix D.

Part 1

National Labor Market Projections. The United States is facing a national challenge to rehabilitate and modernize its aging transportation and environmental infrastructure, and there is a growing demand at all levels for focused research, policy development, and engineering solutions to upgrade the nation's critical infrastructure gap, estimated at $1.5 trillion [1]. The US Congress will soon take up a $1.5 trillion infrastructure spending package, and the related employment opportunities are projected to grow by 11% annually [2]. Labor market projections for CIP code 14.9999 align with occupations as defined by the Bureau of Labor Statistics' (BLS) Standard Occupational Code (SOC) system. The SOC system is analogous to the CIP system, and the two are connected by the CIP-SOC crosswalk, which maps individual (six-digit) degree programs to (six-digit) occupations (NCES 2018). This crosswalk is used to develop a list of SOC-defined occupations to assess labor market demand for

individuals with training in transportation and environmental engineering. Table II-1 presents the amended BLS crosswalk-identified occupations related to a combined degree program in transportation and environment engineering that typically require at least a bachelor's degree for entry into the field. This limited analysis of occupations in this crosswalk that require a doctorate degree yields Engineering Teachers, Postsecondary and Environmental Science Teachers, Postsecondary, but CIP-SOC analysis can miss newly emerging areas for non-higher education positions in the sciences, particularly those that are interdisciplinary. Graduate level education is still common across many of the professions listed. For example, 5.5% of all Environmental Engineers hold doctorate degrees (BLS 2018). The weighted average for the SOC codes listed here is 11.9% holding doctorate degrees, compared to an average of 4.2% across all SOC occupations. This list was used to partially develop the labor market projections for our graduates (in conjunction with information provided in the report by Hanover Research (Appendix D).

Table II-1. CIP-SOC Crosswalk with Codes and Titles for Transportation and Environmental Engineering and Related Fields (CIP=14.9999)

SOC Code	SOC Title
11-1011	Chief executives
11-1021	General and operations managers
11-3071	Transportation, storage, and distribution managers
11-9021	Construction managers
11-9033	Education Administrators, Postsecondary
11-9039	Education administrators, all other
11-9041	Architectural and engineering managers
11-9121	Natural sciences managers
11-9161	Emergency management directors
11-9199	Managers, all other
17-1011	Architects, Except Landscape and Naval
17-1012	Landscape architects
17-1021	Cartographers and photogrammetrists
17-1022	Surveyors
17-2031	Biomedical Engineers
17-2041	Chemical Engineers
17-2051	Civil engineers
17-2081	Environmental engineers
17-2111	Health and safety engineers, except mining safety engineers and inspectors
17-2112	Industrial engineers
17-2121	Marine engineers and naval architects
17-2131	Materials engineers
17-2151	Mining and geological engineers, including mining safety engineers
17-2199	Engineers, all other
19-1031	Conservation scientists
19-2041	Environmental scientists & specialists, including health
19-2099	Physical scientists, all other
19-3051	Urban and regional planners
25-1031	Architecture teachers, postsecondary
25-1032	Engineering teachers, postsecondary
25-1051	Atmospheric, earth, marine, and space sciences teachers, postsecondary

SOC Code	SOC Title
25-1053	Environmental science teachers, postsecondary
25-1199	Postsecondary teachers, all other
41-9031	Sales engineers
47-2073	Operating engineers and other construction equipment operators
47-4011	Construction and building inspectors
170000	Architecture and Engineering Occupations
171000	*Architects, Surveyors, and Cartographers*
172000	*Engineers*

State Labor Market Projections. The Florida Department of Economic Opportunity (FDEO) provides listings of employment data statewide and by workforce region. Overall, job openings for transportation and environmental engineering related occupations in the CIP-SOC crosswalk (Table II-1) for Florida are summarized in Table II-2.

Table II-2. Florida Statewide Projections for CIP-SOC Crosswalk Occupations Related to Transportation and Environmental Engineering, 2017-2025 (FDEO 2018)

SOC Code	Title	Employment		Projected Change		Total Job Openings
		2017	2025	Number	Percent	
11-1011	Chief executives	20,000	21,379	1,379	6.9	12,758
11-1021	General and operations managers	82,913	93,393	10,480	12.6	63,844
11-3071	Transportation, storage, and distribution managers	4,291	4,670	379	8.8	2,925
11-9021	Construction managers	31,251	34,541	3,290	10.5	20,775
11-9033	Education Administrators, Postsecondary	1,544	1,732	188	12.2	1,066
11-9039	Education administrators, all other	1,374	1,528	154	11.2	932
11-9041	Architectural and engineering managers	6,830	7,665	835	12.2	4,609
11-9121	Natural sciences managers	1,035	1,156	121	11.7	756
11-9161	Emergency management directors	155	172	17	11.0	108
11-9199	Managers, all other	43,562	47,821	4,259	9.8	28,695
17-1011	Architects, Except Landscape and Naval	6,509	7,454	945	14.5	4,806
17-1012	Landscape architects	1,954	2,215	261	13.4	1,414
17-1021	Cartographers and photogrammetrists	579	775	196	33.9	599
17-1022	Surveyors	3,718	3,946	228	6.1	2,511
17-2031	Biomedical engineers	725	897	172	23.7	571
17-2041	Chemical engineers	451	496	45	10.0	290
17-2051	Civil engineers	18,882	21,759	2,877	15.2	14,822

SOC Code	Title	Employment		Projected Change		Total Job Openings
		2017	2025	Number	Percent	
17-2081	Environmental engineers	2,704	3,098	394	14.6	2,089
17-2111	Health and safety engineers, except mining safety engineers and inspectors	962	1,083	121	12.6	641
17-2112	Industrial engineers	10,221	11,024	803	7.9	6,204
17-2121	Marine engineers and naval architects	299	334	35	11.7	154
17-2131	Materials engineers	588	645	57	9.7	340
17-2151	Mining and geological engineers, including mining safety engineers					
17-2199	Engineers, all other	5,906	6,473	567	9.6	3,682
19-1031	Conservation scientists	287	322	35	12.2	272
19-2041	Environmental scientists & specialists, including health	5,721	6,352	631	11.0	5,153
19-2042	Geoscientists, except hydrologists and geographers	626	719	93	14.9	597
19-2043	Hydrologists	253	292	39	15.4	243
19-2099	Physical scientists, all other	557	604	47	8.4	415
19-3051	Urban and regional planners	2,053	2,276	223	10.9	1,532
25-1031	Architecture teachers, postsecondary	164	185	21	12.8	130
25-1032	Engineering teachers, postsecondary	1,727	2,015	288	16.7	1,460
25-1051	Atmospheric, earth, marine, and space sciences teachers, postsecondary	412	462	50	12.1	324
25-1053	Environmental science teachers, postsecondary	112	125	13	11.6	87
25-1199	Postsecondary teachers, all other	19,411	21,909	2,498	12.9	15,439
41-9031	Sales engineers	2,037	2,261	224	11.0	1,829
47-2073	Operating engineers and other construction equipment operators	17,542	20,004	2,462	14.0	17,608
47-4011	Construction and building inspectors	7,800	8,977	1,177	15.1	7,411
170000	Architecture and Engineering Occupations	113,063	123,774	10,711	9.5	74,829
171000	*Architects, Surveyors, and Cartographers*	12,760	14,390	1,630	12.8	9,330
172000	*Engineers*	65,992	73,165	7,173	10.9	43,911
	TOTAL ACROSS ALL SOC CODES	305,155	340,759	35,604	AVG = +12.7	227,091

Note: Occupational projections for SOC code 17-2151 Mining and Geological Engineers are not reported for Florida.

Based on Table II-2, employment opportunities across the SOC codes listed in the Hanover Report are

projected to increase by 12.7% from 2017 to 2025 in Florida. This is slightly above the average growth rate projected for all occupations in the state during this same period (11.3%). Using the average reported percentage of Ph.D.'s employed across all occupations (4.2%), this suggests 1495 new jobs from 9538 job openings for Ph.D. graduates in the state. These jobs should be distributed across industry and government, but also in academia where there will be future critical need to train the next generation of educators in this emerging field.

South Florida Labor Market Projections. FAU directly serves seven counties in southeast Florida - a densely populated region with rich geographic, economic, and social diversity and with unique infrastructure and ecological challenges. Urban development and transportation, waste management and pollution control, protection of sensitive ecosystems, Everglades restoration, utilization of limited water resources, rehabilitation and expansion of existing engineering infrastructure, and contingency planning and recovery efforts for natural disasters are examples of the tasks requiring the attention of well-educated and skilled Ph.D. level engineers to design and manage projects and teams to tackle these issues. Due to the existing population, the expected growth, and the aging of much of the state's critical infrastructure, the demand for engineers in FAU's service region is above average for the State. To estimate labor market demand in FAU's service area, FDEO database occupational projections for Workforce Regions 20 through 23, which encompass Palm Beach, Broward, Miami-Dade and Monroe, and Indian River, Martin, and Saint Lucie Counties were examined, and according to Table II-3, in the South Florida region, transportation and environmental engineering related occupations are projected to grow at a rate of 14.1% through 2025 – slightly faster than the state growth rate (12.7%) and higher than the growth rate expected across all occupations in the state (11.3%). Strong growth is also projected for engineering teachers, postsecondary (18.2%), environmental engineers (17.1%), civil engineers, general and other (17%).

For graduates of this program, employment opportunities and job openings across these SOC codes in the private sector, local/state governments, public-private institutions, non-profits and non-governmental organizations in Workforce Regions 20-23 are plentiful and expected to continue to grow with annual job openings on the order of 6892-8085 [3]. Applying the percentage of Ph.D.'s employed across all occupations (4.2%), this corresponds to 474 new jobs from 2962 job openings over the period, which would suggest a sizeable market for graduates of FAU's proposed program. However, it is worth noting that academic job openings for engineering professors will be limited to only about 20 per year across all engineering disciplines. For this reason, FAU will position its degree as one that will prepare graduates for careers as both academic researchers but also as practitioners positioned in government agencies at all levels as well as industry to best meet the region's workforce needs.

Table II-3. Southeast Florida Projections for CIP-SOC Crosswalk Occupations Related to Transportation and Environmental Engineering, 2017-2025 (Workforce Regions 20-23)

SOC Code	Title	Employment		Projected Change		Total Job Openings
		2017	2025	Number	Percent	
11-1011	Chief executives	7,557	8,080	523	6.9	4,823
11-1021	General and operations managers	27,003	30,436	3,433	12.9	20,818
11-3071	Transportation, storage, and distribution managers	1,319	1,457	138	10.5	927
11-9021	Construction managers	10,696	11,813	1,117	10.8	7,099
11-9033	Education administrators, postsecondary	549	605	56	10.9	364
11-9039	Education administrators, all other	473	527	54	13.8	322
11-9041	Architectural and engineering managers	1,768	2,014	246	13.6	1,231
11-9121	Natural sciences managers	347	382	35	10.9	247

SOC Code	Title	Employment		Projected Change		Total Job Openings
		2017	2025	Number	Percent	
11-9161	Emergency management directors	42	46	4	9.3	29
11-9199	Managers, all other	14,806	16,138	1,332	9.6	9,606
17-1011	Architects, except landscape and naval	1,455	1,716	261	17.9	1,138
17-1012	Landscape architects	1,008	1,147	139	12.8	735
17-1021	Cartographers and photogrammetrists	75	105	30	40.0	84
17-1022	Surveyors	1,119	1,226	107	9.0	804
17-2031	Biomedical engineers	151	191	40	27.7	125
17-2051	Civil engineers	5,790	6,791	1,001	17.0	4,700
17-2081	Environmental engineers	747	874	127	17.1	601
17-2111	Health and safety engineers, except mining safety engineers and inspectors	260	289	29	12.3	169
17-2112	Industrial engineers	2,282	2,486	204	8.8	1,415
17-2121	Marine engineers and naval architects	15	19	4	26.7	10
17-2131	Materials engineers	73	83	10	13.6	45
17-2199	Engineers, all other	1,045	1,198	153	13.6	717
19-1031	Conservation scientists	70	77	7	10.5	64
19-2041	Environmental scientists & specialists, including health(1)	1,424	1,606	182	12.9	1,318
19-2099	Physical scientists, all other	148	159	11	6.6	109
19-3051	Urban and regional planners	741	836	95	12.1	573
25-1031	Architecture teachers, postsecondary	60	65	5	8.1	45
25-1032	Engineering teachers, postsecondary	355	420	65	18.2	308
25-1051	Atmospheric, earth, marine, and space sciences teachers, postsecondary	61	70	9	14.8	50
25-1199	Postsecondary teachers, all other	4,820	5,379	559	10.7	3,753
41-9031	Sales engineers	659	745	86	13.2	610
47-2073	Operating engineers and other construction equipment operators	4,464	5,135	671	15.3	4,544
47-4011	Construction and building inspectors	3,219	3,763	544	16.6	3,140
Total All Occupations		94,601	105,878	11,277	AVG = +14.1	70,523

Note: Occupational projections for SOC code 17-2041 Chemical Engineers, 17-2151 Mining and Geological Engineers, and 25-1053 Environmental Science Teachers, Postsecondary are not reported for all Southeast Florida counties.

Potential Top Employers identified by Hanover Research. The external consulting firm Hanover Research was contracted to review the labor market demand for the program on January 22, 2018, and on August 21, 2018, they submitted the results of their market analysis ("Market Analysis," see Appendix D). Need was measured by economic forecasts and job posting trends. The following is a partial list of the top employers for SOC codes listed in the external Hanover Report (Appendix D) and from research in the JobsEQ database. The first ten had the most job openings in the first quarter of 2018, and the remaining are in alphabetical order taken from the JobsEQ database. Some of these employers provided support letters (Appendix C) for this proposed program.

- AECOM
- State of Florida
- Stantec
- CDM Smith
- WGI
- Magic Leap
- Cyber Coders
- Kimley-Horn
- MetaOption, LLC
- HDR
- Arcadis International
- Army Corps of Engineers
- Balfour Beatty
- Bechtel Corp
- Black and Veatch
- Brown and Caldwell
- Carollo Engineers
- CH2M Hill
- DPR Construction
- FPL
- Florida Department of Transportation
- Florida Department of Environmental Protection
- Florida Department of Health
- Geosyntec Consultants
- Golder and Associates
- Hazen and Sawyer, P.A.
- Jacobs Engineering
- Kaufman Lynn Construction
- Keith and Schnars
- Lennar
- Malcolm Pirnie
- Manhattan Construction Group
- Mapei
- MasTec
- Moss and Associates
- PBS&J
- Pirtle Construction
- Radise International
- SRI Consultants
- Suffolk Construction

- Turner Construction
- Water Management Districts

Part 2

Today many industry challenges can only be solved with multi-disciplinary knowledge and the ability to manage scientific teams. A Ph.D.'s ability to analyze large amount of information from different disciplines and identify strategic solutions to meet specific needs of the industry is required. This cannot be achieved by MS graduates who only have 1-2 years of advanced and often myopically focused training. This can be illustrated by examining in detail two South Florida entities with transportation and environmental missions, although similar challenges are faced by many medium and large size companies/municipalities across Florida and the nation.

Example 1 - South Florida Water Management District (SFWMD): Team members at the South Florida Water Management District play an important role in preserving and restoring the natural environment that extends from Central Florida's Upper Chain of Lakes through the Kissimmee River and Lake Okeechobee and south to the Florida Keys. Positions with a multi-disciplined understanding of water quality, hydrology and monitoring programs in complex watersheds require performing a wide range of non-routine and complex scientific-related work that involves evaluation of available information including multiple variable data analysis, development and assessment of alternatives, and justification of conclusions, requiring application of advanced and comprehensive knowledge of discipline-related concepts, methods and practices. In a world of climate change and sea level rise in a growing metropolitan region, where the environment intersects with transportation challenges, advanced training is required to independently plan, schedule, coordinate, manage, conduct and document complex scientific processes or multi-phase scientific projects that support the District's water resources management and environmental restoration initiatives.

Example 2 - Port of Palm Beach: The digital transformation of marine transportation is progressing, and part of this transformation includes the use of sophisticated techniques to improve safety, reduce costs, conserve the environment, and ensure that port operations continue to deliver essential goods and services during a crisis. As the industry evolves to autonomous shipping, remote ship operations and situation awareness for safe harbor operations and docking, these challenges are further complicated by managing logistics during catastrophic events such as severe weather, changing sea levels, earthquakes, tsunamis, natural disasters, and pandemics. Crucial for the success of this critical port infrastructure is the quality of available data such as environmental conditions, harbor topology/bathymetry, traffic and weather, wind, waves, currents and tides. This information has to be location-specific and in real time. Furthermore, an environmental forecasting model is needed, that can predict the local conditions within a short time window. The need for data driven decision support scenario forecasting, and the challenges that come with it can only be managed by someone with Ph.D. level training in a multidisciplinary field.

Support Letters from potential employers in the South Florida Region. Support letters from potential employers of this program in both industry and government are found in Appendix C. Excerpts are shown below:

> According to Chen Moore and Associates, "…we anticipate hiring graduates of this Ph.D. program."
>
> According to Hazen and Sawyer, "This new program will make a valuable contribution by

supplying the next generation of highly trained engineers for our industry, and we look forward to hiring graduates of this program to fill our needs."

According to TY Lin, "We also have the flexibility to allow PHD candidates to work either full or part time while pursuing their degree. I have hired several FAU engineering graduates and have been pleased with their ability to quickly adapt to consulting….Most of my PHD hires come from out of state…"

According to the South Florida Water Management District, "…the District employs more than 300 scientists and engineers, many with a Ph.D. degree…The District will continue to recruit a high-quality workforce in future."

According to CES, "We feel the Ph.D. program in Transportation and Environmental Engineering will definitely provide us with highly trained graduated that we look forward to hiring."

According to TranSystems, "The knowledge and skills obtained from such a Ph.D. education [Transportation and Environmental Engineering] will help to ensure the safety, security and long-term viability of our community."

According to the National Oceanographic and Atmospheric Administration, "As a partner, we look forward to participating in student training opportunities, mentoring, graduate committee advising, joint authorship on publications, and helping to direct this new training curriculum to help develop graduates with the technical, entrepreneurial, and executive leadership skills to address our workforce needs of the future."

According to Smart Structures, "…we plan to employ some of the local Ph.D. graduates in the future."

Postings for Related Positions. The increasing demand for Ph.D. graduates from transportation and environmental engineering programs was demonstrated in recent posted job openings from Indeed.com as listed in Appendix K. The Ph.D. degree was required for top administrative or technical managers as well as chief scientists. This sampling of job advertisements show that the MS or Ph.D. was the preferred qualification over the BS credentials. The demand for Ph.D. in non-academia positions is in an upward trend, which will benefit graduates from the proposed degree program. Sixteen of the eighty-seven largest engineering design firms, all with total revenues in excess of $115 million per year, have offices in Broward and Palm Beach counties, as given by Engineering News Record (July 2017). Close proximity to Latin America and the widened Panama Canal and expanded southeast Florida ports provide unique opportunities for those with international interests. Thus, graduates will meet local, state, national and even international needs and assume positions of responsibility in academic, industrial, and government organizations.

Part 3

The Hanover Report and related research. The external consulting firm Hanover Research provided a summary of their labor market demand analysis ("Market Analysis," see Appendix D) as follows:

Recommendations:

1. FAU CEGE should move forward with marketing its program as a combined Ph.D. degree in

transportation and environmental engineering, as this would be unique in Florida and in the United States.
2. FAU CEGE should position its degree as one that will prepare graduates for careers as both academic researchers and practitioners to best meet the region's workforce needs.

Key Findings

1. This proposed program would be the first of its kind in Florida and nationwide. In Florida, students must choose between a Ph.D. in Civil Engineering (offered by five SUS universities) or a Ph.D. in Environmental Engineering (offered by three SUS universities). Likewise, no Florida competitors offer online or hybrid options for coursework, such as the proposed program. Florida International University, University of Miami, and Florida State University-FAMU offer Ph.D. programs in Civil Engineering with concentrations in Environmental or Transportation Engineering, but they do not offer a combined degree. A review of combined Transportation or Environmental Engineering programs nationally did not reveal any similar hybrid Ph.D. program.
2. Job opportunities related to transportation and environmental engineering in Southeast Florida are plentiful and expected to grow by 2025. Above average job growth (14.1%) is projected for Environmental Engineers and Transportation Engineers in Workforce Regions 20 through 23 from now until 2025. Across the key occupations investigated here, total annual job openings are expected to be in the range of 6892-8085, which would suggest a sizeable job market for graduates. Many of these job openings will be filled by BS and MS graduates with environmental engineering or transportation engineering backgrounds. However, those graduates will be limited in their ability to handle the increasing complexity of the competing transportation and environmental engineering issues related to sustainability and infrastructure. This is the reason for the recent surge in the demand for Ph.D. graduates not just from academia but also from government and industry [4].
3. The State of Florida is not producing sufficient numbers of transportation and environmental engineering graduates with Ph.D. level credentials to satisfy the current and future needs. The SUS transportation and environmental engineering doctoral graduates numbered only 24 in 2016. In just Workforce Regions 20-23, the labor market demand is conservatively estimated to be 6892-8085 jobs. If the percentage of jobs requiring a Ph.D. degree across all professions (4.2%) is applied to the lower number (6892), then the demand could be estimated at 290 each year. The State of Florida produces less than 10% of the current demand for transportation and environmental engineering related Ph.D.'s, so additional programs are necessary to meet the need.

The findings by Hanover Research indicate that the job market trends are consistent with the CIP-SOC code crosswalk analysis and that a combined transportation and environmental engineering program at Florida Atlantic University would be viable. Specifically, the labor market is expected to grow over the next several years, but currently there are not enough graduates being produced to meet workforce demands at all levels in transportation and environmental engineering in the State of Florida.

Random internet searches of news stories over the past few years illustrate the need for highly trained scholars in transportation and environmental engineering to lead scientific teams to solve problems and mitigate real crises. The recent flooding disaster in Nebraska is a poignant example. The combination of unseasonably heavy rain, melting snow from a major cyclone and other recent storms inundated the Midwest in early 2019, killing at least three people and causing $3 billion in damages. Rising water levels breached levees along the Missouri River and forced several towns to evacuate. Some residents were stranded for weeks as already poor roads were blocked by floodwaters and interstate highways turned into temporary rivers with more than 2,000 homes and

340 businesses lost. "The extensive flooding seen in in March 2019 will continue through May and become more dire and may be exacerbated in the coming weeks as the water flows downstream," said Ed Clark, director of NOAA's National Water Center in Tuscaloosa, AL, in a statement. "This is shaping up to be a potentially unprecedented flood season, with more than 200 million people at risk for flooding in their communities." More frequent and severe flooding will continue to grip the country, leading to more extensive rebuilding and recovery efforts that may require rethinking the whole approach to community resiliency of transportation, water resources, and environmental infrastructure. The frequency of natural disasters predicted to occur once in every 100 years are now happening every month. And these events are occurring all over the world including recent wildfires in California, the tsunami in Indonesia, hurricanes in the Caribbean and Puerto Rico, earthquakes in Alaska, tornadoes in Illinois, to name a few. These issues cannot be handled by a workforce with only BS or MS training. Long after the press coverage disappears, the task of rebuilding a more resilient human civilization requires a new paradigm that depends on a deeper understanding of how the transportation, energy, and water resources infrastructure relates to the changing environment. Graduates from this program will be ready to take the lead in solving these types of problems.

According to Foley (2018) [4], the National Science Foundation's (NSF's) biennial Survey of Doctorate Recipients shows that, for the first time, private sector employment of science and engineering Ph.D.'s in the US "is now nearly on par with educational institutions." The data indicate in 2017 that private sector employment reached 42%, while educational institution hiring was 43% of the total. By comparison, educational institutions in 1997 "eclipsed private sector employment by 11 percentage points." Also according to the data specific to the "Other Engineering" category, private sector employment is 53%, while traditional civil engineering doctorates were employed only 45% in the private sector.

References

[1] American Society of Civil Engineers (ASCE). 2017. Report Card for America's Infrastructure. https://www.infrastructurereportcard.org/

[2] United States Department of Labor, Bureau of Labor Statistics, Occupational Outlook Handbook (2018).

[3] FDEO. 2018. "Employment Projections." Florida Department of Economic Opportunity (FDEO). http://www.floridajobs.org/labor-market-information/data-center/statistical-programs/employment-projections

[4] Foley, D.J. (2018). Survey of Doctorate Recipients: 2017, National Center for Science and Engineering Statistics, National Science Foundation, NSF-19-301, Washington, DC.

B. Demand: Describe data that support the assumption that students will enroll in the proposed program. Include descriptions of surveys or other communications with prospective students.

Since planning for the proposed Ph.D. program began, records of inquiries received from potential students who wanted to pursue a doctoral degree with CEGE faculty have been kept, and the results are overwhelmingly positive. There is no sign of slowing down in terms of the demand due to the major emphasis at the federal level on infrastructure renewal and vulnerability of resiliency and mobility threats in the South Florida region. The Department receives an increasing number of inquiries from students interested to study in this field, and also from employers seeking graduates with higher degree specialization.

The Hanover Market Study (Appendix D) states that a "Combined Transportation and Environmental Engineering programs would be expected to expand rapidly, with more than five

times as many students enrolled in 2015 as in 2006. These trends suggest that students are increasingly interested in enrolling in combined engineering doctoral programs with specializations related to transportation and environmental engineering. Enrollment trends for transportation or environmental engineering related Ph.D. programs in Florida suggest that student demand has been steady over the past five years, with most programs enrolling between 30 and 60 students in 2017." **In conclusion, these trends suggest that the goal of enrolling 10 to 15 students in the first year would be feasible.** However, a prospective student survey was recommended to ensure sufficient student interest and to gain further insight into student preferences in terms of delivery format. That survey was conducted in May 2018 in response to this comment, and results were very positive. Prospective, current, and former students and potential employers indicated that 41.8% (n = 55 responses) would enroll in a Ph.D. offered by the FAU Department of Civil, Environmental & Geomatics Engineering (CEGE). This first survey was conducted at Concrete Expo 2018 (April 4, 2018), which is an annual continuing education event sponsored by the Department and the Florida Concrete & Products Association to engage industry, professional engineers, current students, and alumni in the latest state of the art involving concrete materials, construction, and design. A *polleverywhere.com* survey was conducted during the plenary session to determine interest in the proposed program. A similar survey was conducted at Infrastructure Night held on October 24, 2019. Infrastructure Night is another annual continuing education event sponsored by the Department and industry partners to bring together industry, professional engineers, current students, and alumni to discuss infrastructure engineering and planning issues (n = 50 responses). The result showed that 46% of respondents were interested in enrolling in the program (refer to Appendix L for survey instruments).

Testimonials. Full documents are found in Appendix G.

From Aleksander Stevanovic, Former CEGE Transportation Engineering Faculty Member who left FAU to join University of Pittsburgh in 2019

"…from the time I joined FAU in 2009 until I left in 2019, we have missed many opportunities to see our best graduate students to continue their post-graduate education by pursuing their PhD degrees at CEGE. Many of them joined other national and international PhD programs while others… decided to continue their careers in industry. Below is a list of all of those students which essentially represents missed opportunities for FAU – not just to graduate future professors and industry leaders but also to ensure continuous excellence of the academic research. Of course, there are many more MSc students who graduated from FAU CEGE and who could be substituted by qualified PhD students from the nation or abroad, if only the CEGE could offer a PhD degree…"

From: Kazi Hussain, FAU MSCV Class of 2019

"… If there was a Ph.D. program in the CEGE department at FAU when I graduated, I would have definitely applied for it, which would have definitely saved two years of my life. It was always surprising to me that the CEGE department at FAU with so many brilliant faculty and lab facilities did not have its own Ph.D. program. While I was talking to my current supervisor at the University of Nebraska-Lincoln about my previous school, she was also very much surprised, as she is familiar with a couple of faculty as achieving national prominence in their respective fields."

From Rahamat Ullah Tanvir, FAU MSCV Class of 2019

"…Personally, it was very likely that I would continue my Ph.D. studies at FAU after my masters if there was a Ph.D. program in CEGE. I really liked my advisor, the other faculty members as well as the research facilities there. Unfortunately, there was no Ph.D. program, so I had to pursue other

opportunities."

From Md. Fahim Salek, FAU MSCV Class of 2019

"FAU would be the perfect place for me to continue my research because I made a good connection with my supervisor in two years, but the absence of a Ph.D. program in environmental engineering led me to choose another institution to continue my research and study. Now I am doing my Ph.D. at Auburn University and have to start everything from the beginning. I really wish that FAU CEGE had a Ph.D. program that started in the Fall of 2019."

Nationwide Trends in Student Demand. To assess potential student demand for a doctorate degree in transportation and environmental engineering, the enrollment and degree completion trends were examined. The American Society for Engineering Education (ASEE) tracks annual enrollments in engineering disciplines for 358-member institutions (ASEE 2018). The ASEE tracks three relevant engineering disciplines at the doctoral level related to the fields of transportation and also environmental engineering: 1) environmental engineering, 2) civil engineering (with transportation specialization and environmental specialization), and 3) combined civil and environmental engineering. All three doctoral programs related to transportation and environmental engineering have demonstrated gains in enrollment over the last decade as illustrated in Figure 1. Note that enrollment reflects both full-time and part-time students. For this analysis, students enrolled in General Civil Engineering Ph.D. programs but specializing in transportation or environmental engineering are estimated using a factor of 25%, which is the typical percentage of faculty in each disciplinary area of a SUS civil engineering program (refer to Table II-5) .

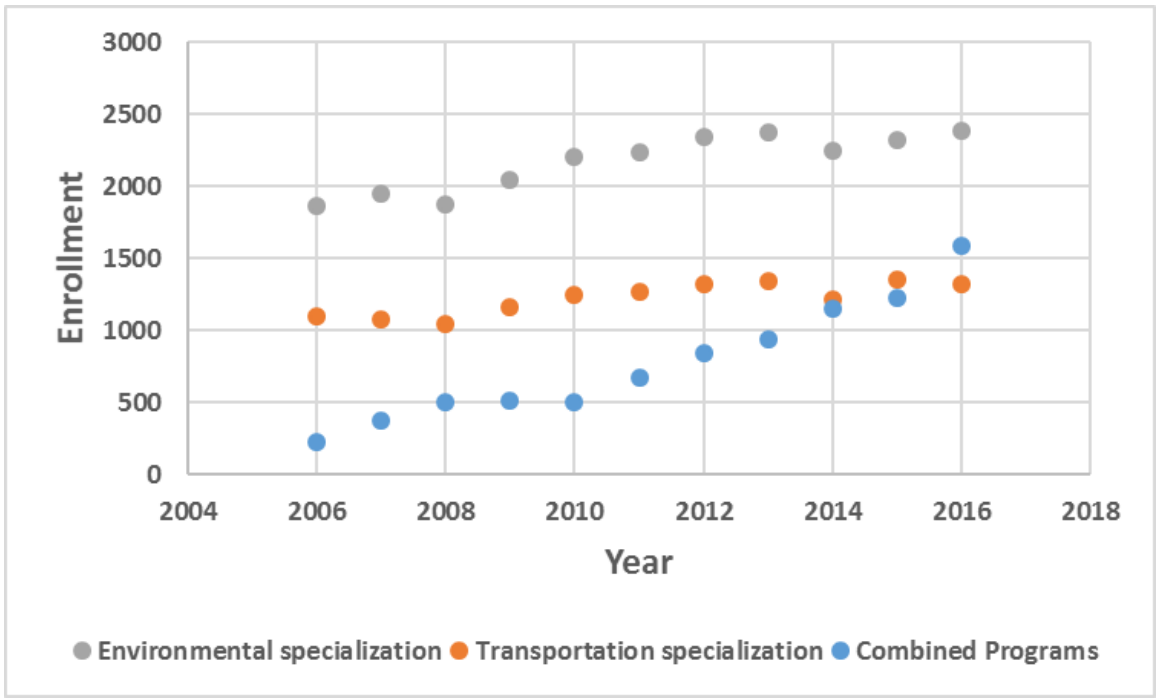

Figure 1. National Historical Headcounts in Transportation and Environmental Engineering Related Doctoral Programs, 2006-2017 (ASEE 2018)

Degree completion trends as reported by the National Center for Education Statistics (NCES) Integrated Postsecondary Education Data System (IPEDS) are analyzed in terms of three metrics: 1) Compound annual growth rate (CAGR), which reflects the percentage growth that would occur each year if the same change occurred yearly between the first year and the final year; 2) Average annual change (AAC), which estimates average year-to-year differences; and 3) Standard deviation of the year-to-year change (STDEV), which indicates how significantly each year's change varies from the AAC. Nationwide trends are summarized in Table II-4, student demand for doctoral programs in transportation and environmental engineering and related fields increased between 2012 and 2016, with an annualized growth of 6.3% (as discussed in the Hanover Report-Appendix D). This compares favorably to the annualized growth rate seen across all Ph.D. programs in the United States during this same period (2.8%) . Table II-4 includes only degree completions reported under the award level of "Doctor's degree – research/scholarship."

Table II-4. National Ph.D. Degree Completions in Fields Related to Transportation and Environmental Engineering, 2012-2016 (IPEDS 2018)

CIP Category	2012	2013	2014	2015	2016	CAGR	AAC	STDEV
Transportation and Highway Engineering	199	217	244	257	255	6.4%	14	12
Environmental & Environmental Health Engineering	316	368	401	419	381	4.8%	16	39
Civil Engineering, General and Other*	404	442	496	535	515	6.3%	28	33
Geological/Geophysical Engineering	4	16	18	15	21	51.4%	4	6
Surveying Engineering	2	0	0	1	9	45.6%	2	4
Total	**925**	**1,043**	**1,159**	**1,227**	**1,181**	**6.3%**	**99**	**72**

**Degree completions in the combined category (Civil Engineering, General and Other) were adjusted to determine the estimated transportation and environmental specializations using a factor of 25%.*
Note that the following CIP fields reported zero completions at the doctorate level: 14.0802 Geotechnical and Geo-environmental Engineering and 14.4401 Engineering Chemistry.

Statewide Trends in Student Demand. In terms of statewide data, doctoral degree conferral trends for transportation or environmental engineering related fields in Florida show an annual increase of nearly 5% between 2012 and 2016 for environmental engineering, but no gains for civil engineering, general doctorate degrees. Except for the University of Florida, most competitor programs are relatively small – graduating between 2 and 13 students in 2016. **However, based on these trends, our short-term goal to graduate five students per year seems obtainable with the proper recruitment strategy.**

Local Trends in Student Demand. In Southeast Florida specifically, the only two universities producing Ph.D. graduates in transportation or environmental engineering (and related) fields are Florida International University (FIU) and the University of Miami (UM). However, it is important to note that UM does not have a transportation specialization. Using the methodology from the external Hanover Research Market Study, the number of Ph.D. candidates for student demand in

transportation and environmental engineering was estimated based on the percentage of faculty in the respective areas (Transportation, Environmental, and Other) in the existing SUS civil engineering or environmental engineering Ph.D. programs (refer to Table II-5).

Table II-5. Breakdown of Faculty Distribution in Florida SUS Programs

Institution	Total Faculty	ENV Faculty	TRANS Faculty	%ENV	%TRANS	%OTHER
Florida International University	30	5	7	17%	23%	60%
Florida State University/ Florida Agricultural and Mechanical University	22	4	6	18%	27%	55%
Florida Tech	25	1	4	4%	16%	80%
University of Central Florida	26	7	4	27%	15%	58%
University of Florida	64	15	7	23%	11%	66%
University of Miami	15	3	0	20%	0%	80%
University of South Florida	30	8	7	27%	23%	50%

An estimate of sub-discipline degree completions was conducted by applying faculty distribution factors from Table II-5 to the total Civil Engineering, General degree completion data. This data is summarized in Table II-6.

Table II-6. Florida SUS Doctoral Degree Completions in Transportation and Environmental Engineering Related Fields, 2012-2016 (IPEDS 2018)

Institution	2012	2013	2014	2015	2016	CAGR	AAC	STDEV
Environmental/Environmental Health Engineering								
University of Central Florida	1	3	1	5	4	41.4%	1	2
University of Florida	9	10	20	7	4	-18.4%	-1	8
University of South Florida	-	1	1	3	4	-	-	-
Total	**10**	**14**	**22**	**15**	**12**	**4.7%**	**1**	**6**
Civil Engineering, General: Environmental Specialization								
Florida International University	1	2	1	2	2	12.0%	0	1
Florida State University/ Florida Agricultural and Mechanical University	1	1	0	1	1	0.0%	0	1
Total	**2**	**3**	**1**	**3**	**3**	**10.7%**	**0**	**2**
Civil Engineering, General: Transportation Specialization								
Florida International University	2	3	2	3	3	10.7%	0	1
Florida State University/ Florida Agricultural and Mechanical University	1	1	0	2	1	0.0%	0	1
University of Central Florida	2	1	2	2	2	0.0%	0	1
University of Florida	2	2	2	2	2	0.0%	0	0
University of South Florida	1	2	1	1	1	0.0%	0	1
Total	**8**	**9**	**7**	**10**	**9**	**3.0%**	**0**	**3**

Uncombined degree conferrals in Civil-Transportation Engineering or Environmental Engineering Ph.D. programs are higher than the national average. Specialized Ph.D. programs in

Transportation/Highway Engineering doctoral degrees have increased by 6.4%, and Environmental/Environmental Health Engineering indicated 4.7% annualized growth, higher than the national average (2.8%). According to this data, the number of doctoral graduates from Florida SUS transportation engineering or environmental engineering related programs was 24 in 2016. Given the Ph.D. labor market demand in South Florida alone is significantly higher (referring to Table II-3, 474 new jobs from 2962 job openings), it seems that the State of Florida is not producing sufficient numbers of graduates with Ph.D. level credentials to satisfy the needs.

C. If substantially similar programs (generally at the four-digit CIP Code or 60 percent similar in core courses), either private or public exist in the state, identify the institution(s) and geographic location(s). Summarize the outcome(s) of communication with such programs with regard to the potential impact on their enrollment and opportunities for possible collaboration (instruction and research). In Appendix D and H, provide data that support the need for an additional program.

The competitive landscape for FAU's proposed program is analyzed by reviewing Ph.D. programs related to transportation and environmental engineering within the State University System of Florida and private institutions in the state. The NCES database reports no doctorate degree completions (CIP code 14.9999) in transportation and environmental engineering fields within Workforce regions 20, 21, 22, and 23 between 2012 and 2016. Florida International University and the University of Miami are FAU's closest competitors geographically.

Table II-7 provides an overview of all doctorate programs related to transportation or environmental engineering identified in the State University System of Florida including the University of Miami and Florida Tech, all of which are delivered as on-site programs. Notably, FAU's proposed Ph.D. in Transportation and Environmental Engineering differs from competitors in that no other Florida university offers a combined Ph.D. in transportation and environmental engineering. Likewise, no Florida competitors offer fully online or hybrid options for coursework, as FAU has proposed. However, two competitors in the SUS (Florida International University and FAMU/Florida State University) do offer Ph.D. programs in Civil Engineering with separate concentrations in Transportation Engineering or Environmental Engineering. These concentration areas are described as *research specialties*, although they are typically not associated with required core coursework. Offering a combined degree program would, therefore, distinguish FAU from the rest of the current programs in the State University System of Florida.

IPEDS (2018) reports the past five years of distance education program completions, which rely on "*one or more technologies to deliver instruction to students who are separated from the instructor*." However, programs classified as distance education are not necessarily fully online and may involve residential requirements. Additionally, because IPEDS does not disaggregate distance and onsite completions by the institution, there is no way to determine the number of distance completions within a given academic field, only the number of institutions that report offering a distance program.

Table II-7. Overview of Doctorate Programs Related to Transportation and Environmental Engineering in the State University System of Florida (NCES 2018)

Institution	Program	Concentrations
Florida International University	PhD in Civil Engineering	Structural Construction and Geotechnical, *Environmental* and Water Resources, *Transportation*
University of Florida	PhD in Civil Engineering	Coastal & Oceanographic, Coastal Ecosystem Dynamics, Geosystems, Materials & Pavements, Public Works, Structural, Sustainable Construction, Water Systems, *Transportation*
	PhD in Environmental Engineering	Air Resources, Coastal Ecosystems, Environmental Nanotechnology, Systems Ecology
University of Central Florida	PhD in Civil Engineering	Geotechnical, Structural, Water Resources, Construction Management, *Transportation Systems*
	PhD in Environmental Engineering	Water Process, Waste Treatment, Air Quality
University of South Florida	PhD in Civil Engineering	International Development, Geotechnical, Materials Science, Structures, *Transportation*, Water Resources
	PhD in Environmental Engineering	--
Florida State University-FAMU*	PhD in Civil Engineering	Structures, Construction, Water Resources, Geotechnical, *Environmental*, *Transportation*
Florida Tech**	PhD in Civil Engineering	Construction Management, Geotechnical, Structural, Water Resources, *Environmental, Transportation*
University of Miami***	PhD in Civil Engineering	Civil, Architectural, or Environmental Engineering

**Joint program between Florida State University and Florida Agricultural and Mechanical University.*
***Private institution not in the State University System of Florida.*

As shown in Table II-8, there are very few universities in the United States that offer distance learning options for doctorate degrees in fields related to transportation and environmental engineering. Those that offer some distance learning coursework are very small programs. One such institution is the University of South Carolina – Columbia (Ph.D. in Civil Engineering, General). The College of Engineering and Computing "offers certain online courses for busy professionals seeking advanced degrees...Students in the program view their classes via streaming video" with "various courses offered three times a year following a tri-semester plan." While their Ph.D. in Civil Engineering, General is not specifically marketed as a hybrid program, students may take advantage of the online coursework. However, all doctoral-level programs require "a research component that must be done in residence."

Table II-8. Degrees Awarded at Institutions offering Distance Learning Options in Fields Related to Transportation and Environmental Engineering, 2012-2016 (IPEDS 2018)

Institution	2012	2013	2014	2015	2016	CAGR	AAC	STDEV
Civil Engineering, General								
Columbia University in the City of New York	7	13	7	9	10	9.3%	1	4
University of Alabama Huntsville	-	-	-	2	2	-	-	-
University of South Carolina - Columbia	6	6	11	9	4	-9.6%	-1	4
Total	**13**	**19**	**18**	**20**	**16**	**5.3%**	**1**	**6**
Environmental/Environmental Health Engineering								
Columbia University in the City of New York	4	4	-	-	-	-	-	-
Total	**4**	**4**	**-**	**-**	**-**	**-**	**-**	**-**

A complete listing of combined engineering Ph.D. programs can be found on the ASEE's Alphabetical List of Participating Graduate Degree Programs (ASEE 2018). Nationally, this list identifies no universities that offer combined transportation and environmental engineering Ph.D. programs, similar to what FAU has proposed. There are some programs that offer both transportation engineering and environmental engineering topics as core coursework, rather than as concentrations, such as The University of South Carolina's Ph.D. in Civil Engineering, General.

Transportation engineering and environmental engineering related university department websites for 30 institutions were reviewed, including those listed by the ASEE, to determine if any offer hybrid or online Ph.D. programs that were not captured by IPEDS data. One such program (combined Ph.D. in Civil and Environmental Engineering) was identified at Clarkson University, which offers an "off campus" Ph.D. option for students in 12 different fields of study, including Civil & Environmental Engineering. The off-campus option is designed for working professionals when their "Ph.D. research directly aligns with research needs of [their] employer." In collaboration with research advisors from Clarkson, students work with a co-advisor at their place of employment to develop a research project that meets the requirements of the Ph.D. program. Employers must also meet Clarkson's conflict of interest policy requirements. Students can transfer up to 30 credits towards the 90 credit coursework requirement and also complete up to 9 credits through online courses. Each department specifies the period the student spends on campus (at the department) and the number of visits (each semester).

Two of the other institutions reviewed (Stanford University and the University of Illinois) offer combined master's degrees (in civil and environmental engineering) online, but not doctoral degrees. Given the scarcity of existing online and hybrid Ph.D. programs in many engineering disciplines, Ph.D. programs within the separate fields of transportation engineering or environmental engineering were also reviewed, and six were identified with hybrid options:

- Auburn University (Ph.D. in Civil Engineering) offers hybrid coursework with department approval
- Columbia University (Ph.D. in Earth and Environmental Engineering) offers partially online courses
- Illinois Institute of Technology (Ph.D. in Civil Engineering and Ph.D. in Environmental Engineering) states in the catalog that online courses are available on a case by case basis

- Mississippi State University (Ph.D. in Civil Engineering) offers hybrid coursework, but no degree completions were reported in 2017
- University of Alabama-Huntsville (Ph.D. in Civil Engineering) offers coursework through a primarily online format
- University of South Carolina-Columbia (Ph.D. in Civil Engineering) has advertised a hybrid format on their website.

Even within the broad fields of transportation engineering and environmental engineering (as well as combined civil engineering programs), offering formal online or hybrid Ph.D. programs appears to be rare. Some institutions may offer a master's degree and/or individual courses online, which may make it possible for students to complete some of their Ph.D. degree coursework requirements off-campus. However, such Ph.D. programs are rarely marketed specifically as a hybrid program. Among existing competitors, the typical target audience is full-time onsite students who are interested in conducting research.

To complement NCES degree completions trends, the Florida State University System Board of Governors also publishes enrollment data, which provides a more up to date snapshot of student demand in the state. Remarkably, enrollment in FAMU/FSU's Ph.D. in Civil Engineering program has almost tripled over the past five years. However, FAU's closest competitor, FIU, has seen an enrollment decrease since 2013. These trends suggest student demand varies from year to year and program to program. The same can be said of the three environmental engineering Ph.D. programs in the state. USF's program, for instance, has doubled enrollments over the past five years. While UCF and UF have remained relatively flat. However, across the entire SUS, Ph.D. enrollments have remained steady over the past five years for programs related to transportation or environmental engineering, suggesting student demand is consistent.

In terms of enrollment volume, all universities except for University of Miami, enrolled at least 33 students in their Ph.D. programs in 2017 across all transportation and environmental engineering related doctoral programs. Assuming students are completing these programs within four to six years, this confirms that FAU's goals of enrolling 7 to 10 students in the first year and graduating 5 or more students per year after the first six years are reasonable. Applying the same methodology previously used in the Student Demand section, Table II-9 shows that the headcounts statewide are generally increasing.

Table II-9. Florida SUS Doctoral Degree Estimated Headcounts in Transportation and Environmental Engineering Related Fields, 2012-2016 (SUS Board of Governors 2018, UM 2018, Florida Tech 2018)

Institution	2012	2013	2014	2015	2016	CAGR
Environmental/Environmental Health Engineering						
University of Central Florida	13	17	15	10	12	-2.0%
University of Florida	52	47	45	49	42	-5.2%
University of South Florida	12	16	15	20	25	20.1%
Total	**77**	**80**	**75**	**79**	**79**	**+0.6%**
Civil Engineering, General: Environmental Specialization						
Florida International University	11	12	10	9	8	-7.7%
Florida State University/ Florida Agricultural and Mechanical University	2	3	4	4	6	31.6%
University of Miami*	3	3	3	3	3	0.0%
Total	**16**	**18**	**18**	**16**	**17**	**+1.5%**
Civil Engineering, General: Transportation Specialization						
Florida International University	16	17	15	13	11	-8.9%
Florida State University/ Florida Agricultural and Mechanical University	4	5	6	7	9	22.5%
University of Central Florida	8	10	10	10	12	10.7%
University of Florida	7	7	7	7	7	0.0%
University of South Florida	13	11	10	11	12	-2.0%
Florida Tech*	1	2	2	2	1	0.0%
Total	**49**	**52**	**50**	**50**	**52**	**+1.5%**

*Private institution not in the Florida SUS

D. Use Table 1 in Appendix A (1-A for undergraduate and 1-B for graduate) to categorize projected student headcount (HC) and Full Time Equivalents (FTE) according to primary sources. Generally undergraduate FTE will be calculated as 30 credit hours per year and graduate FTE will be calculated as 24 credit hours per year. Describe the rationale underlying enrollment projections. If students within the institution are expected to change majors to enroll in the proposed program at its inception, describe the shifts from disciplines that will likely occur.

The headcount given in Table 1-B in Appendix A was estimated based on the current Ph.D. students supervised by the CEGE faculty and inquiries of the Ph.D. program for the last five years. Currently, 12 students enrolled in the Ocean Engineering (OE) Ph.D. program are under the supervision of CEGE faculty members. Seven (7) are expected to switch at the inception of the proposed Ph.D. program in Fall 2020. From that group, three are from industry.

The environmental/water resources group in the Department will receive a multi-year $3 million grant from FEMA to investigate statewide flooding master planning, which will require 3 doctoral students and 2 post-docs for the initial 3-year planning study. The urban mobility and sustainable infrastructure group in the Department has recently received large-scale funding as part of the Tier 1 Transportation Center, and is expected to require 4 doctoral students as part of multi-year projects. Based on prospective student interest, it is estimated that 2-3 Ph.D. students will come from local industry, 2-3 from graduates of the Master of Science in Civil Engineering

program, and 3-4 recruited from foreign countries. In 2017-2018, CEGE faculty were responsible for securing $2.6 million, and in 2018-March 2019, an additional $2.1 million is secured. In addition, two new faculty hires (one transportation engineering and one environmental engineering) are being added to the Department with external searches being completed in Spring 2019. It is anticipated that both of these new hires will use startup funds to bring doctoral students (not counted in the estimate). Thus, the proposed degree program is projected to have a headcount that should be able to graduate 3-5 Ph.D. students each year after year 5.

Out of 12 Ph.D. students currently registered for the OE Ph.D. program, 7 would have switched to the proposed Ph.D. program if it started today. The remaining 5 in the structural and geotechnical engineering area will stay in the OE Ph.D. program. Therefore, the impact of the Ph.D. in transportation and environmental engineering on the OE Ph.D. program is minimal because CEGE will continue recruiting Ph.D. students in structural engineering and geotechnical engineering for the sustainable infrastructure track in the Ph.D. in Ocean Engineering. Even without those students, the OE Ph.D. program is self-sustaining, as the number of graduates has surpassed the state requirement of 15 over a 5-year period.

E. Indicate what steps will be taken to achieve a diverse student body in this program. If the proposed program substantially duplicates a program at FAMU or FIU, provide, (in consultation with the affected university), an analysis of how the program might have an impact upon that university's ability to attract students of races different from that which is predominant on their campus in the subject program. <u>The university's Equal Opportunity Officer shall review this section of the proposal and then sign and date Appendix B to indicate that the analysis required by this subsection has been completed</u>.

The FAU College of Engineering and Computer Science has been very successful in achieving diversity in its student body. We typically rank high nationally in numbers of B.S. degrees awarded to African Americans and Hispanics. The College is a major player in SECME, Inc. (Southeastern Consortium for Minorities in Engineering). FAU is recognized for providing more SECME scholarships (25) than any other participating university, and for its outstanding university-industry SECME partnership. The FAU-Palm Beach County program is considered a role model for the entire SECME organization. With its broad input from the community, business and industry, SECME has contributed much to student diversity in the College.

The Division of Student Services within the College of Engineering and Computer Science has an outstanding record of supporting student success and professional development. The Division is a major factor in the numbers of women and minorities who successfully complete their degree programs at FAU and who go on to positions of leadership in their communities and in their professions. In a recent FAU survey of student satisfaction with advising and support services, the College of Engineering and Computer Science ranked first among the colleges of the University. Efforts to promote diversity are on-going. The diversity of the southeast Florida region is expected to achieve levels that will not have an ethnic or racial majority in the near future. The FAU student body in general is expected to continue to reflect the diversity of the region. Indeed, FAU was recently pronounced to be the most diverse university in the public university system of Florida. It was also designated as a Hispanic Serving Institution by the US Department of Education. The current undergraduate and graduate degree programs in the College of Engineering and Computer Science reflect that diversity. It is, therefore, reasonable to believe that this new proposed program will also reflect the diversity of the university. The Ph.D. program in Transportation and Environmental Engineering will target groups that are under-represented in engineering.

The proposed program will make recruitment of such students a high priority in its recruitment plan. In particular, universities and colleges in the State of Florida and throughout the nation will be targeted for student recruitment through brochures and other recruitment efforts. Additionally, faculty recruitment will emphasize identification of qualified minority candidates which in turn will attract minority students through identification with faculty as potential role models and mentors. As of the Spring 2019 semester, the CEGE Department diversity of graduate students is as follows with 46% female (Figure 2):

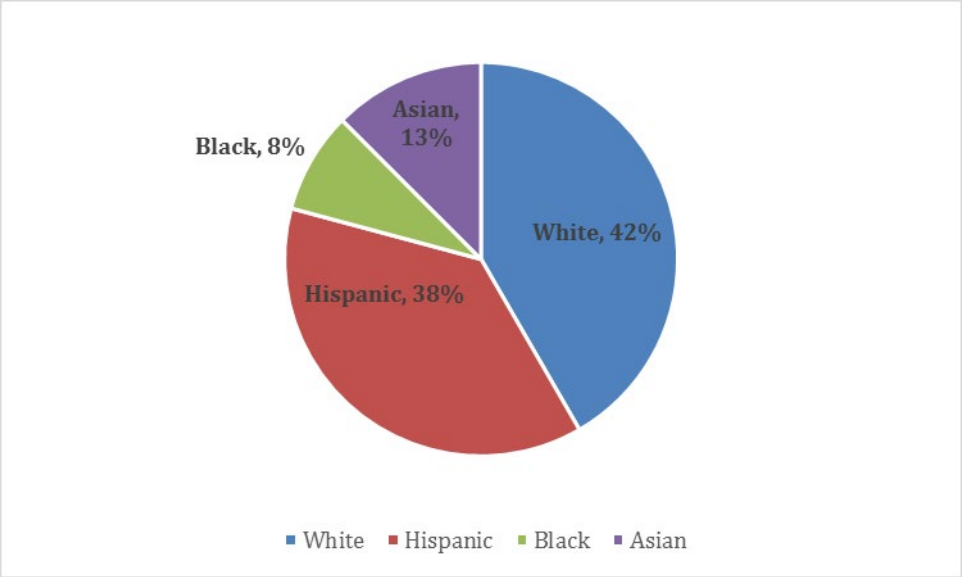

Figure 2. CEGE Department graduate program diversity chart.

III. Budget

A. Use Table 2 in Appendix A to display projected costs and associated funding sources for Year 1 and Year 5 of program operation. Use Table 3 in Appendix A to show how existing Education & General funds will be shifted to support the new program in Year 1. In narrative form, summarize the contents of both tables, identifying the source of both current and new resources to be devoted to the proposed program. (Data for Year 1 and Year 5 reflect snapshots in time rather than cumulative costs.)

With the recent faculty hires in environmental and transportation engineering for the 2019-2020 academic year, faculty staffing in the Department is sufficient to initiate the program. The faculty salary and benefits needed to support this program will come entirely from reallocated base E&G funds. For Year 1, the budget includes $225,916 in funds reallocated from the Department to fund faculty salaries and benefits for the current faculty members in the program, and the recent new faculty members being hired on vacant lines starting Fall 2019 (Masoud Lashaki and David Kan). The reallocated salaries and benefits extend into the fifth year and include any increases in percent effort for current faculty as well as salaries and benefits for two new faculty members (one starting in Fall 2021 and one starting in Fall 2023), for a total of $516,370 for Year 5. See Table 4 (Appendix A) for a complete listing of faculty involved with the program.

Reallocated base funding is also being used to support one AMP student coordinator position at 25% effort in Year 1 ($19,635) and 45% effort by Year 5 ($35,342) to this program based on the anticipated growth in student enrollment.

The Department currently supports 4 graduate teaching assistantship positions at $17,000 each with E&G funding. These positions will be reallocated to this program (as shown by the $68,000, listed in Appendix A, Table 2, Column 1). The Department has a history of supporting graduate research assistantships (GRA) through research contracts and grants. Funding for four GRA positions at $17,000 each are projected in year one that would come from sponsored research within the department (as shown by the $68,000 listed in Appendix A, Table 2, Column 5). By Year 5, the Department will support 7 teaching assistantships with reallocated E&G funding within the Department and College (6 senior level Ph.D. students who have passed the qualifying exam at $25,000 each, and one new recruit at $20,0000 for a total of $170,000). This total is represented in Appendix A, Table 2, Column 9. By year 5, eight (8) GRA positions will be supported by sponsored research in the Department (2 senior level at $25,000 and 6 new recruits at $20,0000 for a total of $170,000). This is shown in Appendix A, Table 2, Column 12.

Expenses in Table 2 (Appendix A) include computers/printers, copier, phones, postage, printing, travel, office supplies, information technology supplies, and specialized software. An allocation for recruiting (brochures, travel, etc.) is also requested to be able to attract new students from outside agencies and industry in our service areas. This proposed program is a priority for the College such that funding will be reallocated to match the university/College priorities. There are minimal impacts to existing programs from this reallocated amount because GRA support comes from pending and existing research grants and faculty will devote time for dissertation supervision not additional teaching loads.

B. Please explain whether the university intends to operate the program through continuing education, seek approval for market tuition rate, or establish a differentiated graduate-level tuition. Provide a rationale for doing so and a timeline

for seeking Board of Governors' approval, if appropriate. Please include the expected rate of tuition that the university plans to charge for this program and use this amount when calculating cost entries in Table 2.

This item does not apply to this program proposal. We are proposing to offer this degree program with traditional E&G funding and regular FAU tuition and fee rates. The Tuition and Fee breakdown for graduate students are shown in Table III-1 and Table III-2 below.

Table III-1 shows the breakdown of FAU graduate tuition and fees (2018).

Table III-1. FAU graduate tuition and fees as of 2018.

Fees per Credit Hour	In-State	Out-of State
Matriculation **Fee** (**Tuition**)	$303.71	$303.71
Non-Resident **Fee**	$0.00	$623.80
Student Financial Aid	$15.18	$46.37
Capital Improvement Fee	$6.76	$6.76
Activity and Service Fee	$12.32	$12.32
Athletic Fee	$17.27	$17.27
Health Fee	$9.42	$9.42
Technology Fee	$5.16	$5.16
Total per Credit Hour	**$369.82**	**$1024.81**

Applying the fees listed in Table III-1, the total cost of the program would be as summarized in Table III-2.

Table III-2. FAU graduate student program costs as of 2018.

	B.S. to Ph.D. (72 credits)	M.S. to Ph.D. (42 credits)
In-State	$26,627.04	$15,532.44
Out-of-State	$73,786.32	$43,042.02

C. If other programs will be impacted by a reallocation of resources for the proposed program, identify the impacted programs and provide a justification for reallocating resources. Specifically address the potential negative impacts that implementation of the proposed program will have on related undergraduate programs (i.e., shift in faculty effort, reallocation of instructional resources, reduced enrollment rates, greater use of adjunct faculty and teaching assistants). Explain what steps will be taken to mitigate any such impacts. Also, discuss the potential positive impacts that the proposed program might have on related undergraduate programs (i.e., increased undergraduate research opportunities, improved quality of instruction associated with cutting-edge research, improved labs and library resources).

The impact of the reallocation of resources for the proposed program to the existing BS and MS programs will be minimal for the first five years. First, the current faculty are delivering BS and MS programs and supervising 13 students enrolled in the Ocean Engineering Ph.D. program simultaneously. Second, the 0.69 PY FTE for the first year will be offset by the two new faculty hires in Fall 2019. Similarly, the 1.44 PY FTE for the fifth year will be offset by another two new hires in Fall 2021 and Fall 2023, respectively.

D. Describe other potential impacts on related programs or departments (e.g., increased need for general education or common prerequisite courses, or increased need for required or elective courses outside of the proposed major).

Several CEGE faculty are supervising 12 students currently enrolled in the Ph.D. in Ocean Engineering (OE) as part of the Sustainable Infrastructure track. Once the proposed Ph.D. program is established, we anticipate that up to seven (7) of those students will most likely transfer to the new degree program, which will cause a temporary setback to the OE program. However, this foreseeable, short-term setback will not adversely affect this program to meet the BOG requirement of 15 graduates within five years because they already have healthy student enrollments, and we anticipate that about half of the doctoral students supervised by CEGE faculty are in the field of structural engineering or geotechnical engineering, who would be more suited to the OE Ph.D. program. Therefore, CEGE will continue to support the OE Ph.D. program with a pipeline of structural and geotechnical engineering focused candidates.

E. Describe what steps have been taken to obtain information regarding resources (financial and in-kind) available outside the institution (businesses, industrial organizations, governmental entities, etc.). Describe the external resources that appear to be available to support the proposed program.

Because of the very pressing demand for trained engineering professionals in Florida, the proposed program is attracting generous offers of help and financial support in the forms of donations from business and industry, private contributions, and contributions in-kind. Once the degree has been approved by the BOT, an extensive program of development and fundraising for support will be implemented by the College's Director of Development and the College's Executive Advisory Board. Conversations with professional societies and with business and industry show very strong interest in in-kind gifts. Possibilities include use of equipment and/or facilities; provision of speakers, instructors, and mentors; the contribution of real-world design problems; etc. Donations, research contracts, grants, and in-kind gifts supportive of the program are expected. These funds are listed in Appendix A-Table 2 (Columns 5 and 12) under Contracts & Grants, as discussed in Section III.A.

IV. Projected Benefit of the Program to the University, Local Community, and State

Use information from Tables 1 and 2 in Appendix A, and the supporting narrative for "Need and Demand" to prepare a concise statement that describes the projected benefit to the university, local community, and the state if the program is implemented. The projected benefits can be both quantitative and qualitative in nature, but there needs to be a clear distinction made between the two in the narrative.

Quantitative

If the proposed Ph.D. program is implemented, the research active CEGE faculty will grow from 35% to 75% and corresponding average annual research expenditures will increase from $1.1 million to $2.4 million within the next five years. Another Department strategic goal is to leverage these funds to attract one new State or federally funded center of excellence. The corresponding scholarly work products (books, monographs, and other peer-reviewed publications) will increase to more than 100 per year to promote the international reputation of the Department's world-class faculty.

According to the Hanover Research market analysis, job opportunities related to transportation and environmental engineering in Southeast Florida are plentiful and expected to grow by 2025. Above average job growth (14.1%) is projected for Transportation Engineers and Environmental Engineers in Workforce Regions 20 through 23 from now until 2025. Across the key related occupation codes, total annual job openings are expected to be in the range of 6900-8100 in Southeast Florida alone, which would suggest a sizeable job market for graduates of FAU's proposed program. This workforce will provide solutions to long term economic viability and environmental sustainability of the south Florida community, the state of Florida, and beyond.

For a one-month period taken from February 15, 2018 to March 15, 2018, there were 409 job openings in Workforce Regions 20-23 in just the top 15 transportation and environmental engineering related occupations (FDEO, 2017). In 2016, the estimated output of SUS transportation and environmental engineering related doctoral programs produced only 24 degree completions, some of which may not remain in Florida. If a new FAU degree program can add another 15-20 graduates that secure locally available jobs, this would mean an addition of $1.5 million dollars to the local economy based on a weighted average of the 2017 median hourly salaries for the list of transportation and environmental engineering related occupation codes working 40 hours per week, 52 weeks per year, equivalent to $96,550 for the Florida job market and $96,620 for the South Florida market (BLS 2018).

In the Hanover Report, it is stated that, "*enrollments in combined engineering Ph.D. programs have expanded rapidly, with nearly seven times as many students enrolled in 2017 as in 2006 (Yoder 2017).*" These trends suggest that students are increasingly interested in enrolling in combined engineering doctoral programs with specializations related to transportation and environmental engineering. Uncombined degree conferrals in Transportation Engineering and also Environmental Engineering Ph.D. programs are higher than the national average. Transportation and Highway Engineering doctoral degrees have increased by 6.4%, and Environmental/Environmental Health Engineering indicated 4.8% annualized growth, higher than the national average (2.8%).

Qualitative

The labor market outlook for transportation and environmental engineering-related occupations is strong. The Florida Department of Economic Opportunity (FDEO) forecasts economic growth of around 16% in South Florida through 2022 for these fields. Institutions in Florida are not currently producing enough graduates to meet the labor market demand for the local environmental engineering workforce. SUS schools produced only 24 graduates in transportation and environmental engineering related programs in 2016, while the FDEO projects 6900-8100 annual job openings in related positions in Workforce Region 20-23. If the percentage of jobs requiring a Ph.D. degree across all professions (4.2%) is applied, then the demand could be estimated at 290-340 each year. Thus, the SUS is fulfilling less than 10% of the annual workforce needs in these critical fields for future growth.

This focused Ph.D. program will help to attract top students, enhance faculty scholarship productivity, expand external research funding, increase private and public participation from community partners, and make great strides toward achieving research and academic excellence to increase the pre-eminence and ranking of Florida's State University System. The aim is to produce a high-quality workforce that is ready to step in directly to industry, government, and academia and contribute to Florida's future growth.

V. Access and Articulation – Bachelor's Degrees Only

A. If the total number of credit hours to earn a degree exceeds 120, provide a justification for an exception to the policy of a 120 maximum and submit a separate request to the Board of Governors for an exception along with notification of the program's approval. (See criteria in Board of Governors Regulation 6C-8.014)

This item does not apply to this program proposal.

B. List program prerequisites and provide assurance that they are the same as the approved common prerequisites for other such degree programs within the SUS (see link to the Common Prerequisite Manual on the resource page for new program proposal). The courses in the Common Prerequisite Counseling Manual are intended to be those that are required of both native and transfer students prior to entrance to the major program, not simply lower-level courses that are required prior to graduation. The common prerequisites and substitute courses are mandatory for all institution programs listed, and must be approved by the Articulation Coordinating Committee (ACC). This requirement includes those programs designated as "limited access."

If the proposed prerequisites are not listed in the Manual, provide a rationale for a request for exception to the policy of common prerequisites. NOTE: Typically, all lower-division courses required for admission into the major will be considered prerequisites. The curriculum can require lower-division courses that are not prerequisites for admission into the major, as long as those courses are built into the curriculum for the upper-level 60 credit hours. If there are already common prerequisites for other degree programs with the same proposed CIP, every effort must be made to utilize the previously approved prerequisites instead of recommending an additional "track" of prerequisites for that CIP. Additional tracks may not be approved by the ACC, thereby holding up the full approval of the degree program. Programs will not be entered into the State University System Inventory until any exceptions to the approved common prerequisites are approved by the ACC.

This item does not apply to this program proposal.

C. If the university intends to seek formal Limited Access status for the proposed program, provide a rationale that includes an analysis of diversity issues with respect to such a designation. Explain how the university will ensure that Florida College System transfer students are not disadvantaged by the Limited Access status. NOTE: The policy and criteria for Limited Access are identified in Board of Governors Regulation 6C-8.013. Submit the Limited Access Program Request form along with this document.

This item does not apply to this program proposal.

D. If the proposed program is an AS-to-BS capstone, ensure that it adheres to the guidelines approved by the Articulation Coordinating Committee for such programs, as set forth in Rule 6A-10.024 (see link to the Statewide Articulation Manual on the resource page for new program proposal). List the prerequisites, if any, including the specific AS degrees which may transfer into the program.

This item does not apply to this program proposal.

INSTITUTIONAL READINESS

VI. Related Institutional Mission and Strength

A. Describe how the goals of the proposed program relate to the institutional mission statement as contained in the SUS Strategic Plan and the University Strategic Plan (see link to the SUS Strategic Plan on the resource page for new program proposal).

This proposed program is consistent with the Florida Board of Governor's Strategic Plan (2012-2025), specifically:

Excellence: By providing a new academic program in the area of transportation engineering and environmental engineering, FAU will be helping to strengthen the quality and reputation of academic programs, scholarship, research, innovation, and community and business engagement. This unique Ph.D. will grow the number of Florida's new academic programs with state, national and international preeminence. will improve the quality and relevance of FAU's two research pillars (I-SENSE and Harbor Branch) with world class consequential research that actively engages the community and businesses in a meaningful, measurable way. It will increase externally funded research and patents, leading to broad external recognition of our academic and research programs. Also, it will help to meet the community needs and fulfill unique institutional responsibilities by promoting the FAU mission statement of academic and personal development, discovery, and lifelong learning through excellence and innovation in teaching, outstanding research and creative activities, public engagement and distinctive scientific and cultural alliances, all within an environment that fosters inclusiveness. Furthermore, the program will address the community's acute need for transportation and environmental engineering graduates and professionals. The goal will be to attract more high profile research centers like the Tier 1 Department of Transportation (FMRI Institute) to grow the number of centers and institutes recognized nationally for scholarship, research, and commercialization.

Productivity: By providing a new academic program in the area of transportation and environmental engineering, we will be increasing the degree productivity in the needed focus area of STEM in the high demand disciplines of transportation and environmental engineering. FAU will be increasing the research and commercialization activities, and increasing the level of community and business engagement. The new program will increase access and production of professional degrees in the state of Florida, while including students from traditionally underrepresented groups, returning non-traditional students (which is a strength of FAU), and distance learning students, (100% of coursework is available in distance learning format). Most particularly because the program will be delivered in online and hybrid formats. The new program will also increase externally funded research and patents, while fostering a culture of entrepreneurship. Also, the proposed program will help to meet the community's need for transportation and environmental engineering graduates and professionals trained in a culture of

academic and personal development, discovery, lifelong learning, and public engagement. Finally, students and faculty will engage in Florida's growing industry and the business community that is focused on mobility and the environment – both big parts of Florida's economic engine.

Strategic Priorities for a Knowledge Economy: By providing a new academic program in the area of transportation and environmental engineering, FAU will be directly increasing student access and success in degree programs in the STEM fields and other areas of strategic emphasis that respond to existing, evolving, and emerging critical needs and opportunities. In addition, faculty and student researchers will be better able to attract more research funding from external sources and promote more collaboration with private industry on research projects. Finally, this new program should directly increase the number of highly trained STEM graduates who are employed in Florida, in which a large number of transportation and environmental engineering related jobs remain available. The innovative graduate internship with the collaboration of external members of the dissertation/supervisory committee will improve graduate's career skills needed to succeed in the workplace and increase the percentage of graduates who are employed in Florida.

FAU Institutional Goals

Goal 1: *Access to and production of degrees*.
By providing a new academic program in the area of transportation and environmental engineering, FAU will be increasing access to and production of professional degrees in the State of Florida.

Goal 2: *Meeting statewide professional and workforce needs*.
By providing a new academic program in the area of transportation and environmental engineering, FAU will be helping to meet critical needs in STEM fields that deal with the priorities of transportation mobility issues and infrastructure design and construction of the natural and the built environment. In addition, the mere fact that Florida is prone to natural disasters such as flooding, droughts, hurricanes, and wildfires that impact tourism, mobility, and sustainability creates a special need for doctoral graduates in transportation and environmental engineering.

Goal 3: *Building world-class academic programs and research capacity*.
By providing a new academic program in the area of transportation and environmental engineering, FAU will be helping to increase externally funded research and patents while broadening external recognition of our academic and research programs. Notably, faculty and students affiliated with the Department won the 2012 National Council of Examiners for Engineering and Surveying (NCEES) Award ($25,000 Grand Prize Winner) for faculty/student participation in the design of the City of Dania Nanofiltration Facility that is the first water treatment plant to receive a LEED Gold certification in the world. The proposed program will create new opportunities for engineering collaboration with science and urban/regional planning.

Goal 4: *Meeting community needs and fulfilling unique institutional responsibilities*.
By providing a new academic program in the area of transportation and environmental engineering, FAU will support its institutional mission statement of promoting academic and personal development, discovery, and lifelong learning through excellence and innovation in teaching, outstanding research and creative activities, public engagement and distinctive scientific and cultural alliances, all within an environment that fosters inclusiveness. Furthermore, the program will address the community's acute need for transportation and environmental engineering graduates and professionals.

FAU's current Strategic Plan created a system of pillars and platforms to catapult the university to

become the fastest growing in the country in its bid to move FAU toward national prominence. Two of the pillars of the university are directly aligned to this proposed doctoral degree program. I-SENSE, which is the Institute for Sensing and Embedded Network Systems Engineering that supports advancements in computing and sensing technologies targeted toward infrastructure systems, marine and environmental systems, and health/behavior. The other pillar is the Harbor Branch Oceanographic Institute for ocean science and engineering/environmental sciences research effort. The Department created two strategic focus groups for strengthening emerging research: 1) urban mobility and 2) environmental sustainability. This proposed program will be a perfect addition to those pillars.

The current FAU Strategic Plan also lists a set of 6 goals in which our proposed academic program in transportation and environmental engineering can help the University build on existing strengths in the following ways:

1. Boldness: Build a geographically-diverse population of students who excel in focused academic areas and engage in enriching activities that drive them to timely graduation at FAU. This program will contribute to the two pillars of I-SENSE and ocean science and engineering/environmental sciences as well as providing timely graduation by offering an engineering doctoral degree with 72 credits as opposed to 90-96.
2. Synergy: Connect the most talented faculty, staff, and students via the pillars and platforms. This program will contribute to the two main pillars of I-SENSE and ocean science and engineering/environmental sciences as well as providing opportunities for doctoral students to mentor undergraduate research and inquiry while engaging with the community.
3. Place: Deep engagement with South Florida's global communities
4. Quality: Continuously assessed programs. The proposed program will be offered with SAC's continuous improvement model for excellence and will be run with a resilient, lean organizational structure that capitalizes on existing world class faculty and staff.
5. Brand: A world-class undergraduate program in environmental engineering will communicate FAU's excellence and key internal stakeholders to a global audience of external constituency groups.
6. Strategy: This new program will allow FAU to become more competitive for public and private funding opportunities.

B. Describe how the proposed program specifically relates to existing institutional strengths, such as programs of emphasis, other academic programs, and/or institutes and centers.

FAU has strategic pillars that are institutional activities that create new knowledge to benefit society. Two of the pillars of the university are directly aligned to this proposed doctoral degree program. I-SENSE, which is the Institute for Sensing and Embedded Network Systems Engineering that supports advancements in computing and sensing technologies targeted toward infrastructure systems, marine and environmental systems, and health/behavior. The other pillar is the Harbor Branch Oceanographic Institute for ocean science and engineering/environmental sciences research effort.

The proposed program also relates to the following university platforms:
1. Big Data Analytics (supporting the development of tools to mine large datasets)
2. Community Engagement and Economic Development (supporting work with communities to develop solutions to address engineering challenges and economic prosperity)
3. Diversity (transportation and environmental engineering typically has a larger percentage of

women and minority students enrolled compared to the other engineering disciplines)
4. Global Perspectives and Participation (supporting opportunities to share technology and discoveries with other institutions around the globe)
5. Healthy and Environmentally Sustainable Campus (supporting opportunities to incorporate scholarship into campus operations)
6. Leadership, Innovation, and Entrepreneurship (supporting engagement of faculty and students in the professional development of leadership, intellectual property, and creation of startup companies)
7. Peace, Justice, and Human Rights (supporting programs that share best practices and promote tolerance particular with respect to environmental justice)
8. Undergraduate Research and Inquiry (supporting opportunities for Ph.D. students to mentor undergraduate students)

The Department created two strategic focus groups for strengthening emerging research: 1) urban mobility and 2) environmental sustainability. CEGE faculty are responsible for $2.6 million external research funding (FY2017-18), providing a solid base for student support, and the proposed doctoral program will provide significant leverage to help double research expenditures by bringing more national/state research centers like our Tier 1 University Transportation Center supported by USDOT, as well as our other research labs and centers: Freight Mobility Research Institute (FMRI), Laboratory for Adaptive Traffic Operations and Management (LATOM) at the Transportation Engineering Research Hub, Hydrosystems Research Laboratory (HRL), and the Laboratories for Engineered Environmental Solutions (Lab.EES).

Specific institutes and centers with a high degree of potential collaboration include:

- The Adams Center for Entrepreneurship in the College of Business. The center works with FAU faculty and students with entrepreneurship interests and assists them with conducting and publishing significant research (Director Kimberly Gramm)
- The Florida Center for Environmental Studies. The center serves as a facilitator and coordinator of research and training related to the environment and as a locus for environmental information. Grounding its activities in the Florida sub-tropical environment, the center's mandate encompasses global tropical and sub-tropical environments and issues related to water dominated ecosystems (Director, Colin Polsky)
- The Pine Jog Environmental Research Center is an environmental education center with the purpose of developing, providing and modeling environmental education programs which foster an awareness and appreciation of the natural world, promote an understanding of ecological concepts and instill a sense of stewardship toward the Earth and all its inhabitants (Director, Susan Toth)
- The Weppner Center for Civic Engagement's mission is to develop partnerships between the University and community by providing service opportunities to faculty, staff and students; and to promote the link between curriculum and service fostering civic awareness (Director, Nori Carter)
- The Institute for Sensing and Embedded Network Systems Engineering (I-SENSE) was established in early 2015 to coordinate university-wide activities in the Sensing and Smart Systems pillar of FAU's Strategic Plan for the Race to Excellence. The major theme areas of infrastructure systems, marine & environment, and medicine & behavior are of interest (Director, Jason Hallstrom)

C. Provide a narrative of the planning process leading up to submission of this proposal. Include a chronology in table format of the activities, listing both university personnel directly involved and external individuals who participated in

planning. Provide a timetable of events necessary for the implementation of the proposed program.

In 2003, the Dean of the College of Engineering, Karl Stevens, came to a Department faculty meeting to discuss the University's strategic plan, which showed the creation of new degree programs related to the Department's strengths. At that time, several inquiries were made by Department faculty as to when the new degree proposal should be prepared, and in the meantime multiple versions of the proposal were developed. On July 1, 2009, the name of the Department of Civil Engineering was officially changed to the Department of Civil, Environmental & Geomatics Engineering after the merger of the Civil Engineering program with the Geomatics Engineering program. In Spring 2009, CEGE faculty were instructed to prepare a proposal for a new doctoral degree program. The exploratory proposal was submitted to the Dean's office. Several versions of the feasibility study were generated over the next few years spanning changes in the Dean and Provost office leadership as well as a temporary institutional moratorium on new Ph.D. programs.

In 2013, the Department leadership changed, and a strategic plan was put in place involving 3 main objectives: 1) Strengthening the geomatics engineering program with renewed recruiting efforts and a pathway to a graduate degree, 2) Creating a joint doctoral degree with Ocean Engineering and also Computer Science as a prelude to established the Department's own degree program, and 3) Creating a new undergraduate degree program in Environmental Engineering. In 2014 at the behest of members of the Department Advisory Council, Dr. Meeroff requested a meeting with the Provost's Office with Drs. Michelle Hawkins and Russ Ivy. She explained the new procedures and expressed the Provost Office's general support for the proposed program.

In Spring 2018, an external market study was solicited from Hanover Research, and an external SACS accreditation review concluded that a Ph.D. program for the Department was necessary for the long-term success of CEGE's Strategic Plan emphasis on research and student success. The following timelines (Table IV-1 and Table IV-2) summarize the planning activities and implementation activities associated with this degree proposal.

Table IV-1. Ph.D. Proposal Planning Process Timeline

Date	Participants	Planning Activity
Fall 2003	Yong, Sobhan, Nix, Reddy, Arockiasamy, Scarlatos	Department Advisory Council members approach the faculty to investigate a Ph.D. degree program, and the faculty develop an exploratory pre-proposal
Spring 2004 – Fall 2006	CEGE faculty	Feasibility studies performed
February 13, 2007	CEGE faculty	Revised draft of the Ph.D. proposal
November 14, 2007	CEGE faculty	Revisions solicited by the faculty to the Ph.D. proposal
Fall 2007 – Spring 2008	CEGE faculty and industry partners	Letters of support solicited from community partners
February 3, 2009	CEGE faculty	Exploratory committee established to revise the Ph.D. proposal
July 1, 2009	CEGE faculty	Department name changed to Civil, Environmental & Geomatics Engineering

Date	Participants	Planning Activity
March 29, 2011	CEGE faculty	Revised Ph.D. proposal for internal review
October 6, 2013	Interim Chair Yong, Meeroff, Kaisar, Bloetscher, Nagarajan, Stevanovic, Teegavarapu	Preliminary strategic plan and short term needs assessment for two year period of interim chair appointment (includes Ph.D. program)
October 19, 2013	Yong, Meeroff, Sobhan, Zilouchian, Ilyas	Feasibility study sent to the COE&CS Dean's Office for comment
October 22, 2013	Yong, Meeroff, Sobhan, Zilouchian, Ilyas	Modifications made to the feasibility study
February 20, 2014	OE, CEGE faculty	Negotiations begin on creation of the Sustainable Infrastructure track within the Ph.D. in Ocean Engineering
Spring 2014	Hawkins, Ivy, Meeroff, Yong	Meetings with Provost Office to discuss pathway to new Ph.D. program in CEGE
April 22, 2014	Department Advisory Council, Alumni Advisory Council	Feasibility study and pre-proposal presented to the Department Advisory Council and Alumni Advisory Council for comment in a workshop format. Council members request faculty to move forward with the proposal.
Fall 2014 – Spring 2015	Yong, Bloetscher, Meeroff, Abatte, Davis, Roberts, Bourassa, Dumbaugh	Revisions to the Ph.D. proposal to incorporate sustainable infrastructure engineering with participation from geoscience, urban and regional planning, architecture, and Harbor Branch
Fall 2015	OE, CEGE faculty	Faculty approve Sustainable Infrastructure Option in Ph.D. in Ocean Engineering effective Spring 2016
December 12, 2017	Meeroff, Bloetscher	Surveys of SUS and nationwide doctoral curricula
December 20, 2017	Batalama, Yong, Meeroff, Bloetscher	Dean Batalama asks CEGE to prepare a new feasibility study for a Ph.D. program for the Department
February 14, 2018	Bloetscher, Meeroff, Yong, Peluso, Alperin, Szabo, Floyd	Inquiry into reducing the number of credits required by the Ph.D. program at the institutional level
February 28 – March 28, 2018	FAU Graduate Programs Committee, Graduate Council	FAU considers proposal to reduce doctoral credit hours for new programs from 80 to 72 beyond the bachelor's degree
March 19-20, 2018	Pezeshk, Schnabel, Xie	SACS external review concludes that a Ph.D. program is necessary for the future sustainability of the Department's research productivity
April 1, 2018	CEGE Faculty	Strategic Plan adopted by the faculty
April 30, 2018	Faculty Senate	Faculty approve 72 credit hours for new doctoral programs
October 22, 2019	Geosciences, Urban and Regional Planning	Approval letters for Ph.D. students to take courses in departments outside of CEGE received

Date	Participants	Planning Activity
November 1, 2019	External Academic Review	The Provost Office of FAU invited two faculty from Ph.D. granting institutions with similar programs to review FAU for this new Ph.D. program in Transportation and Environmental Engineering

Table IV-2. Events Leading to Implementation of the Proposed Ph.D. Program

Date	Implementation Activity
March 5, 2018	Scope of work prepared for Hannover Marketing Group
April 10, 2018	Hanover debriefing from the interim report
June 6, 2018	Revisions to the market study scope
June 14, 2018	Provost Office approval for the updated market study
July 6, 2018	Graduate Dean's office notified of industrial partnerships for the proposed Ph.D. program
July 11, 2018	Initial comments of revised market study provided to Hanover
September 11, 2018	Revisions to the pre-proposal based on a market study
November 1, 2018	Additional feedback provided to a market study
November 13, 2018	Final revisions to the market study
December 23, 2018	Draft pre-proposal prepared for Provost Office review
January 17, 2019	Pre-proposal and market study preliminary approval by the Provost's office
January 31, 2019	Preliminary comments solicited from the BOG from the FAU Provost's office
February 1, 2019	Additional edits to the pre-proposal after Dean's office and Provost's office review
February 8, 2019	Documents submitted to CAVP
February 21, 2019	More information requested by the Provost's office prior to CAVP meeting
February 22, 2019	CAVP meeting with a positive recommendation and minor comments
February 25, 2019	Full proposal template requested from the Provost's office
March 8, 2019	CEGE Department approval
March 11, 2019	College of Engineering and Computer Science Graduate Committee approval
March 20, 2019	UGPC approval
March 22, 2019	Academic Affairs approval
March 26, 2019	TASL approval
March 27, 2019	UGC approval
April 5, 2019	AP&BC approval
April 18, 2019	Steering Committee approval
April 29, 2019	Faculty Senate approval
June 4, 2019	FAU Board of Trustees Committee on Academic and Student Affairs approval
September, 2019	Comments received from Florida Board of Governors

Date	Implementation Activity
February 11, 2020	FAU Board of Trustees re-approval of updated budget
April, 2020	Additional comments received from Florida Board of Governors
June, 2020	Florida Board of Governors approval

VII. Program Quality Indicators - Reviews and Accreditation

Identify program reviews, accreditation visits, or internal reviews for any university degree programs related to the proposed program, especially any within the same academic unit. List all recommendations and summarize the institution's progress in implementing the recommendations.

All of our academic programs are accredited by the Southern Association of Colleges and Schools (SACS). Our undergraduate civil engineering and geomatics engineering programs are accredited by the Accreditation Board for Engineering and Technology (ABET). The last accreditation visit for the undergraduate civil engineering program review was in the Fall of 2014. The results were outstanding, with no concerns, deficiencies or comments. The undergraduate Environmental Engineering degree program will undergo its initial accreditation visit in Fall 2020. We anticipate the program will be accredited retrospective to Fall 2018.

In the 2018 BOG program review, the three reviewers (two external and one internal) wrote in the final report "a stated goal of the Dean and numerous faculty members is for CEGE to become nationally recognized for high quality education and research. Indeed, this comprises CEGE's vision statement. However, nationally-recognized high quality research is most often associated with programs that produce Ph.D. graduates. While MS students and undergraduates are certainly capable of producing high quality results, they tend to require significantly more oversight from faculty members to produce those results. Ph.D. students, due to their more advanced level of training, tend to be more capable of working on their own. As a consequence, a single faculty member can pursue numerous promising avenues of research working with Ph.D. students, whereas they are more constrained working with MS students or undergraduates." They continued to write, "We believe CEGE requires a Ph.D. program if it seeks to become a nationally-recognized research leader. Students in that program must be able to focus their research as well as their coursework upon their specific area of expertise. Faculty members and administrators should closely consider the various options for getting there."

In Spring 2018, the CEGE faculty authored a strategic plan (Appendix F) that includes objectives, strategies, and measurable outcomes. The vision of the Department is to be nationally recognized as an eminent engineering program with excellence in education, research and community engagement, and its mission is to provide its engineering students with a high-quality education on fundamental concepts and engineering design, and to conduct cutting-edge research in urban mobility/infrastructure and water resources/environmental sustainability in state-of-the-art learning environments to benefit communities in Florida and beyond.

VIII. Curriculum

A. Describe the specific expected student learning outcomes associated with the proposed program. If a bachelor's degree program, include a web link to the Academic Learning Compact or include the document itself as an appendix.

Student Learning Outcomes

1. An ability to analyze and apply advanced knowledge of transportation and environmental engineering significantly beyond the master's degree level
2. An ability to communicate effectively with a range of audiences in written, oral, and graphical forms
3. An ability to independently conduct research, explore solutions to complex problems, apply fundamental concepts, demonstrate critical thinking and creative innovation, and create new knowledge related to transportation and environmental engineering

Program Educational Objectives

A. Graduates will advance the knowledge in science, technology, engineering and mathematics relevant to transportation and environmental engineering by engaging in lifelong learning, including professional licensure, developing new technologies, patents, and publications
B. Graduates will serve as effective professionals in careers consistent with the research-based foci of transportation and environmental engineering
C. Graduates will participate as leaders in emerging issues pertaining to transportation and environmental engineering for promoting local, regional and national economic and social development

Core Competencies

- Ability to complete a coordinated sequence of coursework as directed by the dissertation/supervisory committee
- Ability to gain practical experience in applied settings in the context of graduate internship
- Ability to generate new knowledge through research and other forms of scholarship
- Ability to understand fundamental principles of research methodology used in basic and applied research
- Ability to design and conduct novel research that adds to the body of knowledge of the discipline
- Ability to demonstrate advanced knowledge and expertise in a specific field relevant to transportation and environmental engineering

B. Describe the admission standards and graduation requirements for the program.

Admission Standards

1. Applicants must have a Master's Degree in Engineering, Science, Urban Planning, Transportation Logistics, or Mathematics from an accredited college or university. A student with outstanding scholastic achievement (GPA ≥ 3.2 in the last 60 credit hours of undergraduate coursework) who holds only a baccalaureate degree may be admitted directly to this Ph.D. program and be eligible to earn the Masters' *en Passant* with a Master of Science in Civil Engineering degree;

2. Applicants must have a 3.0 GPA (on a 4.0 scale) or better in the last 60 credits of work attempted and must have an official transcript forwarded directly to the FAU Graduate College from each college-level institution attended;

3. Applicants must submit the Graduate Record Examination (GRE) score. The GRE requirement

can be waived with proof of passing the Fundamentals of Engineering (FE) or Principles and Practice of Engineering (PE) exam. The GRE requirement is waived for applicants that have a Master of Science degree from FAU's College of Engineering and Computer Science.

4. Applicants must demonstrate proficiency in both written and spoken English. A student from a non-English-speaking country is required to take the Test of English as a Foreign Language (TOEFL) and achieve a score of at least 550 (paper-based) or 213 (computer-based) or 79 (iBT). This requirement may be waived for students who have obtained a prior degree from a U.S. institution;
5. Applicants must submit to the Graduate College at least two letters of recommendation attesting to the student's ability to pursue with distinction a curriculum of advanced study and research in a chosen area;
6. Applicants should abide by the policies and regulations and the graduate admission requirements of the University as outlined in this University Catalog;
7. Conditional admission may be permitted if the above conditions are not met.

Graduation Requirements
The degree will be conferred on candidates who have fulfilled the following requirements:

1. Completed the curriculum for Ph.D. in Transportation and Environmental Engineering:
   - Successful completion of 72 credits of course and dissertation work beyond the baccalaureate degree with a minimum grade of "B." Up to 30 credits of coursework from an approved Master's Degree may be applied;
   - Students must maintain a minimum 3.0 GPA in all coursework attempted for the degree;

Core Course	Sustainability and Pollution Prevention	ENV 6932	3
Core Course	Transportation System Analysis	TTE 6501	3
	2 semesters of Graduate Seminar	CGN 5937	0
	Academic Specialization Electives*		9
	Free Electives**		6
	Dissertation (minimum)**		21

*Of the minimum 9 credits of Academic Specialization Electives, which must be at the 6000 level, select from the approved Mobility, Sustainability, and Interdisciplinary Electives lists.
**These can be from the approved list of academic specialization electives or other courses approved by the Dissertation/Supervisory Committee. No more than 3 credits of directed independent study may be used to satisfy this requirement.
***Up to 3 credits of graduate internship (EGN5940) can be used to satisfy the 21-credit dissertation minimum. These credits may not be taken until successfully passing the qualifying exam to enter candidacy.

2. Successful completion of a qualifying exam is required prior to completion of 21 credits of coursework beyond the Master's Degree;
3. Successful completion of a dissertation proposal defense is typically required before registering for dissertation credits;
4. Prior to the dissertation defense, the student is required to have published or have accepted for publication a refereed research paper in a field of study deemed acceptable by the dissertation committee. A journal article is preferred, but a peer-reviewed conference paper is also acceptable;

5. Successful completion of an oral defense of the written doctoral dissertation based on original research in the student's area of specialization. The Dissertation/Supervisory Committee, the Department Chair and the Graduate College must have approved the dissertation and oral defense;
6. Complied with the University's Graduate Policies and Regulations and satisfied the University's Graduate Degree Requirements.

Dissertation/Supervisory Committee: Upon acceptance into the Ph.D. Program, a student will select or be assigned an advisor. The student's Ph.D. dissertation committee will have a minimum of four members. Three committee members must be from the FAU graduate faculty or associate graduate faculty according to the FAU Graduate College guidelines, at least one of which is from the Department of Civil, Environmental & Geomatics Engineering. The final member may be a qualified expert from industry or academia with affiliate graduate faculty status. One of the members shall serve as the chair of the supervisory committee. In unusual circumstances, with the approval of the Department Graduate Committee, two members may co-chair; however, off-campus experts or adjunct faculty may not serve as sole committee chair. The Dissertation/Supervisory Committee shall approve the plan of study, monitor academic progress, approve the dissertation topic, prepare, give, and evaluate the Qualifying Exam, evaluate the dissertation defense, and approve the final doctoral dissertation document.

Qualifying Exam: After successful completion of 21 credits of coursework beyond the Master's Degree and within 12 months of completion of graduate coursework, the student will be required to complete a qualifying examination. This written exam is in the field of concentration given by each member of the Dissertation/Supervisory Committee. Performance on any part of the qualifying exam in the judgment of the Dissertation/Supervisory Committee may result in a pass, fail, or fail with the option to re-take. Students may request in writing to repeat the exam. Students failing the Qualifying Exam twice will be dismissed from the program. After passing the Qualifying Exam with the approval of the dissertation/supervisory committee, a student advances to candidacy.

Proposal Defense: After successful completion of the Qualifying Exam and prior to applying for graduation, the candidate will orally defend the dissertation proposal to the Dissertation/Supervisory Committee for approval.

Dissertation Defense: The doctoral dissertation shall be written in the format specified by the Graduate College. The dissertation must be defended orally and represent an original piece of research that advances the body of knowledge in the field. A written dissertation is submitted to the members of the committee may approve, suggest additional work or reject the dissertation work after the defense.

C. Describe the curricular framework for the proposed program, including number of credit hours and composition of required core courses, restricted electives, unrestricted electives, thesis requirements, and dissertation requirements. Identify the total numbers of semester credit hours for the degree.

Students entering the Ph.D. in Transportation and Environmental Engineering with a bachelor's degree are required to complete 72 credit hours of graduate coursework, up to 30 credits of coursework from an approved Master's Degree may be applied, at least 21 credit hours must be formal coursework, 6 credits of core coursework (ENV 6932 - Sustainability and Pollution Prevention 3 credits and TTE 6501 - Transportation System Analysis 3 credits), at least 18 credits must be at the 6000 level, with 9 credits of academic specialization electives selected in consultation

with the dissertation/supervisory committee to provide depth, and 6 credits of free electives to provide breadth, and a minimum of 21 dissertation credit hours with an optional graduate internship (0-3 credits). The student begins the curriculum by selecting an advisor and a dissertation/supervisory committee to create a plan of study. After passing the qualifying exam, the student advances to candidacy and begins taking dissertation credits. The proposal defense must occur after coursework is completed and prior to filing the intent to graduate. A publication is required prior to the dissertation defense.

D. Provide a sequenced course of study for all majors, concentrations, or areas of emphasis within the proposed program.

A student in this program entering with a master's degree in Engineering, Science, Urban Planning, Transportation Logistics, or Mathematics from an accredited college or university begins the curriculum by selecting an advisor and a dissertation/supervisory committee to create a plan of study. The core foundations of the degree program include 6 credit hours (ENV 6932 - Sustainability and Pollution Prevention 3 credits and TTE 6501 - Transportation System Analysis 3 credits). The academic specialization includes 9 credit hours of specific elective courses to be determined in consultation with the dissertation/supervisory committee and selected from the approved list of Mobility, Sustainability, and Interdisciplinary academic specialization electives. Up to 6 credits of free electives are selected in consultation with the dissertation/supervisory committee. These can be from the approved list of academic specialization electives or other courses approved by the Dissertation/Supervisory Committee. No more than 3 credits of directed independent study may be used to satisfy 21 credit course requirement. After passing the qualifying exam, the student advances to candidacy and begins taking dissertation credits with an optional graduate internship (0-3 credits). The proposal defense must occur after coursework is completed and prior to filing the intent to graduate. A publication is required prior to the dissertation defense. The sequence of study is summarized in tabular form in Table VIII-1.

Table VIII-1. Ph.D. Program of Study Flight Plan.

Year/Semester	Course Number	Course Name	Credits
Year 1 Fall Semester	Select advisor, dissertation/supervisory committee & create a plan of study		
Year 1 Fall Semester	ENV 6932	Sustainability and Pollution Prevention	3
Year 1 Fall Semester	Academic Specialization Elective 1	Select from the approved list	3
Year 1 Fall Semester	Academic Specialization Elective 2	Select from the approved list	3
Year 1 Fall Semester	CGS 5937	Graduate Seminar	0
Year 1 Spring Semester	TTE 6501	Transportation System Analysis	3
Year 1 Spring Semester	Academic Specialization Elective 3	Select from the approved list	3
Year 1 Spring Semester	Free Elective 1		3
Year 1 Summer Semester	Free Elective 2		3
Year 2 Fall Semester	Qualifying Exam, Advance to Candidacy		
Year 2 Fall Semester	EGN 7980	Dissertation	9
Year 2 Fall Semester	CGS 5937	Graduate Seminar	0
Year 2 Spring Semester	EGN 7980	Dissertation	6-9
Year 2 Spring Semester	Proposal Defense		
Year 2 Summer Semester	EGN 7980	Dissertation	1-3
Year 2 Summer Semester	EGN 6940	Graduate Internship	1-3
Year 3 Fall Semester	EGN 7980	Dissertation	1-3
Year 3 Fall Semester	EGN 6940	Graduate Internship	1-3
Year 3 Spring Semester	EGN 7980	Dissertation	1-3
Year 3 Spring Semester	EGN 6940	Graduate Internship	1-3
Year 3 Summer Semester	File Intent to Graduate, Publication, Dissertation Defense		

For students entering in the direct B.S. to the Ph.D. path, the sequence will include an additional 30 credits of coursework to obtain the *Master's en Passant*.

E. Provide a one- or two-sentence description of each required or elective course.

A brief summary of the required and elective courses affiliated with the program are found in Table VIII-2. Departmental support letters indicating that the courses offered outside of CEGE will be available for the proposed program are listed in Appendix J.

Table VIII-2. Ph.D. Curriculum Chart.

Core Classes								
ENV6932	Sustainability and Pollution Prevention					3 credits		
TTE6501	Transportation System Analysis					3 credits		
Academic Specialization Electives Approved List								
Mobility Electives			**Sustainability Electives**			**Interdisciplinary Electives**		
TTE6259	Traffic Signal Systems	3 credits	ENV6115	Air Pollution & Control	3 credits	CGN6616	Infrastructure Maint. & Mgmt.	3 credits
TTE6505	Hwy. Traffic Charac. & Meas.	3 credits	ENV6356	Solid Waste Management	3 credits	CEG6105	Adv. Foundations Eng.	3 credits
TTE6507	Trans. & Supply Chain Sys.	3 credits	ENV6418	Water Supply & Trt.	3 credits	CEG6124	Soil Stabil. & Geosyn.	3 credits
TTE6508	Maritime Freight Ops.	3 credits	ENV6507	Wastewater Engineering	3 credits	CES6107	Adv. Mech. of Materials for CE	3 credits
TTE6272	Intelligent Trans. Sys.	3 credits	ENV6668	Env. Sys. & Processes	3 credits	CES6119	Finite Element Mthds in CE	3 credits
TTE6526	Airport Plng. & Design	3 credits	CWR6235	Open-Channel Hydraulics	3 credits	CES6585	Structural Dynamics	3 credits
TTE6651	Sustainable Public Trans.	3 credits	CWR6525	Dynamic Hydrology	3 credits	EEL6819	Neural Complex & Art. Neural Networks	3 credits
TTE6815	Hwy Engineering	3 credits	CWR6818	Water Resource Sys. Eng.	3 credits	EML6417	Solar Energy Engineering	3 credits
CEG6129	Pavement Analysis & Design	3 credits	EES6025	Modeling Methods in WREE	3 credits	EML6456	Wind Turbine Sts.	3 credits
CEG6505	Numerical Mthods in Geotech Eng.	3 credits	URP6406	Sustainable Cities	3 credits	URP6277	GIS Apps. in Planning	3 credits
CES6325	Bridge Design	3 credits	EVR6334	Env. Restoration	3 credits	GEA6277	Human-Env. Interactions	3 credits
URP6711	Trans. Planning	3 credits	EVR6358	Restoration Impl. & Mgmt.	3 credits	GLY6888	Coastal Hazards	3 credits
EOC6663	Intelligent Underwater Vehicles	3 credits	GLY6746	Global Env. Change	3 credits	GLY6737	Coastal Environments	3 credits
EEL6682	Intelligent Control	3 credits	URP6425	Env. Analysis in Planning	3 credits	URP6429	Env. Policy & Programs	3 credits
College of Engineering and Computer Science Courses								
EGN6908	Directed Independent Study					1-3 credits		
EGN6934	Special Topics					1-3 credits		
EGN6940	Graduate Internship					1-3 credits		
EGN7980	Dissertation					1-15 credits		

The following are the descriptions of the courses offered for the proposed Ph.D. program.

Core Classes:
Sustainability and Pollution Prevention (ENV6932) 3 credits
This course introduces students to the principles of engineering sustainability, life cycle cost analysis, pollution prevention and environmental resource management of infrastructure planning and design.

Transportation System Analysis (TTE6501) 3 credits
Concepts of operations research using various models to optimize holistic operations of transportation systems from the perspectives of sustainability, resilience, environmental impacts, and robustness. Programming model development and optimizations based on mathematical interpretations of descriptive problems.

College of Engineering and Computer Science Courses:

Directed Independent Study (EGN6908) 1-3 credits
Reading and research on selected appropriate topics.

Special Topics (EGN6934) 1-3 credits
New developments and advanced work in specialized areas of engineering designed for individual student interest.

Graduate Internship (EGN6940) 1-3 credits
Summer industrial work experience in student's major field of study. Grading: S/U

Dissertation (EGN7980) 1-15 credits. Grading: S/U

Academic Specialization Electives Approved List:

1. Mobility Electives

Traffic Signal Systems (TTE6259) 3 credits
This course teaches students about advanced concepts of traffic signal systems that are currently used in the U.S. Students design, evaluate and optimize various components of traffic signal operations both for individual intersections and coordinated traffic signal systems.

Highway Traffic Characteristics and Measurements (TTE6505) 3 credits
This course instructs students on the concept of advanced traffic operations including the characteristics of functional relationships between traffic modeling and travel demand forecasting. Students evaluate transportation scenarios and design solutions to improve traffic operations.

Transportation and Supply Chain Systems (TTE6507) 3 credits
A study of engineering decision problems for transportation and supply chain systems, relying primarily on the quantitative methods of operations research. Topics include an introduction to the components of logistics systems, such as suppliers, customers, inventory, orders and freight transportation systems and the interactions between these components; a thorough coverage of models and solution techniques for the design and control of logistics systems, primarily network and network-based optimization models; and study in the application of such models and solution techniques.

Maritime Freight Operations (TTE6508) 3 credits
Addresses important transportation modeling techniques for maritime freight transport. Mathematical models are used to represent transportation problems, and commercial computer software packages are used to evaluate and investigate modern freight transportation systems.

Intelligent Transportation Systems (TTE6272) 3 credits
Provides instruction on topics related to intelligent transportation systems, including theoretical fundamentals of systems engineering, traffic flow theory, architecture of telecommunications networks, freeway and arterial management and other topics related to ITS.

Airport Planning and Design (TTE6526) 3 credits
Factors influencing the selection of type, size and location of an airport, natural hazards and environmental impacts; selection of runway, taxiway, and apron configuration; air navigation aids and lighting.

Sustainable Public Transportation (TTE6651) 3 credits
Designed to outline the principles of transit systems in the urban transportation arena, functional relationships that govern bus and rail transit, and issues associated with unbalanced flow and lane control, transportation system management and railroad economics and policies.

Highway Engineering (TTE6815) 3 credits
Route selection including environmental impacts, vertical and horizontal alignment, intersection design, evaluation of subgraded soil strengths, and pavement design, drainage, and overlay design.

Pavement Analysis and Design (CEG6129) 3 credits
Stresses and strains in flexible and rigid pavements, materials characterization, pavement performance, mechanistic design principles, AASHTO design method, pavement rehabilitation.

Numerical Methods in Geotechnical Engineering (CEG6505) 3 credits
Dynamic and static analysis of shallow and deep foundations, flow-through porous media, excavations, embankments, one-, two- and three-dimensional consolidation and earthquake response analysis.

Bridge Design (CES6325) 3 credits
Planning, design, and construction of bridges. Discussion of bridge types and factors affecting the selection of type: concrete versus steel, prestressed, composite, segmental concrete bridges; design issues and techniques; detailed case study of a particular bridge; recent technological developments in bridge engineering.

Introduction to Transportation Planning (URP6711) 3 credits
Overview of transportation planning, methods, and emerging planning issues.

Intelligent Underwater Vehicles 1 (EOC 6663) 3 credits
Engineering principles for intelligent, unmanned, untethered, underwater vehicles (IU3 vehicles). Topics include vehicle kinematics; and tasks, behavior, locomotion, power sources and sensors.

Intelligent Control (EEL 6682) 3 credits
Recent trends related to learning and decision-making capabilities of intelligent control systems using neural networks and fuzzy logic. Emphasis on controller design for industrial applications.

2. Sustainability Electives

Air Pollution and Control (ENV6115) 3 credits
Review of air quality and air pollution problems. Sources, characteristics, and effects of specific air pollutants; Lower atmospheric motion dynamics; Dispersion and interaction of pollutants in the atmosphere; Smog effects; Air quality standards and regulations; Air pollution control methods; Acid rain.

Solid Waste Management (ENV6356) 3 credits
Quantities and composition of refuse; Municipal and industrial solid waste disposal methods; Sanitary landfills; Incineration; Grinding and composting of refuse; Energy recovery from solid wastes; Hazardous waste; Optimization techniques to solid waste operation and management.

Water Supply and Treatment (ENV6418) 3 credits
Bacteriological, chemical, and physical water quality standards; distribution systems; water treatment theory and design; aeration; coagulation and flocculation; sedimentation; filtration; disinfection; softening; membranes.

Wastewater Engineering (ENV6507) 3 credits
Wastewater characterization, collection, and pumping. Physical unit operations and biological treatment unit process design including screening, sedimentation, filtration, activated sludge, disinfection, sludge digestion, and sludge disposal.

Environmental Systems and Processes (ENV6668) 3 credits
Physical, chemical, and biological processes, reactor theory, particle transport, mass transfer, mixing, advection, dispersion, diffusion, sorption, phase transfer.

Open-Channel Hydraulics (CWR6235) 3 credits
Review of basic hydraulics: Continuity, momentum and energy balance; Uniform and steady flow; Non-uniform flow; Critical flow; Gradually-varied flow; Surface profiles; Chezy's and Manning's formulas; Laminar and turbulent flow; Velocity distribution; Unsteady flow; Rapidly varying flow; Flood routing; Design of open-channels.

Dynamic Hydrology (CWR6525) 3 credits
Dynamics and statistics of principal hydrometeorological processes; Hydrologic cycle; Precipitation, Infiltration; Evapotranspiration; Surface runoff; Percolation; Groundwater motion; Stormwater management; Hydrologic modeling; Water budget; Hydrologic time series, Stochastic analysis; ARARMA models.

Water Resource System Engineering (CWR6818) 3 credits
Nature of water resource systems; Systems analysis, Objective functions; Optimal policy analysis; Linear programming; Dynamic programming; Political and economic objectives; Water resource subsystems; Deterministic and stochastic parameters; Large-scale, multi-objective projects; Water allocation; Supply and demand; Hierarchical modeling of water resource systems.

Modeling Methods in Water Resources and Environmental Engineering (EES6025) 3 credits
Classification of PDEs; fundamentals of numerical analysis; numerical stability, consistency, and convergence; method of characteristics; variational principles; finite differences; finite elements; integral-boundary element method; applications to water resource and environmental engineering problems.

Sustainable Cities (URP6406) 3 credits
Explores the intellectual foundations and historical development of sustainability as a concept, places it within the larger context of various development theories and looks at how it has influenced real-world practice in planning and public policy.

Environmental Restoration (EVR6334) 3 credits
Course introduces students to the rapidly expanding practice of restoring degraded ecosystems and landforms through a mixture of lecture, discussion, field visits, and individual research projects.

Restoration Implementation and Management (EVR6358) 3 credits
Restoration projects require the approval of multiple government agencies and cooperation of affected landowners and stakeholders at every phase. This course covers the legal aspects of government approval, creating communication plans for coalition building and collaboration with stakeholders, conflict resolution and ethics in restoration. The course uses a combination of discussion of academic literature, lecture, case studies and guest speakers, including from state and federal agencies, consulting firms and non-governmental organizations.

Global Environmental Change (GLY 6746) 3 credits
An introduction to the study of global climate change through time. Included and in-depth studies of the causes of and evidence for past environmental changes, major perturbations of global natural environmental systems, the effects of sea level changes, solar variations, and planetary dynamics on climate, and details of Quaternary paleoclimate models.

Environmental Analysis in Planning (URP6425) 3 credits
Analysis of natural and urban environments, and the application of planning systems.

3. Interdisciplinary Electives:

Infrastructure Maintenance and Management (CGN6616) 3 credits
The course involves evaluating infrastructure systems (water, sewer, stormwater, roads, bridges, rail, power) to identify concepts on repair, replacement and maintenance, including dollars to spend on same.

Advanced Foundation Engineering (CEG6105) 3 credits
Rigid and flexible earth retaining structures; shallow and deep foundations; laterally loaded piles; sheet-pile walls, braced excavations, cellular cofferdams, and buried culverts; consolidation settlement, stress distribution, elastic settlement, load bearing capacity; seepage and dewatering of foundation excavations.

Soil Stabilization and Geosynthetics (CEG6124) 3 credits
Soil chemistry, mineralogy, and properties; techniques of soil reinforcement, soil improvement, and soil treatment; chemical stabilization; mechanical stabilization; designing with geosynthetics; foundations and pavement applications.

Advanced Mechanics of Materials for Civil Engineers (CES6107) 3 credits
Stress and strain tensors, failure criteria, variational principles, torsion of thin wall members, unsymmetrical bending, theories of plates, shells, elastic foundations, and plastic analysis of structures.

Finite Element Methods in Civil Engineering (CES6119) 3 credits
Variational principles, weighted residual methods, convergence criteria, shape functions for one-, two-, and three-dimensional elements, isoparametric elements, and applications to structural and geotechnical engineering systems.

Structural Dynamics (CES6585) 3 credits
Response of lumped parameter systems to dynamic loading: formulation and solution of problems of one or more degrees of freedom for discrete systems, modal analysis, numerical integration, and transform techniques. Response of continuous systems. Introduction to earthquake engineering: response spectra, energy absorption capacity of structures, estimation of damping, seismic design, seismic codes, and soil-structure interaction. Wind effects on structures and hurricane-resistant design. Blast-resistant design. Approximate design methods.

Neural Complex and Artificial Neural Networks (EEL 6819) 3 credits
Multifaceted representation of neural activity in terms of neurobiology, cognitive science, art of computation, cybernetics and physics of statistical mechanics. Neural network modeling mimicking biological neural complex and development of artificial neural networks.

Solar Energy Engineering (EML 6417C) 3 credits
The fundamentals of solar radiation, transmission, and absorption; flat plate and focusing collectors, thermal storage, heating and cooling of structures, distillation, process heat generation, and power generation. Two hours lecture and six hours lab are required.

Wind Turbine Systems (EML 6456) 3 credits
This course reviews wind turbine systems and practical means of harnessing green energy. The course covers turbine technology, power rating and efficiency, blade-hub-nacelle-tower systems, wind data analysis, turbulence and rotational sampling, rotor aerodynamics, control systems, economics and environmental aspects.

GIS Applications in Planning (URP6277) 3 credits
This course provides urban and regional planning applications of GIS. Included are demonstrations of environmental planning, community and economic development planning, urban design, and land use planning. Students learn to use GIS as a tool for decision-making.

Human-Environmental Interactions (GEA6277) 3 credits
This course provides graduate students in geography with an environment to practice the various methods and approaches learned in their graduate program. It uses a multidisciplinary approach to explore diverse aspects of human-environment interactions in a specified region.

Coastal Hazards (GLY6888) 3 credits
A global review of natural and human-induced hazards as they affect coastal zones, including the identification of site specific and regional coastal hazards. Mitigation and management are related to individual and community hazard perceptions, risk assessment and response. Emphasis is placed on the susceptibility of the SE Florida region to oil (chemical) spills, coastal floods due to extreme events, and to the potential impacts of global sea level rise.

Coastal Environments (GLY 6737) 3 credits
Dynamics of depositional systems in coastal environments. Emphasis on variability of sediments, geomorphology and littoral processes associated with coastal dunes, lagoons, estuaries, beaches and nearshore environments.

Environmental Policy and Programs (URP 6429) 3 credits
Policy and analytic perspectives on major issues in environmental planning systems.

F. For degree programs in the science and technology disciplines, discuss how industry-driven competencies were identified and incorporated into the curriculum and indicate whether any industry advisory council exists to provide input for curriculum development and student assessment.

The curriculum was developed with the assistance of the Department Advisory Board comprised of 16 industry representatives, 7 of which are from companies and agencies that have an environmental engineering and 9 from entities with a transportation engineering focus as shown in Table VIII-3.

Table VIII-3. 2018-2019 Civil Engineering Department Advisory Council Members Involved in Curriculum Development.

Name	Company Name	Position
Jorge L. Armenteros	Continental Florida Materials	Vice President Cement Sales
Ben H. Chen	Chen and Associates	Founder and Chairman
Donald A. Eckler	*Eckler Engineering*	President
Aneesh Goly	Smart Structures	President
Jeffrey Greenfield	*Broward County*	Project Manager
Edward J. Kent	*Parsons*	Technical Director
Alan Klevens	*Transystems*	Principal & Vice President
Adam Maze	DRMP, Inc.	Leader/Project Manager
Matt Olender	Thornton Tomasetti	Principal and Director
Mark Plass	*Florida Dept. of Transportation*	District IV Traffic Operations
S. S. Rajpathak	SRI Consultants, Inc.	President
Will Suero	HDR	Vice President
Ryan Wheeler	Caulfield & Wheeler, Inc.	Vice President

Among the top "soft skills" requested by employers queried in the curriculum development process include: communication, cooperative/team player, self-motivated, supervision/management, project management, analytical thinking, problem solving, detail-oriented, initiative, and organization. The proposed curriculum will provide critical job placement

skill development via the innovative research internship partnership with industry.

G. For all programs, list the specialized accreditation agencies and learned societies that would be concerned with the proposed program. Will the university seek accreditation for the program if it is available? If not, why? Provide a brief timeline for seeking accreditation, if appropriate.

Commission on Colleges of the Southern Association of Colleges and Schools (SACS) is the only accreditation agent for the proposed degree program. In December 2013, it reaffirmed Florida Atlantic University's accreditation for a period of 10 years. The institution will seek re-accreditation in 2024.

H. For doctoral programs, list the accreditation agencies and learned societies that would be concerned with corresponding bachelor's or master's programs associated with the proposed program. Are the programs accredited? If not, why?

The accreditation agency for corresponding bachelor's degrees associated with the proposed program is the Accreditation Board for Engineering and Technology (ABET). The College of Engineering and Computer Science offers 8 degree programs (Computer Science, Computer Engineering, Electrical Engineering, Mechanical Engineering, Ocean Engineering, Civil Engineering, Geomatics Engineering and Environmental Engineering). The first 7 of which are ABET accredited. The new B.S. in Environmental Engineering curriculum (Fall 2016) is designed to meet all requirements for accreditation by the Accreditation Board for Engineering and Technology (ABET), as developed for Environmental and Similarly Named Programs by the learned societies of the American Academy of Environmental Engineers and Scientists (AAEES) and its cooperating societies: American Institute of Chemical Engineers (AIChE), American Society of Agricultural and Biological Engineers (ASABE), American Society of Civil Engineers (ASCE), American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), American Society of Mechanical Engineers (ASME), Institute of Transportation Engineering (ITE), Intelligent Transportation Systems Society (ITSS), SAE International, and the Society for Mining, Metallurgy, and Exploration (SMME). The program's first 3 graduates were in December 2018, and the initial accreditation on-site visit is scheduled for Fall 2020 with fully retroactive status to include the first graduates. The Request for Evaluation is scheduled for January 2020 with a self-study report due in the summer of 2020.

I. Briefly describe the anticipated delivery system for the proposed program (e.g., traditional delivery on main campus; traditional delivery at branch campuses or centers; or nontraditional delivery such as distance or distributed learning, self-paced instruction, or external degree programs). If the proposed delivery system will require specialized services or greater than normal financial support, include projected costs in Table 2 in Appendix A. Provide a narrative describing the feasibility of delivering the proposed program through collaboration with other universities, both public and private. Cite specific queries made of other institutions with respect to shared courses, distance/distributed learning technologies, and joint-use facilities for research or internships.

Program staff and faculty will be headquartered on the Boca Raton campus of FAU, but some of the research laboratories may be located in one of the satellite campuses (SeaTech, Davie, Ft. Lauderdale, Jupiter, Harbor Branch, etc.). Therefore, many of the classes in the program will need to be delivered via eLearning or distance learning formats, and currently all graduate courses offered by the Department of Civil, Environmental & Geomatics Engineering are offered as

eLearning or distance learning. This program will have an emphasis on hybrid online content to increase access and allow part-time students and professionals to obtain their degrees while still working. Most of the coursework will have class meeting times scheduled for the evening hours for students who want face-to-face time with faculty, providing working professionals the opportunity to attend classes outside of normal working hours if desired.

All current graduate course offerings delivered by CEGE are scheduled to meet after working hours or on weekends to accommodate working students. These courses are all delivered using the distance learning format with live lecture sessions featuring asynchronous recording and hybrid online lecture content. In addition, it is planned to use the following possible modes and formats of delivery: live online course content with real time video conferencing interaction and recording capabilities, fully online courses, laboratory sessions using FAU and/or outside agencies/businesses/industries facilities, and the traditional live course format.

A blended system of delivery modes and formats, each chosen to best fit the pedagogical needs of the particular course and student outcomes will provide convenient access and minimize travel and work disruption for students in the program. The most effective delivery system will undergo continuous improvement after the needs of the students and the achievement of the student outcomes in each course are assessed by the faculty, students, and industry council.

It is anticipated that most courses will have a substantial online component and many are currently offered entirely online or mostly online. Courses originating in the Boca campus of FAU can be delivered to other FAU campuses using the University's existing state-of-the-art videoconferencing capabilities already in place.

IX. Faculty Participation

A. Use Table 4 in Appendix A to identify existing and anticipated full-time (not visiting or adjunct) faculty who will participate in the proposed program through Year 5. Include (a) faculty code associated with the source of funding for the position; (b) name; (c) highest degree held; (d) academic discipline or specialization; (e) contract status (tenure, tenure-earning, or multi-year annual [MYA]); (f) contract length in months; and (g) percent of annual effort that will be directed toward the proposed program (instruction, advising, supervising internships and practica, and supervising thesis or dissertation hours).

The Department of Civil, Environmental & Geomatics Engineering has 17 faculty currently available for this program. Four more faculty joining in Fall 2019, Fall 2021 and Fall 2023 will be also available for the program. All faculty members teaching courses that are primarily design in content are qualified to teach the subject matter by virtue of professional licensure, board certification, or by education and equivalent design experience. Refer to Table 4 in Appendix A for existing and anticipated full-time (not visiting or adjunct) faculty who will participate in the proposed program through Year 5. Also listed in Table 4 are affiliate faculty from College of Science and College of Design and Inquiry. Their roles include, but are not limited to, supervision of Ph.D. dissertations from broader perspectives. Affiliate faculty's CV's are also listed in Appendix E.

B. Use Table 2 in Appendix A to display the costs and associated funding resources for existing and anticipated full-time faculty (as identified in Table 4 in Appendix A). Costs for visiting and adjunct faculty should be included in the category of Other Personnel Services (OPS). Provide a narrative summarizing projected costs and

funding sources.

With the recent faculty hires anticipated in environmental and transportation engineering for the 2019-2020 academic year, faculty staffing in the Department is sufficient to initiate the program. The faculty salary and benefits needed to support this program will come entirely from reallocated base E&G funds. For Year 1, the budget includes $265,778 in funds reallocated from the department to fund faculty salaries and benefits for the current faculty members in the program, and the recent new faculty members being hired on vacant lines. The reallocated salaries and benefits extend into the fifth year and include any increases in percent effort for current faculty as well as salaries and benefits for two new faculty members (one starting in Fall 2021 and one starting in 2023), for a total of $436,409 for Year 5. See Table 4 for a complete listing of faculty involved with the program.

C. Provide in the appendices the abbreviated curriculum vitae (CV) for each existing faculty member (do not include information for visiting or adjunct faculty).

See Appendix E for faculty CV's.

D. Provide evidence that the academic unit(s) associated with this new degree have been productive in teaching, research, and service. Such evidence may include trends over time for average course load, FTE productivity, student HC in major or service courses, degrees granted, external funding attracted, as well as qualitative indicators of excellence.

The Department of Civil, Environmental & Geomatics Engineering is very productive in terms of teaching, research and service. Since its inception in 2001, the undergraduate student body has grown from 6 (Fall 2001) to 416 (Spring 2019, headcounts: Civil – 245, Geomatics – 24, Environmental – 41, Pre-Professional with the designation of Civil, Environmental or Geomatics – 106). There are 45 students currently in the MS program, and 12 Ph.D. students, supervised by CEGE faculty, are registered in the sustainable infrastructure track in the Ph.D. in Ocean Engineering. The Department has produced an average of 54 BS degrees and 11 MS degrees each year for the last five years. The faculty, consisting of 15 full time, delivers 30-32 classes each spring and fall semester.

During the 2018-2019 fiscal year, the faculty wrote 26 research proposals as PIs to federal, state and local funding agencies, with 12 of them being awarded for a total of $2.63 million. The Department houses Freight Mobility Research Institute (FMRI), a US Department of Transportation funded University Transportation Center. FMRI has partnership with Hampton University, Portland State University, Texas A&M University at College Station, University of Florida, University of Memphis and University of Minnesota at Twin Cities. FMRI received an initial funding level of $10.5 million, including matching funds, from US DOT.

The faculty is also very active in university business through various levels of faculty committees. Some are also active in the national committees of professional associations. 70% of faculty served as reviewers for technical journals during the last academic year. Four faculty members received the Engineering Education of the Year awards from the National Council of Engineers since 2014, and one faculty member received the FAU Distinguished Teacher of the Year award in 2014 and FAU Distinguished Mentor of the Year award in 2015; A capstone design project supervised by Drs. Meeroff and Bloetscher received the 1st place award from NCEES $25,000 prize for the Dania Beach LEED Gold Water Treatment Plant Expansion Project; Bloetscher and Meeroff also authored the textbook, "*Practical Concepts for Capstone Design Engineering*," which was adopted by 63 schools worldwide; one faculty member's research on intelligent transportation system was cited in a recent

article in Time Magazine.

Due to the interdisciplinary nature of the proposed Ph.D. program, postdocs and associate graduate faculty will also provide assistance. A listing of those affiliated resources is summarized in Table VIII-4.

Table VIII-4. List of postdoctoral researchers and affiliated graduate faculty associated with the proposed Ph.D. program.

Last Name	First Name	Status	Department
Bullard	Lofton	Associate Graduate Faculty	Engineering & Computer Science
Chen	Ben	Associate Graduate Faculty	Civil, Environmental & Geomatics Engineering
Callaway	Edgar	Associate Graduate Faculty	Electrical Engineering & Computer Science
Challamael	Noel	Associate Graduate Faculty	Ocean and Mechanical Engineering
Dalgleish	Fraser	Associate Graduate Faculty	Ocean and Mechanical Engineering
Goly	Aneesh	Associate Graduate Faculty	Civil, Environmental & Geomatics Engineering
Indeglia	Paul	Associate Graduate Faculty	Civil, Environmental & Geomatics Engineering
Jaramillo	David	Associate Graduate Faculty	Electrical Engineering & Computer Science
Kalish	Kristopher	Associate Graduate Faculty	Electrical Engineering & Computer Science
Liu	Dan	Postdoc	Civil, Environmental & Geomatics Engineering
Liu	Hanlin	Associate Graduate Faculty	Ocean and Mechanical Engineering
Mitrovic	Nikola	Postdoc	Civil, Environmental & Geomatics Engineering
Ouyang	Bing	Associate Graduate Faculty	Ocean and Mechanical Engineering

Last Name	First Name	Status	Department
Romance	Nancy	Associate Graduate Faculty	Electrical Engineering & Computer Science
Saliah-Hassane	Hamadou	Associate Graduate Faculty	Electrical Engineering & Computer Science
Smith	Richard	Associate Graduate Faculty	Ocean and Mechanical Engineering
Yim	Solomon	Associate Graduate Faculty	Ocean and Mechanical Engineering

X. Non-Faculty Resources

A. Describe library resources currently available to implement and/or sustain the proposed program through Year 5. Provide the total number of volumes and serials available in this discipline and related fields. List major journals that are available to the university's students. Include a signed statement from the Library Director that this subsection and subsection B have been reviewed and approved.

The University Libraries include the S.E. Wimberly Library on the Boca Raton campus, collections housed at the Broward County Public Library to serve FAU in downtown Fort Lauderdale, a shared-use library with Broward College in Davie, a 20,000-square-foot library on the John D. MacArthur campus in Jupiter and a library at Harbor Branch Oceanographic Institute. The Wimberly Library is a 165,000-square-foot building in the heart of the Boca Raton campus that serves over 900,000 visitors annually. It provides faculty and student group study rooms, a graduate study lounge, study carrels, seating for approximately 1,239, an electronic classroom, facilities for individuals with disabilities, an audiovisual media center and a computer lab. In addition to the computers available for use throughout the library, the entire building is equipped for laptop wireless connectivity. Reference assistance is offered in person or by telephone, email, chat or text. Library instruction sessions may be arranged for classes, or for individual students or faculty members. A five-story addition provides students with a 24-hour study location and housing for several special collections. The University Libraries' extensive holdings of approximately 3.7 million items include books, periodicals, government documents, microforms, maps, media and unique special collections in book arts, American Revolutionary War and Civil War documents, print and recorded music, rare books and manuscripts, and archival materials. The libraries also provide a wealth of electronic resources, including more than one million full-text electronic books and over 100,000 full-text electronic journals, plus access to more than 400 proprietary databases. An online catalog of library holdings provides a listing of materials in the FAU Libraries and the other 11 Florida public university libraries. The library pays for student and faculty access to hundreds of databases, many with full-text articles and books, which are available through the Internet both in the library or off-campus using EZproxy. Through memberships in the Southeast Florida Library Information Network (SEFLIN) and the Center for Research Libraries (CRL), the collections of area libraries and the CRL are available to FAU students, faculty and staff. Research materials, both digital and hard copy, not available in the FAU Libraries' collection may be obtained locally, nationally, and globally through interlibrary loan.
For more information, visit library.fau.edu.

The number of related periodicals is 284, including the following titles:

- AACE international transactions
- ACS Applied Materials & Interfaces
- Advanced cement based materials
- Advances in environmental research
- Advances in Structural Engineering
- African Journal of Environmental Science and Technology
- Air Pollution Consultant
- Air, Soil and Water Research
- AMBIO: A Journal of the Human Environment
- Annales des Ponts et Chaussées
- Applied Catalysis B: Environmental
- Applied Materials Today
- Architectural Design
- Architectural History
- Architectural Record
- Architectural Science Review
- Architectural Theory Review
- Archives of Civil & Mechanical Engineering
- Archives of environmental health
- arq: Architectural Research Quarterly
- Atmospheric Pollution Research
- Australian Journal of Civil Engineering
- Australian Journal of Electrical & Electronics Engineering
- Australian Journal of Environmental Management
- Basic and applied ecology
- Biocycle
- Biodegradation
- Bioresource technology
- Building Acoustics
- Building Design
- Buildings & Landscapes: Journal of the Vernacular Architecture Forum
- Bulletin of engineering geology and the environment
- Bulletin of environmental contamination and toxicology
- Business and the Environment
- Cement and concrete research
- Change Over Time
- Chemosphere
- Chemosphere - Global Change Science
- Circuit World
- Circuits and Systems
- Civil Engineering
- Civil Engineering and Environmental Systems
- Civil Engineering Systems
- Clean - Soil, Air, Water
- Climate Policy
- CoDesign

- Compost Science & Utilization
- Computer-aided civil and infrastructure engineering
- Control engineering practice
- Corporate Social Responsibility and Environmental Management
- Critical reviews in environmental science and technology
- Current Opinion in Environmental Science & Health
- Current Opinion in Environmental Sustainability
- Design issues
- Design week
- Dian Li Yu Neng Yuan=Energy and Power Engineering
- disP - The Planning Review
- Distributed Generation & Alternative Energy Journal
- Earthquake engineering and engineering vibration
- Earthquake Engineering and Structural Dynamics
- EC&M Electrical Construction & Maintenance
- Ecological indicators
- Ecotoxicology and environmental safety
- Ecumene
- Electric Machines and Power Systems
- Electric Perspectives
- Electric Power Components & Systems
- Electrical Engineering
- Electrical Engineering in Japan
- Electrical Wholesaling
- Engineering geology
- Engineering structures
- ENR Engineering News-Record
- Environment
- Environment & Urbanization
- Environment and Planning B: Planning and Design
- Environment and Planning B: Urban Analytics and City Science
- Environment international
- Environment Systems & Decisions
- Environment, Development and Sustainability
- Environmental Biology of Fishes
- Environmental Biosafety Research
- Environmental Chemistry Letters
- Environmental Communication
- Environmental Development
- Environmental Forensics
- Environmental Geochemistry and Health
- Environmental hazards
- Environmental History
- Environmental Humanities
- Environmental impact assessment review
- Environmental Innovation and Societal Transitions
- Environmental management
- Environmental Management and Health
- Environmental microbiology

- Environmental Modeling & Assessment
- Environmental monitoring and assessment
- Environmental Politics
- Environmental Pollution
- Environmental Practice
- Environmental Progress
- Environmental Progress and Sustainable Energy
- Environmental research
- Environmental research letters
- Environmental science & policy
- Environmental Science & Technology
- Environmental Science & Technology Letters
- Environmental Science and Pollution Research International
- Environmental Science: Water Research & Technology
- Environmental technology
- Environmental Technology Letters
- Environmetrics
- EPA Journal
- Ethics, Policy & Environment
- European Environment
- European Journal of Environmental and Civil Engineering
- European journal of soil biology
- European Transactions on Electrical Power
- Fabrications: The Journal of the Society of Architectural Historians Australia & New Zealand
- Frontiers of Architecture and Civil Engineering in China
- Frontiers of Environmental Science & Engineering in China
- Future Anterior: Journal of Historic Preservation History Theory & Criticism
- Geographical and Environmental Modelling
- Geography and Natural Resources
- Geomechanik und Tunnelbau = Geomechanics And Tunnelling
- Geosystem Engineering
- Gesta
- Global Change Biology
- Global Environmental Change Part B: Environmental Hazards
- Global Environmental Change: Human and Policy Dimensions
- Global environmental politics
- Global Sustainability
- Great Plains Research
- Green Chemistry
- Greener Management International
- Hazardous Waste Consultant
- High Power Laser Science and Engineering
- HKIE Transactions
- Hospitality Design
- ICFAI Journal of Environmental Economics
- IEEJ Transactions on Electrical and Electronic Engineering
- IETE Journal of Research
- IETE Technical Review

- Impact Assessment & Project Appraisal
- Indoor Air
- Integrated Environmental Assessment and Management
- International Construction
- International journal for numerical and analytical methods in geomechanics
- International Journal for Numerical Methods in Biomedical Engineering
- International Journal for the History of Engineering and Technology
- International Journal of Agricultural and Environmental Information Systems (IJAEIS)
- International Journal of Architectural Computing
- International Journal of Architectural Heritage: Conservation, Analysis, and Restoration
- International journal of communication systems
- International Journal of Digital Literacy and Digital Competence (IJDLDC)
- International Journal of Electrical Engineering Education
- International journal of emerging electric power systems
- International Journal of Energy Sector Management
- International Journal of Environmental Health Research
- International Journal of Environmental Studies
- International Journal of Geotechnical Engineering
- International Journal of Information Systems for Crisis Response and Management (IJISCRAM)
- International Journal of Open Source Software and Processes (IJOSSP)
- International Journal of Phytoremediation
- International Journal of Space Structures
- International Journal of Structural Integrity
- International Review for Environmental Strategies
- IOP Conference Series: Materials Science and Engineering
- ISA Transactions
- ISABB Journal of Health and Environmental Sciences
- ITS Journal
- Journal of Aerosol Science
- Journal of Architectural Conservation
- Journal of Architectural Education
- Journal of Architectural Engineering
- Journal of bridge engineering
- Journal of cleaner production
- Journal of Coastal Conservation
- Journal of Cold Regions Engineering
- Journal of composites for construction
- Journal of Construction Engineering and Management
- Journal of Earthquake Engineering
- Journal of Electromagnetic Analysis and Applications
- Journal of electrostatics
- Journal of Energy Engineering
- Journal of Entrepreneurship in Emerging Economies
- Journal of environmental management
- Journal of environmental psychology
- Journal of environmental radioactivity
- Journal of Environmental Science and Health . Part A: Environmental Science and Engineering and Toxicology

- Journal of Environmental Science and Health, Part C: Environmental Carcinogenesis and Ecotoxicology Reviews
- Journal of Environmental Studies and Sciences
- Journal of Environmental Systems
- Journal of Exposure Science and Environmental Epidemiology
- Journal of Flood Risk Management
- Journal of Geotechnical and Geoenvironmental Engineering
- Journal of geotechnical engineering
- Journal of hazardous materials
- Journal of Hazardous, Toxic, and Radioactive Waste
- Journal of Infrastructure Systems
- Journal of intelligent transportation systems
- Journal of Material Cycles and Waste Management
- Journal of Materials Chemistry B: Materials for Biology and Medicine
- Journal of Materials in Civil Engineering
- Journal of Occupational & Environmental Medicine
- Journal of Performance of Constructed Facilities
- Journal of Porous Materials
- Journal of Professional Issues in Engineering Education and Practice
- Journal of Risk and Uncertainty in Engineering Systems, Part A: Civil Engineering
- Journal of Sensor Technology
- Journal of Signal Processing Systems
- Journal of soil contamination
- Journal of Structural Engineering
- Journal of Surveying Engineering
- Journal of Technical Writing and Communication
- Journal of terramechanics
- Journal of the Air & Waste Management Association
- Journal of the American Institute of Planners
- Journal of the American Water Works Association
- Journal of the Franklin Institute, of the State of Pennsylvania, for the Promotion of the Mechanic Arts; Devoted to Mechanical and Physical Science, Civil Engineering, the Arts and Manufactures
- Journal of the Illuminating Engineering Society
- Journal of the Society of Architectural Historians
- Journal of Transportation Engineering, A: System
- Journal of Transportation Engineering, Part A: Systems
- Journal of Transportation Engineering, Part B: Pavements
- Journal of Urban Planning and Development
- KSCE Journal of Civil Engineering
- Landscape and urban planning
- Laser & Photonics Reviews
- Lighting Research & Technology
- Local environment
- Low Carbon Economy
- Marine environmental research
- Marine pollution bulletin
- Marine structures
- Monographs of the Western North American Naturalist

- Natural Hazards
- Natural hazards review
- Nature Nanotechnology
- Nature Reviews Materials
- Nexus Network Journal: Architecture & Mathematics
- npj Clean Water
- Occupational Hazards
- Opflow
- Philips Journal of Research
- Photogrammetric record
- Pollution Engineering
- Power engineering
- Practice Periodical of Hazardous, Toxic, and Radioactive Waste Management
- Practice Periodical on Structural Design and Construction
- Protection of Metals and Physical Chemistry of Surfaces
- Regional environmental change
- Remediation : The Journal of Environmental Cleanup Costs, Technologies & Techniques
- Revue Européenne de Génie Civil
- Revue Française de Génie Civil
- Road Materials and Pavement Design
- Russian Electrical Engineering
- Sadhana: Academy Proceedings in Engineering Sciences
- SAH Newsletter
- Science of The Total Environment
- Ship Technology Research (Schiffstechnik)
- Ships and Offshore Structures
- Soil Dynamics and Earthquake Engineering
- Soil Mechanics and Foundation Engineering
- Stahlbau
- Structural Engineering International
- Structural Optimization
- Structural Safety
- Structure and Infrastructure Engineering: Maintenance, Management, Life-Cycle Design and Performance
- Subsurface Sensing Technologies and Applications
- Sustainable Cities and Society
- Sustainable Facility
- The Architects' Journal
- The Canadian Architect
- The International Journal of Life Cycle Assessment
- The Journal of Architecture
- The Journal of Computational Multiphase Flows
- The Journal of Environmental Education
- Thin-walled structures
- Transportation Geotechnics
- Transportation Quarterly
- Tunneling and underground space technology
- Vernacular Architecture
- Virtual and Physical Prototyping

- Waste & Recycling News
- Waste Age
- Waste management
- Waste Management & Research
- Waste News
- Waste360
- Waste360 (Online)
- Water and Environment International
- Water, Air, and Soil Pollution
- Wiley Interdisciplinary Reviews: Energy and Environment
- World Wastes
- 工程热物理学报 = Journal of Engineering Thermophysics
- 环境科学学报英文版 = Journal of Environmental Sciences
- 资源与生态学报英文版 = Journal of Resources and Ecology

29 Databases:

Database	Description
Abstracts in New Technology & Engineering (Proquest)	ANTE is an abstracting and indexing service monitoring publications from the U.K. and the U.S. Coverage includes new technologies such as information technology and computing, electronics, biotechnology, medical technology, as well as engineering (including construction, electrical and chemical engineering) and allied subject areas. Sources covered include periodicals, conference proceedings, technical reports, trade journal/newsletter items, patents, books, and press releases.
Aluminium Industry Abstracts	Provides comprehensive coverage of the world's technical literature on aluminium/aluminum, production processes, products, applications, and business developments.
American Institute of Physics (AIP) Journals	Provides access to full-text physics journal articles.
Applied Science & Technology Source	Includes Applied Science & Technology Full Text, Applied Science & Technology Index Retrospective and additional content. This database offers a diverse array of full-text and indexed content that covers the full spectrum of the applied sciences and computing disciplines from acoustics to aeronautics, and neural networks to nuclear engineering.
Art and Architecture Source	Includes Art Full Text, Art Index Retrospective and additional content. This art research database covers a broad range of subjects from fine, decorative and commercial art, to various areas of architecture and architectural design. It features full-text articles, indexing and abstracts for an array of journals, books and more.
Avery Index to Architectural Periodicals	Covers the current literature of architecture and design, indexing more than 1000 US and foreign journals.
Biotechnology Research Abstracts	This database provides citations and abstracts to research articles on biotechnology (medical, agricultural, and environmental) and bioengineering.
Ceramic Abstracts	Comprehensive database for the ceramics industry. Source materials include over 3000 journals, proceedings, patents, standards and industry literature.

Database	Description
Civil Engineering Abstracts	This link opens in a new window This database provides indexing and abstracts from more than 4,000 current serial and non-serial titles, including content from ASCE and ICE. It covers all civil aspects from architecture, structural design and construction engineering to environmental, seismic engineering and forensics.
Compendex (Engineering Village)	Compendex is the most comprehensive interdisciplinary engineering database in the world. It contains over 8 million records and references over 5,000 international engineering sources including journal, conference, and trade publications.
Copper Technical Reference Library	Provides an online bibliographic database of the world's literature on copper, copper alloys, and copper technology.
Corrosion Abstracts	Corrosion Abstracts provides the world's most complete source of bibliographic information in the area of corrosion science and engineering.
Emerald eJournals Premier	Emerald eJournals Premier provides access to all current content and selected archive material for all Emerald eJournals. Subjects include engineering, computing & technology, and management.
Engineered Materials Abstracts	Begun in 1986, Engineered Materials Abstracts is an electronic database containing Ceramics, Composites and Polymers subfiles. Sources covered include over 3,000 periodicals, conference proceedings, technical reports, trade journal/newsletter items, patents, books, and press releases.
Environmental Engineering Abstracts	Covers the world literature pertaining to technological and engineering aspects of air and water quality, environmental safety, and energy production.
IOPscience	Provides access to scientific, medical and technical journals hosted by IOP (Institute of Physics)
Materials Business File	Materials Business File focuses on industry news, international trade data, government regulations and management issues related to the metals and materials industries.
Materials Science & Engineering Database (Proquest)	The ProQuest Engineering Collection contains engineering related full-text articles, granular access to millions of figures and tables within articles, and the entire range of bibliographic records from the CSA Engineering Research Database, a comprehensive index to world literature on technological and engineering innovations.
MathSciNet (AMS)	MathSciNet (EBSCOhost) |1940-present
Mechanical and Transportation Engineering Abstracts	Provides citations, abstracts, and indexing of the serials literature in mechanical and transportation engineering and their complementary fields, including forensic engineering, management and marketing of engineering services, engineering education, theoretical mechanics and dynamics, and mathematics and computation. This database provides in depth, comprehensive international coverage of engineering literature, monitoring more than 3000 serial titles as well as numerous non-serial publications.
METADEX	A comprehensive source for information on metals and alloys: their properties, manufacturing, applications, and development.
Risk Abstracts	Risk Abstracts encompasses risk arising from industrial, technological, environmental, and other sources, with an emphasis on assessment and management of risk.
SciFinder	Provides comprehensive chemical and related scientific information including journal articles, patents, chemical reactions, and chemical regulatory data.
SciTech Collection (ProQuest)	This collection covers science and technology research, combining full-text journals with detailed indexing of global literature on natural sciences, engineering and technology.

Database	Description
Toxicology Abstracts	Toxicology Abstracts covers issues from social poisons and substance abuse to natural toxins, from legislation and recommended standards to environmental issues.
TOXLINE	Provides access to information in all areas of toxicology, including chemicals and pharmaceuticals, pesticides, environmental pollutants, and mutagens and teratogens.
Web of Science	Three unique citation databases which allow searching cited references as well as traditional searches independently or in combination: Science Citation Index Expanded, Social Sciences Citation Index, and Arts and Humanities Citation Index.

Print volumes:

Subject General	Sub-Categories	Call Number Range	Total Number of Print Volumes
Hydrology, Water		GB651-GB2998	5046
Environmental sciences		GE1-GE350	805
Human ecology, Anthropogeography	Urban geography, rural settlements, settlements by region	GF126-GF900	159
Human ecology, Anthropogeography	Environmental influences on humans, Human influences on the environment, Settlements, Cities, Urban geography	GF51-GF125	228
Environmental management		HD30.255	34
Transportation and communications	Railroads. Rapid transit systems	HE1001-HE5600	324
Transportation and communications	Freight, Passenger traffic, Urban transportation	HE1-HE311	345
Transportation and communications	Traffic engineering, Roads and highways, Streets, Traffic surveys, Bridges, Tunnels, Vehicular tunnels	HE331-HE380	150
Transportation and communications	Water transportation	HE380.8-HE560	74
Transportation and communications	Automotive transportation	HE5601-HE5725	118
Communities. Classes. Races	Human settlements, Communities, Urban groups, The city, Urban sociology, Garden cities, "The city beautiful", City planning, Urban renewal, Urban redevelopment	HT51-HT178	2134
Environmental law		KF3775-KF3821	95
Architecture	General, Architecture and the state, History, Architecture as a profession, Study and teaching, Research, General works, Architectural criticism, Architectural drawing and design	NA1-NA4050	2521

Subject General	Sub-Categories	Call Number Range	Total Number of Print Volumes
Architecture	Special classes of buildings	NA4100-NA8480	820
Architecture	Aesthetics of cities, City planning and beautifying	NA9000-NA9429	323
Landscape architecture		SB469-SB598	98
Engineering, Civil engineering	Engineering instruments, meters, Industrial instrumentation, Human engineering, Systems engineering, Environmental engineering, Engineering design, Engineering economy, Management of engineering works	TA165-TA194	343
Engineering, Civil engineering	Engineering machinery, tools, and implements, Engineering mathematics, Engineering analysis, Mechanics of engineering, Applied mechanics, Acoustics in engineering Acoustical engineering, Materials of engineering and construction, Mechanics of materials, Disasters and engineering, Surveying, Structural engineering, Engineering geology, Rock mechanics, Soil mechanics, Underground construction, Earthwork, Foundations, Tunneling, Tunnels, Transportation engineering	TA213-TA1280	3698
Environmental technology, Sanitary engineering	Municipal engineering, Environmental protection, Environmental pollution, Environmental effects of industries and plants, Water supply for domestic and industrial purposes, Water pollution, Water purification. Water treatment and conditioning, Saline water conversion, Water distribution systems, Sewage collection and disposal systems, Sewerage, Municipal refuse, Solid wastes, Special types of environment Including soil pollution, air pollution, noise pollution, Industrial and factory sanitation, Industrial and factory wastes, Hazardous substances and their disposal	TD1-TD1066	1187
Highway engineering. Roads and pavements		TE1-TE450	729
Railway construction		TF200-TF320	16
Bridge engineering		TG1-TG140	25

Subject General	Sub-Categories	Call Number Range	Total Number of Print Volumes
Building construction	Systems of building construction Including fireproof construction, concrete construction, Details in building design and construction Including walls, roofs, Buildings: Construction with reference to use- Including public buildings, dwellings, Construction by phase of the work, Environmental engineering of buildings, Sanitary engineering of buildings, Plumbing and pipefitting, Heating and ventilation, Air conditioning, Illumination, Lighting,Decoration and decorative furnishings, Protection of buildings	TH1000-TH9745	315
Building construction	Architectural engineering. Structural engineering of buildings	TH845-TH895	37
Total			19624

And two print journal subscriptions:

- Florida Scientist
- Scientific American

Describe additional library resources that are needed to implement and/or sustain the program through Year 5. Include projected costs of additional library resources in Table 2 in Appendix A. Please include the signature of the Library Director in Appendix B.

No additional library resources are anticipated.

B. Describe classroom, teaching laboratory, research laboratory, office, and other types of space that are necessary and currently available to implement the proposed program through Year 5.

Instructional and Classroom Support:

Classrooms: FAU has 371 instructional venues across its seven campuses, with 110 designated as "general classroom" and 210 as "class lab" usage. OIT provides the infrastructure, instructional technology, and AV support for 82 percent of those rooms. Of the OIT-supported classrooms, 100 percent now have presentation ability, which includes a computer, projector, DVD player, Sympodium (which serves as computer monitor and electronic whiteboard), and document camera, as well as the ability to connect a laptop and use it as the presentation medium. Over 96 percent of the centrally scheduled (some college-managed) classrooms are equipped with presentation capability. OIT has AV technicians on staff whenever classes are in session, including evenings and Saturdays. These staff members can assist faculty and presenters with learning to use the equipment and provide troubleshooting in the event of a technical problem. Of FAU's 370 classrooms, 23 have the lecture-capture capability, and 31 of those rooms can also provide live video conferencing for classes as well as thesis and dissertation presentations and other events.

Instructional and Open Computer Labs: FAU has nineteen open labs (Boca Raton: twelve; Fort Lauderdale: one; Davie: three; Jupiter: three) and twenty-five instructional labs (Boca Raton: seven; Fort Lauderdale: nine; Davie: six; Jupiter: three). In addition, the Department's students have access to a large computer lab in the library (IS113) and 24-hr card access to labs in buildings 4 and 96. OIT provides support and management for all general instructional and open computer labs on all FAU campuses. This provides students with a high level of uniformity across all campuses. Computers in campus labs have a consistent look and feel, a uniform set of software packages, and access to the printers. Instructional labs provide a teaching console with a computer and projector and computers for each student. Specifications and capabilities in each lab are listed on the OIT Website. The computer center's open laboratory is open from 8:00 a.m. - 10:00 p.m. seven days per week. All computer laboratories in the residence halls, the student apartments, and the Student Union are open twenty-four hours seven days per week.

Virtual Computer Labs: FAU also has virtual computing labs, which will allow students anywhere to connect to a virtual computer and launch applications licensed by FAU via VMWare. Current licensed applications include Microsoft Office, Minitab, SPSS, Visual Studio, Notepad, and essentially all software programs necessary for required coursework such as AutoCAD, Revit, EPANet, etc. Applications will be added to the suite as necessary. This project is vital for supporting distance learning students, who require access to discipline-specific applications that are currently available in the physical computing labs.

Training: OIT's Instructional Technologies division offers training for the multitude of services OIT provides. Training is available for faculty, staff, and students in the effective use of technology through free instructor-led courses on Google Applications for Education (documents, presentations, spreadsheets, forms, websites, groups, calendar and Google+). In-person training for learning management systems (LMS) and classroom technology are limited to faculty and graduate teaching assistants. These classes are taught in a computer lab with a hands-on approach. A schedule of the computer training courses is posted on the OIT Website and is published in the weekly University announcements. Computer training courses are offered at the Boca Raton campus and FAU's partner campuses, including Davie, Fort Lauderdale, and Jupiter. In 2018, over 700 training sessions took place, including 460 software application-related workshops and 273 LMS sessions. To enable students to complete necessary course tasks, all students have access to online LMS tutorials. OIT also provides special courses for departments or other groups and one-on-one sessions on request. These special courses include classes on the use of Word for graduate students who are working on theses and dissertations, orientation on the use of eClassroom/videoconference technologies, and training on the University's Web content management system, OmniUpdate. In addition to designing and delivering training, OIT staff members develop documentation and tutorials including online training videos. Upcoming online training tutorials will feature topics such as an Introduction to eClassrooms, Teaching via Videoconference, and Using Personal Lecture Capture Tools. OIT also makes Microsoft IT Academy online training available to faculty and staff upon request. OIT participates in the annual New Faculty Orientation by providing information about technology support, resources, and services available to faculty at FAU. In addition to centralized training in technology through OIT, FAU's colleges have courses dedicated to helping students become comfortable working with technology.

Video Production and Event Support: OIT provides faculty the opportunity to video record lecture snippets or demonstrations that can be used for classes. It also records and/or Webcasts academic presentations, invited speakers, key meetings (e.g., the search and interview of candidates for FAU president, and the State of the University Address), commencement, and other

ceremonies using a variety of platforms.

Applications: FAU licenses the learning management system for University use. FAU also licenses access to Respondus StudyMate, Respondus LockDown Browser, SafeAssign, TurnItIn, iTunes U, and lecture capture via Mediasite. Lecture videos are available via the learning management system in various formats to accommodate an array of connection speeds. The full list of software available for college and department purchase for on-site use is available online.

College Computing Facilities
(Mahesh Neelakanta, Director, Technical Services Group, http://tsg.eng.fau.edu/)
The Technical Services Group is responsible for the computer laboratories and computer support in the College of Engineering and Computer Science. The following laboratories are available in the College (Engineering East Building 96, Engineering West Building 36):
College Open Use Labs:

EW 130 - Mechanical Engineering Open Lab (20 Computers)
EE 207 - Engineering Open Use Computing & Teaching Lab (30 Computers, 60 Seats)
EE 213 - Engineering Open Use Computing & Teaching Lab (18 Computers, 36 Seats)

College Research, Teaching & Computer Labs:
Engineering West Building 36 Labs:
EG 132 - Experimental Methodology Lab

Instructional Services Building 4 Labs:
IS 101 - CITSS Transportation Lab
IS 103 – Bloetscher/Meeroff Capstone Design Lab
IS 113 – Computer Aided Design Lab

Engineering East Building 96 Labs:
EE 203 - Microprocessor, Logic Design, Microcontroller Lab
EE 205A - Engineering Student Work Lab
EE 208 - Senior Projects, Design I and II Lab
EE 209 - Controls & Communications Lab
EE 212 - Innovation Lab
EE 408A - Apple Lab
EE 408B - Signal Image & Video Processing Lab
EE 409 - Multipurpose Lab (CSI)
EE 410A - Web Development Lab
EE 410B - Digital Signal Processing Lab
EE 413 - Mobile Computing, Sensor and Wireless Lab
EE 507A - Empirical Software Engineering Lab (ESEL)
EE 507B - BioInformatics Lab
EE 508 - RF, Microwave & Satellite Communications Lab

Department teaching laboratory, research laboratory, and office space: The Florida Atlantic University Department of Civil, Environmental & Geomatics Engineering has several instructional laboratories and research laboratories occupying 9,231 ft^2 of space. Table X-1 lists all laboratories used by environmental engineering students, their location and floor space.

Table X-1. Environmental Engineering Teaching/Research Laboratories

LABORATORY NAME	ROOM #	Teaching (T), Research (R)	AREA (ft^2)
Environmental Engineering Process Laboratory	EG-152C	R	303
Environmental Engineering Research Laboratory	EG-154	R	253
Environmental Photochemistry Research Laboratory	EG-153	R	82
Nutrient Analysis Research Laboratory	EG-150	R	79
AutoCAD Laboratory	IS-113	T	1,800
Civil, Environmental & Geomatics Engineering Design Laboratory	IS-103	T	869
Hydrosystems Research Laboratory	EG-229	R	133
Environmental Nanotechnology Laboratory	BS-504	R	662
Environmental Chemistry Teaching Laboratory	EG-263	T	1,202
Hydrodynamics Laboratory [Ocean Engineering]	EG-157	T	1,522
Total			**6,905**

Additional details on the current status of the facilities summarized in Table 14 are described as follows:

Environmental Engineering Process Laboratory, **EG-152C**. This laboratory was renovated in 2015 and is the unifying place to achieve departmental goals of educating competent, licensed professional engineers responsible for the sustainability of the environment. The major renovation added a walk-in temperature controlled room and a much needed separation from the Materials and Structures lab space in EG152B, which is now closed off with a 10-ft wall and drop ceiling. This space is equipped to allow students to fully experience the state-of-art capabilities of environmental instrumentation and acquire needed knowledge in water purification and mitigating environmental disasters.

Environmental Engineering Research Lab, EG-154. The laboratory fosters thesis-based research training to produce the next generation of engineering educators and researchers, a national priority. Its mission is to provide access to scientific and analytical equipment for research and training of civil engineers in the environmental disciplines who are interested in improving the quality of life through sustainability and protection of our environment and natural resources. This means the development of sufficient clean water supplies; the prevention of river, lake, ocean, and groundwater pollution; the maintenance of air quality; the remediation of land and water bodies contaminated with hazardous chemicals; and working with our local industry partners to provide solutions to their technological needs.

Environmental Photochemistry Research Lab, EG-153. This lab houses the photocatalytic oxidation chamber and the provisionally-patented photochemical iron-mediated aeration technologies that FAU has pioneered for detoxifying waste. Students can push the boundaries of water and wastewater treatment using advanced oxidation processes.

Nutrient Analysis Research Lab, EG-150. This lab is home to FAU's total organic carbon and total nitrogen analyzer as well as solids testing systems. With these facilities, students can explore the nature of nutrient pollution in the environment to better protect our oceans, our coastal zone, our water supplies, and our Everglades.

AutoCAD Laboratory, IS-113. Central to engineering education, the AutoCAD Laboratory is constantly upgraded with the latest computer technology, processor speed, and cloud-based sharing of sophisticated 2-D and 3-D design and analysis software for computer-aided design, building information modeling, cost estimation, water resource modeling, and hydraulic simulations with an adjoining printing/plotting area.

Civil, Environmental & Geomatics Engineering Design Laboratory, IS-103. This lab features a private student team planning/meeting space designed to foster students' presentations and team collaboration. There is a state-of-the-art wireless overhead high-definition projection system with projection screen and an automatic high-definition tracking camera to allow students to record presentations.

Hydrosystems Lab, EG-229. This lab supports simulation and modeling capabilities essential for hydrological, climate variability and climate change studies. It houses several stand-alone machines along with different computational environments accessing cluster computing resources with large RAM and specialized servers. A number of hydrological modeling software, GIS, and several others dealing with hydro-meteorology (precipitation data processing, infilling, radar-based precipitation analysis) software developed at FAU are also available on several computational platforms. A variety of software dealing with optimization and artificial neural networks, data mining and statistical analysis are also available. Computationally intensive tasks that handle large data sets in space and time and processing capabilities to handle geospatial analysis and geostatistics are also available for hydrologic simulation and water resources management studies.

Environmental Nanotechnology Laboratory, BS-504. Established in 2015, this lab is equipped for investigating environmental nanotechnology and its interactions with environmental chemistry, with research instruments such as dynamic light scattering, zeta potential analyzer, quartz crystal microbalance, UV-vis spectrometer, and gas chromatograph. The research conducted in the lab focuses on interactions of nanoparticles with environmental and biological surfaces and application of nanotechnology in water treatment, environmental remediation, and renewable energy.

Environmental Chemistry Laboratory, EG-263. In 2010, the College of Engineering and Computer Science funded construction of the Environmental Chemistry Laboratory in a space previously serving mechanical engineering graduate students. The laboratory contains a teaching station computer with SmartBoard technology that projects to two plasma TV screens. Directly across is an L-shaped teaching assistant prep area equipped with laboratory dishwasher, distilled water machine, dual sinks, goggle sterilizing cabinet, dry stock storage, lab refrigerator/freezer, and eyewash/safety shower station. Across the entrance is a flammable cabinet next to the spill kit containment area, a standing 20°C BOD incubator, and storage cabinet. There is 6-ft fume hood with explosion-proof flammables and corrosives storage underneath. The hood is equipped with water supply. There are four stainless steel sinks and five rows of bench stations for students. Along the back wall is where the incubators, drying oven, biosafety cabinet, and autoclave sterilizer are located. The current laboratory is adequate for current and projected instructional and undergraduate teaching/research needs for the near future. Previous needs with respect to

additional rapid response pH meters, optical dissolved oxygen probes, and an additional spectrophotometer were addressed in 2014. The HVAC system was completely upgraded in 2018-2019.

Hydrodynamics Laboratory, EG-157. The Hydrodynamics Laboratory supports the needs of the Department of Civil, Environmental and Geomatics Engineering and the Department of Ocean and Mechanical Engineering. The laboratory is located in EG157 and occupies approximately 1522 ft^2. There is a single door exit and a rolling shutter exit to the outside of the building and double door exit to the inside of the building. There is a sink in the room. There is also a 30-ft × 17-ft loft at the second floor level with access through a spiral staircase. The room has 24-ft of counter space (on top of cabinets and drawers). The laboratory is equipped with two 3-ft × 6-ft storage cabinets. There is access from the laboratory to the wind tunnel housed at the back of the room. The lab houses a state-of-the-art hydraulic bench, wave tank, open channel flow apparatus, wind tunnel, and fluid mechanics experiments. The fluid hydraulics bench demonstration unit was replaced in 2014, which was the most needed item to properly deliver the student outcomes in the CWR 3201C Applied Hydraulics course. The following additions to the laboratory would enhance student learning of basic concepts in the near term:

- Flow Over Weir/Notch Apparatus
- Head Loss Measurement of Pipe System
- Pipe Friction Test
- Reynolds Number Experiment Apparatus
- Pelton Turbine Model
- Validation Model of the Bernoulli Equation

C. Describe additional classroom, teaching laboratory, research laboratory, office, and other space needed to implement and/or maintain the proposed program through Year 5. Include any projected Instruction and Research (I&R) costs of additional space in Table 2 in Appendix A. Do not include costs for new construction because that information should be provided in response to X (E) below.

The current classroom, teaching laboratory, research laboratory, office, and other space are adequate for implementing and/or maintaining the proposed program through Year 5.

D. If a new capital expenditure for instructional or research space is required, indicate where this item appears on the university's fixed capital outlay priority list. Table 2 in Appendix A includes only Instruction and Research (I&R) costs. If non-I&R costs, such as indirect costs affecting libraries and student services, are expected to increase as a result of the program, describe and estimate those expenses in narrative form below. It is expected that high enrollment programs in particular would necessitate increased costs in non-I&R activities.

No new capital expenditure is anticipated. Additional resources, described in Table 4, are needed to support program faculty (and startup funds and office setup funds), staff, travel, office equipment and supplies, promotional and advertising efforts, and specialized laboratory and instructional equipment and software.

E. Describe specialized equipment that is currently available to implement the proposed program through Year 5. Focus primarily on instructional and research requirements.

Existing College staff and resources are available which currently provides strong support for the Environmental Engineering Bachelor's degree program. This support includes:

- Computer technician services through the Technical Services Group (TSG)
- Promotional and advertising support through the College Development
- Assistance with Development and Fundraising activities
- Assistance from the Division of Engineering Student Services and Advising with student recruitment and retention, student counseling and petitions, scholarships, and program K-14 outreach activities
- Assistance from the Division of Engineering Student Services and Advising with career development, undergraduate research opportunities, business and industry relations, co-op and internship activities, and placement upon graduation
- Financial management and accounting services
- Other academic, research, personnel, and community outreach services

Financial support will come from a variety of sources, including:

- Florida Atlantic University. The Office of the Provost has committed the continuing funding required for faculty and staff salaries and benefits, as well as for some operational expenses.
- College Carry-Forward Monies. The College has Carry-Forward monies that will be used for the purchase of instructional equipment and other appropriate program needs.
- Donations from Business and Industry. The Environmental Engineering program is generating unprecedented offers of help and financial support.
- Private Contributions. Once the program has been approved, an extensive program of development and fundraising for support of the program will be implemented. Some private contributions for program support are already in the works.
- Contributions in Kind. There are endless opportunities for business and industry to support the program through in-kind contributions. Possibilities include use of equipment and/or facilities; provision of speakers and student mentors; the contribution of design problems; provision of summer employment and consulting opportunities for faculty; internships, part-time employment, and scholarships for students; etc.

The following tables (Table X-2, Table X-3, and Table X-4) include lists of equipment available to deliver the student outcomes of the proposed environmental engineering degree program.

Table X-2. Environmental Engineering Laboratory Existing Equipment

Equipment	Quantity
Bench space, total	40 ft^2
Glassware cabinets	3
Fume hoods, 4 ft × 3.2 ft	3
Custom Bioassay System	1
Biosafety Cabinet, Labconco Purifier Delta Class II, Type A2	1
Chemical Oxygen Demand Heating Block	2
Chromatographic Ion analyzer, Waters	1
Compact Autoclave Sterilizer, NAPCO Model 9000D	1
Composite Sampler, Masterflex E/S	1
Digital Incubator, VWR Model 1525	2
Digital Incubator, VWR Model 1545	1
Digital Mass Balances	2
DR5000 Digital UV-Vis Spectrophotometer	1

Drying Oven, VWR Model 135FM Horizontal Air-Flow	1
Drying Oven, Cole Parmer	1
Filtration Apparatus (vacuum pump, filter holders, manifold)	1
Fluorometer, Ocean Optics	1
High Performance Liquid Chromatography Unit (Waters Breeze System)	1
IDEXX Colilert and Enterolert Quantitation System	1
Ion Specific Probes (nitrate, ammonia, sodium, fluoride)	4
Ion Specific Meters	2
Jar Testing System	1
Koch Membrane Demofilter Unit	1
Large Scale Autoclave Sterilizer	1
Landtec GEM5000+ Air Analyzer	1
Muffle Furnace, Barnstead Type 1400	1
Photoreactor (safety cabinet, microscale reactor, pilot unit; 5-,15-,550-W lamps)	1
Falling Film Pilot Plant Photocatalytic Reactor	1
Portable Turbidity Meters	2
Refrigerated Centrifuge	1
Refrigerator/Freezer	4
Research Vessel, "Minnow", 9.4 ft WaterTender	1
Reverse Osmosis pilot plant	1
Total Organic Carbon Analyzer (Teledyne Tekmar, Apollo unit, with Total Nitrogen, Soil Sampler)	1
Water Purification (Barnstead Diamond UV system, replacement cartridges)	1
Portable Weather Station	3
VWR Circulating Chiller	1
VWR Circulating Water Bath	1
Membrane Skid for RO applications	1
YSI 556 MPS Portable Meter	2
YSI 9000 Photometer	1

Table X-3. Engineering Chemistry Laboratory Existing Equipment

Equipment	Quantity
Compound microscope with a camera attachment	1
BOD Incubator	2
Autoclave Sterilizer	1
Glassware cabinets	3
Fume hood, 6 ft × 3.2 ft	1
Magnetic Stirrer/Hotplate	6
Microbalances	3
DR4000 UV/Vis Spectrophotometer	1
Laboratory Refrigerator/Freezer	1
Distilled Water Machine	1
Ultrasonic Cleaner	1
Gas Law Apparatus Kit	6
BOD Intellical Probe and meter	3

Equipment	Quantity
Carbon dioxide vent probe kit	2
Digital barometer	1
Meter docking station	5
pH probe for HqD meter	2
pH probe for sension2	2
Portable spec meter	1
Molecular model kits	10
sensION2 pH/ISE meter	1
Variable pipetters	18
Turbidometer	2
Dessicator cabinets	2
Biosafety Cabinet, Labconco Purifier Delta Class II, Type A2	1
High capacity drying oven	1
High capacity incubator	1
Filtration Apparatus (vacuum pump, filter holders, manifold)	1
Hach Sension3 pH meters	5
Hach Digital Titrator Field Kits	5
Milton Roy Spectronic 601	1
Spectronic 20, Bausch & Lomb	1
YSI 5010 BOD Probe	1
YSI 5100 DO Meter	5
Vortex Mixers	3
UV Viewing Cabinets	3

Table X-4. Hydrodynamics Laboratory Existing Equipment

Equipment	Quantity
Wind Tunnel (Aerolab 28″x 40″) open circuit low-turbulence wind tunnel	1
Falling Ball Viscometers	5
Fluid Circuit System (for pipe flow experiments) replaced in fall 2014 by a Computer Controlled Fluid Friction in Pipes Unit with Hydraulics Bench with SCADA	1
Scaled Model for Spillway	1
Inclined Manometer	1
Pitot tube	2
U-tube Manometer	1
Large Wave Tank	1
Small Wave Tank	1
Sting Balance (for wind tunnel)	1
Hydrometers	4
Orifice Meter (fluid circuit system)	1
Venturi Meter (fluid circuit system)	1
PIV system (for 3D Stereoscopic particle velocity measurements)	1
Equipment for fluid property measurements	Several
Weighing Scales	5

Equipment	Quantity
Software	
HEC-HMS from USACE	30 computers
HEC-RAS from USACE	30 computers
EPANET from EPA	30 computers

F. Describe additional specialized equipment that will be needed to implement and/or sustain the proposed program through Year 5. Include projected costs of additional equipment in Table 2 in Appendix A.

In terms of additional specialized equipment needed to sustain the program during its growth in the first five years, the main component will involve expanding existing capabilities up to 8 teaching stations for class experiments involving solids filtration, water and wastewater treatment principles, greenhouse effect, mass balance/dilutions, and subsurface contamination as well as creating a new air pollution laboratory. The air pollution lab will need to have instruments for organic and inorganic contaminant characterization, a GC/MS (gas chromatography/mass spectrometry) instrument station for organic contaminants in water and air and soil, an ICP/MS (inductively coupled plasma/mass spectrometry) instrument for trace metals contaminants in water, air, and soil matrices, a meteorological station; clean room; air sampling equipment, gas monitoring equipment, handheld FID/PID, electronic nose, mercury meter, air velocity monitor, calibration gases, air quality meters for particle measurement, ammonia, hydrogen sulfide, carbon monoxide, carbon dioxide, methane, VOCs, etc. A major renovation in 2014-2015 involving EG152C, EG150, EG153, and EG154 added a walk-in temperature controlled room, expanded nutrient analysis facilities, and a much needed separation from the Materials and Structures lab space for EG152C, which was closed off with a 10-ft wall and drop ceiling. A second major renovation project in the same building upgraded the HVAC systems in 2018-2019.

The current Hydrosystems Research Laboratory is adequate for current instructional and research needs. However, only two workstations can fit in the space, so as demand dictates, more space and additional workstations and software licenses may need to be obtained.

The Engineering Chemistry Laboratory is adequate for current instructional and research needs. Previous needs with respect to additional rapid response pH meters, optical dissolved oxygen probes, and an additional spectrophotometer were addressed in 2014.

The shared Hydrodynamics Laboratory space and equipment are barely adequate for current instructional needs. The fluid hydraulics bench demonstration unit was replaced in 2014, which was the most needed item to properly deliver the student outcomes. The following additions to the laboratory would enhance student learning of basic concepts:

- Flow Over Weir/Notch Apparatus
- Head Loss Measurement of Pipe System
- Pipe Friction Test
- Reynolds Number Experiment Apparatus
- Pelton Turbine Model
- Validation Model of Bernoulli Equation

The Environmental Nanotechnology Laboratory is currently being stocked in part with Dr. Yi's startup funds.

To cope with rapid growth in enrollment, a coordinated plan is necessary for meeting the future laboratory needs of the environmental engineering program. A dedicated line of funding for equipment is unlikely in the near future. In the past, the College has been able to set aside varying amounts for equipment purchase and minor renovations for civil engineering laboratories based on prioritized lists of essential items. However, it is difficult to plan for equipment acquisitions when available funds range from very little to several tens of thousands of dollars and may appear on short notice. The faculty and industry council have identified resource development as a top priority in all their recently held bi-annual meetings. Plans are in motion spearheaded by the DAC and Department leadership team ($450K campaign) to solicit laboratory naming sponsorships to assist with equipment acquisition and repair budgets. We expect to develop a cohesive resource development plan that, among other considerations, will include a mechanism for expanding and maintaining our laboratory facilities and equipment in a logical, prioritized manner.

Additional transportation and environmental engineering labs and office space are at Davie and SeaTech campuses.

G. Describe any additional special categories of resources needed to implement the program through Year 5 (access to proprietary research facilities, specialized services, extended travel, etc.). Include projected costs of special resources in Table 2 in Appendix A.

There will be no additional resources needed to implement the program through Year 5.

H. Describe fellowships, scholarships, and graduate assistantships to be allocated to the proposed program through Year 5. Include the projected costs in Table 2 in Appendix A.

The Department currently supports 14 graduate assistantships for full-time students. It has a history of supporting graduate research assistantships (GRA) through research contracts and grants. Funding for four additional GRA's positions would come from sponsored research in Year 1 ($68,000). By Year 5, ten more GRA's compared to the current level will be supported by sponsored research based on the projected full-time enrollment ($170,000). More details are found in Section III-A.

I. Describe currently available sites for internship and practicum experiences, if appropriate to the program. Describe plans to seek additional sites in Years 1 through 5.

The College of Engineering and Computer Science strongly advocates professional work experience for all of its students prior to graduation. Many students in the College accomplish this by working part time or full time during their studies. Others accomplish this goal by internships, many of which are made through the College's extensive database of over 500 companies that offer internship opportunities and regularly hire FAU graduates. The Division of Engineering Student Services assists students in identifying internships opportunities and works closely with the FAU Career Development Center. A team member from the Career Development Center is embedded in the Division and is charged with constantly maintaining and expanding the list of available internships through a portal known as Handshake. An existing course (EGN5940 – Graduate Internship 1-3 credits) is available for this purpose.

Starting with the current Department Advisory Board for the Department of Civil, Environmental & Geomatics Engineering, members with ties to the transportation and environmental engineering

fields will be approached to identify opportunities within their firms and sphere of influence. After year one, a program-specific industry advisory council will be formed and will have one of its three standing subcommittees to focus on developing internships opportunities. A tracking system will be put in place to monitor success and student outcomes for continuous improvement purposes, and the program will be assessed annually.

This academic program takes advantage of a unique curriculum to reduce time to degree completion, increase completion rates, and make better use of limited funding by aligning doctoral research with student career opportunities and on-the-job training. It relies on strong partnerships among the university, government entities, industry and the agencies that hire doctoral graduates. Streamlining the pipeline to graduation will improve research productivity and build the talent needed to sustain innovation in the public and private sector to bring about economic prosperity, public health and national security (National Research Council, 2012). Furthermore, if trainees are directly working with employers (businesses, government agencies, nonprofits, etc.) that hire graduates from doctoral programs, those entities can engage with the research institution to provide internships, student projects, mentoring, Ph.D. committee advising with a courtesy graduate appointment, joint authorship on publications, and real-time, hands-on, job training opportunities that lead to full time employment after graduation as well as long lasting research collaborations between academia and industry.

It is a unique feature of this doctoral degree program that dissertation committees consist of academic and qualified industry co-supervisors. Unlike conventional graduate programs, the industry dissertation co-supervisors are directly involved in curriculum development and guided off-campus internships designed to develop technical, entrepreneurial, and executive leadership skills directly leading to industry sponsored post-doctoral employment opportunities. The student interns spend a significant amount of their residency working directly at the industry/government partner site. As a result, students are able to not only pursue high-level academic research, but also potentially join the workforce immediately upon graduation or sooner.

Florida Atlantic University's recent NRT-HDR proposal entitled: "Towards a Data-Driven Nation: Investigative Development of Interdisciplinary Data Science and Engineering" was used to develop the first doctoral internship relationships with industry. The NSF Research Traineeship (NRT) program is designed to encourage implementation of a bold, potentially transformative STEM graduate education training model. FAU proposes to enlist partner agencies in the community that potentially hire graduates from research-based master's and doctoral degree programs to help shape the direction of the research applications. As part of the program, a research trainee internship was developed in which graduate student interns will obtain the skills, knowledge, and competencies needed to pursue a range of STEM careers in the agencies that hire graduates with advanced degrees in engineering. FAU has put together a consortium of strategic collaborations with the private sector, government agencies, federal laboratories, and academic partners to provide this special opportunity for their graduate students.

Currently established internship programs and partnerships in development include the following agencies (letters of support are found in Appendix C):

- National Oceanic and Atmospheric Administration (NOAA)
- Florida Department of Transportation
- Florida Department of Environmental Protection
- Florida Department of Health
- FEMA

- Fermilab
- USGS
- US Coast Guard
- FPL
- US Fish and Wildlife
- Centers for Disease Control
- Geosyntec Consultants
- Water Management Districts

APPENDIX A. TABLES 1-4

TABLE 1-B
PROJECTED HEADCOUNT FROM POTENTIAL SOURCES
(Graduate Degree Program)

Source of Students (Non-duplicated headcount in any given year)*	Year 1		Year 2		Year 3		Year 4		Year 5	
	HC	FTE	HC	FTE	HC	FTE	HC	FTE	HC	FTE
Individuals drawn from agencies/industries in your service area (e.g., older returning students)	3	1	3	1	3	1	3	1	3	1
Students who transfer from other graduate programs within the university**	7	6	0	0	0	0	0	0	0	0
Individuals who have recently graduated from preceding degree programs at this university	2	1	2	1	3	2	3	2	4	2
Individuals who graduated from preceding degree programs at other Florida public universities	0	0	0	0	0	0	0	0	0	0
Individuals who graduated from preceding degree programs at non-public Florida institutions	0	0	0	0	0	0	0	0	0	0
Additional in-state residents***	0	0	0	0	0	0	0	0	0	0
Additional out-of-state residents***	0	0	0	0	1	1	1	1	2	2
Additional foreign residents***	2	2	3	3	3	3	4	4	4	4
Headcount of contitued enrollments from the previous year	0	0	10	8	13	10	18	14	22	17
Totals	**14**	**10**	**18**	**13**	**23**	**17**	**29**	**22**	**35**	**26**

* List projected annual headcount of students enrolled in the degree program. List projected yearly cumulative ENROLLMENTS instead of admissions.
** If numbers appear in this category, they should go DOWN in later years.
*** Do not include individuals counted in any PRIOR category in a given COLUMN.

TABLE 2
PROJECTED COSTS AND FUNDING SOURCES

Instruction & Research Costs (non-cumulative)	Year 1								Year 5						
	Funding Source							Subtotal coulumns 1+...+7	Funding Source						Subtotal coulumns 9+...+ 14
	Reallocated Base* (E&G)	Enrollment Growth (E&G)	New Recurring (E&G)	New Non-Recurring (E&G)	Contracts & Grants (C&G)	Philanthropy Endowments	Enterprise Auxiliary Funds		Continuing Base** (E&G)	New Enrollment Growth (E&G)	Other*** (E&G)	Contracts & Grants (C&G)	Philanthropy Endowments	Enterprise Auxiliary Funds	
Columns	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Faculty Salaries and Benefits	130,681	0	0	0	0	0	0	**$130,681**	298,578	0	0	0	0	0	**$298,578**
A & P Salaries and Benefits	19,635	0	0	0	0	0	0	**$19,635**	35,342	0	0	0	0	0	**$35,342**
USPS Salaries and Benefits	0	0	0	0	0	0	0	**$0**	0	0	0	0	0	0	**$0**
Other Personal Services	0	0	0	0	0	0	0	**$0**	0	0	0	0	0	0	**$0**
Assistantships & Fellowships	68,000	0	0	0	68,000	0	0	**$136,000**	170,000	0	0	170,000	0	0	**$340,000**
Library	0	0	0	0	0	0	0	**$0**	0	0	0	0	0	0	**$0**
Expenses	7,600	0	0	0	0	0	0	**$7,600**	12,450	0	0	0	0	0	**$12,450**
Operating Capital Outlay	0	0	0	0	0	0	0	**$0**	0	0	0	0	0	0	**$0**
Special Categories	0	0	0	0	0	0	0	**$0**	0	0	0	0	0	0	**$0**
Total Costs	**$225,916**	**$0**	**$0**	**$0**	**$68,000**	$0	**$0**	**$293,916**	**$516,370**	**$0**	**$0**	**$170,000**	$0	**$0**	**$686,370**

*Identify reallocation sources in Table 3.
**Includes recurring E&G funded costs ("reallocated base," "enrollment growth," and "new recurring") from Years 1-4 that continue into Year 5.
***Identify if non-recurring.

Faculty and Staff Summary

Total Positions	Year 1	Year 5
Faculty (person-years)	0.69	1.44
A & P (FTE)	0.25	0.45
USPS (FTE)	0	0

Calculated Cost per Student FTE

	Year 1	Year 5
Total E&G Funding	$225,916	$516,370
Annual Student FTE	10	26
E&G Cost per FTE	$22,592	$19,860

TABLE 3
ANTICIPATED REALLOCATION OF EDUCATION & GENERAL FUNDS*

Program and/or E&G account from which current funds will be reallocated during Year 1	Base before reallocation	Amount to be reallocated	Base after reallocation
TAG000277 Civil Engineering	2,432,893	225,916	**$2,206,977**
Totals	$2,432,893	$225,916	**$2,206,977**

TABLE 4
ANTICIPATED FACULTY PARTICIPATION

Faculty Code	Faculty Name or "New Hire" Highest Degree Held Academic Discipline or Speciality	Rank	Contract Status	Initial Date for Participation in Program	Mos. Contract Year 1	FTE Year 1	% Effort for Prg. Year 1	PY Year 1	Mos. Contract Year 5	FTE Year 5	% Effort for Prg. Year 5	PY Year 5
A	Madasamy Arockiasamy, Ph.D. Structural Engineering	Professor	T	Fall 2020	9	0.75	0.05	0.04	9	0.75	0.15	0.11
A	Fred Bloetscher, Ph.D. Environmental & Water Resources	Professor	T	Fall 2020	10	0.83	0.02	0.02	10	0.83	0.05	0.04
A	Jinwoo Jang, Ph.D. Structural Engineering	Assistant Prof.	TE	Fall 2020	9	0.75	0.02	0.02	9	0.75	0.05	0.04
A	Evangelos Kaisar, Ph.D. Transportation Engineering	Professor	T	Fall 2020	9	0.75	0.10	0.08	9	0.75	0.15	0.11
A	Daniel Meeroff, Ph.D. Environmental Engineering	Professor	T	Fall 2020	9	0.75	0.10	0.08	9	0.75	0.15	0.11
A	Sudhagar Nagarajan, Ph.D. Geomatics Engineering	Assistant Prof.	TE	Fall 2020	9	0.75	0.05	0.04	9	0.75	0.10	0.08
A	Barry Rosson, Ph.D. Structural Engineering	Professor	T	Fall 2020	9	0.75	0.02	0.02	9	0.75	0.05	0.04
A	Panagiotis Scarlatos, Ph.D. Environmental & Water Resources	Professor	T	Fall 2020	9	0.75	0.02	0.02	9	0.75	0.05	0.04
A	Khaled Sobhan, Ph.D. Geotechnical Engineering	Professor	T	Fall 2020	12	1.00	0.02	0.05	9	0.75	0.05	0.04
A	Aleksandar Stevanovic, Ph.D. Transportation Engineering	Assoc. Prof.	T	Fall 2020	9	0.75	0.10	0.08	9	0.75	0.15	0.11
A	Hongbo Su, Ph.D. Geomatics Engineering	Assistant Prof.	TE	Fall 2020	9	0.75	0.05	0.04	9	0.75	0.10	0.08
A	Ramesh Teegavarapu, Ph.D. Water Resources	Professor	T	Fall 2020	9	0.75	0.10	0.08	9	0.75	0.15	0.11
A	James VanZwiten, Ph.D. Energy Sustainability	Res. Assi. Prof.	MYA	Fall 2020	9	0.75	0.00	0.00	9	0.75	0.05	0.04
A	Peng Yi, Ph.D. Environmental Engineering	Assistant Prof.	TE	Fall 2020	9	0.75	0.10	0.08	9	0.75	0.15	0.11
A	Yan Yong, Ph.D. Structural Engineering	Professor	T	Fall 2020	12	1.00	0.02	0.02	12	1.00	0.05	0.05
B	New Hire, Ph.D. Environmental Engineering	Assistant Prof.	TE	Fall 2020	9	0.75	0.05	0.04	9	0.75	0.10	0.08
B	New Hire, Ph.D. Transportation Engineering	Assistant Prof.	TE	Fall 2020	9	0.75	0.05	0.04	9	0.75	0.10	0.08
C	New Hire, Ph.D. Structural/Geotechnical Eng	Assistant Prof.	TE	Fall 2021	0	0.00	0.00	0.00	9	0.75	0.15	0.11
C	New Hire, Ph.D. Transportation/Environmental	Assistant Prof.	TE	Fall 2023	0	0.00	0.00	0.00	9	0.75	0.10	0.08
A	Eric Dumbaugh, Ph.D. Urban Planning	Assoc. Prof.	T	Fall 2020	9	0.75	0.00	0.00	9	0.75	0.00	0.00
A	Dale Gawlik, Ph.D Biological Sciences	Professor	T	Fall 2020	9	0.75	0.00	0.00	9	0.75	0.00	0.00
A	Louis Merlin, Ph.D. Urban planning	Assistant Prof.	TE	Fall 2020	9	0.75	0.00	0.00	9	0.75	0.00	0.00
A	Diana Mitsova, Ph.D. Urban Planning	Assoc. Prof.	T	Fall 2020	9	0.75	0.00	0.00	9	0.75	0.00	0.00
A	Colin Polsky, Ph.D. Environmental Science	Professor	T	Fall 2020	9	0.75	0.00	0.00	9	0.75	0.00	0.00
A	John Renne, Ph.D. Urban Planning	Assoc. Prof.	T	Fall 2020	9	0.75	0.00	0.00	9	0.75	0.00	0.00
A	Tera Root, Ph.D. Geosciences	Assoc. Prof.	T	Fall 2020	9	0.75	0.00	0.00	9	0.75	0.00	0.00
A	Zhixiao Xie, Ph.D. Geosciences	Professor	T	Fall 2020	12	1.00	0.00	0.00	12	1.00	0.00	0.00
	Total Person-Years (PY)							**0.69**				**1.44**

Faculty Code			PY Workload by Budget Classsification Year 1	Year 5
		Source of Funding		
A	Existing faculty on a regular line	Current Education & General Revenue	0.53	0.88
B	New faculty to be hired on a vacant line	Current Education & General Revenue	0.16	0.30
C	New faculty to be hired on a new line	New Education & General Revenue	0.00	0.26
D	Existing faculty hired on contracts/grants	Contracts/Grants	0.00	0.00
E	New faculty to be hired on contracts/grants	Contracts/Grants	0.00	0.00
		Overall Totals for **Year 1**	**0.69**	**Year 5** **1.44**

APPENDIX B. SIGNATURE PAGE

APPENDIX B

Please include the signature of the Equal Opportunity Officer and the Library Director.

Signature of Equal Opportunity Officer — Date: 3/20/19

Signature of Library Director — Date: 3/15/19

This appendix was created to facilitate the collection of signatures in support of the proposal. Signatures in this section illustrate that the Equal Opportunity Officer has reviewed section II.E of the proposal and the Library Director has reviewed sections X.A and X.B.

FLORIDA ATLANTIC UNIVERSITY

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May 12, 2020

TO: Traki Taylor, Assistant Vice Chancellor of Academic Affairs, Florida Board of Governors

FROM: Russ Ivy, Senior Associate Provost, Florida Atlantic University Russ Ivy

RE: Revised Proposal of Ph.D. in Transportation and Environmental Engineering

Please find attached FAU's revised submission of the proposal for a Ph.D. in Transportation and Environmental Engineering. Below is a summary of the changes made to the document in response to the comments from BOG staff in a letter from Dr. England dated, May 5, 2020.

Substantive Issues:

1) Section II.A of the proposal has been expanded to address the deficiency of the CIP-SOC analysis in strongly showing labor demand for graduates of the proposed degree. The degree proposal in question is of course a doctoral program in an emerging interdisciplinary STEM field—which is one of the most challenging areas to show non-higher ed teaching demand in the traditional CIP-SOC approach. We have added letters of support from employers in South Florida who not only express interest in the degree program, but also indicate a need for such employees at their own agency/company. This is combined with several job ads in areas where these graduates would be competitive. There are job ads included that specifically mention a Ph.D. or a masters with several years of experience where a Ph.D would substitute/equate for some of that required experience. We have additionally added stories from recent headlines about disasters/problems where graduates of this program could clearly take the lead in solving the complex problems or making sure we are better prepared for these events in the future. We have done this to better explain the need for this level of training in Transport/Environmental engineering.

2) Corrections to Appendix A, Table 2 were not necessary. The narrative (Section III.A) was expanded for greater clarification of the items outlined by BOG staff and thus aid in making the tie between the table and narrative more transparent.

3) Appendix I has been updated to more fully explain the B.S. to Ph.D. admission path. This program will follow the B.S. to Ph.D. path that has been approved by the College of Engineering and Computer Science for all of its doctoral programs. Catalog language from the College for this option has been copied here to add clarity.

Technical Issues:

1) Last paragraph in section IIB was expanded to give more detail about 2 different events where the survey was distributed also describing the audience at the events and the number of survey participants. Copy of the survey is given now in Appendix L.

2) This degree program is not being proposed as market rate or any other program with a differential tuition and fee rate beyond the general rate set for the university. This is spelled out in more detail in section IIIB.

3) This issue was merely a typographical error referencing the wrong Table in Appendix A. That has been corrected in section III.E.

Should anything else be required from us to provide greater clarity to the proposal, please let me know.

cc: Dr. Bret Danilowicz
Dr. Christy England
Mr. Jeremy Hudak
Ms. Lynda Page
Ms. Brittanian Gamble

An Equal Opportunity/Equal Access Institution