To: The Faculty of the College of Engineering
From: The Faculty of the Division of Environmental and Ecological Engineering
Subject: Creation of Degree: Bachelor's of Science in Environmental and Ecological Engineering (BSEEE)

The Faculty of the Division of Environmental and Ecological Engineering (EEE) have approved the creation of the Bachelor's Degree in Environmental and Ecological Engineering (BSEEE). This action is now submitted to the Engineering Faculty with a recommendation for approval.

The degree requirements below will take effect following receipt of all necessary approvals, including those from the College of Engineering faculty, the University Administration, the University Board of Trustees and the Indiana Commission on Higher Education.

Reasons:
The Division of Environmental and Ecological Engineering was created in 2006, in part to provide an administrative and academic home that would support efforts across the College of Engineering related to the environment. As per the College's definition of a Division, EEE is able to act as an independent academic unit and offer academic programs. The Faculty of the EEE believe that it is in the best interests of the College and its undergraduate students to offer a Bachelor's Degree in Environmental and Ecological Engineering.

This degree program has been designed in response to student demand, to job growth in an area of national need, and to similar programs at peer universities.

—*Student Demand:* Since 2008, the EEE has been working with the ABET-accredited Multidisciplinary Engineering (Registrar code: MUEN) Program to offer an EEE plan of study within MUEN. This program has experienced quick growth, with approximately 55 students currently in the program, or having expressed the intent to enter the program upon completing CODO or FYE requirements. Based on growth patterns and comparisons to similar programs at other universities, EEE expects an initial steady state of approximately 40 graduates per year.

—*Job Growth:* The US Bureau of Labor Statistics predicts that the number of Environmental Engineering jobs will grow "much faster than average" with the addition of almost 17,000 jobs (31% increase) over the next decade. The creation of this degree program will position Purdue Engineering students well to meet this need.

—*Similar Programs:* A survey of peer institutions shows that most offer specific BS degrees in Environmental Engineering fields.

The program has been designed to be able to seek ABET accreditation for Environmental Engineering. It has also been designed to provide a significantly different student experience than other environmentally-related undergraduate programs in the College and at Purdue (so that it will integrate well with the existing curricula).

Objectives and Outcomes:

The following will be the objectives and outcomes of the BSEEE Degree program:

Objectives:

Graduates of the EEE Undergraduate program will:

(1) be prepared to assume immediate employment in the fields of environmental and ecological engineering or to continue education in an advanced degree program;

(2) participate fully and ethically in the advancement of the profession within five years of graduation, as measured by one or more of the following:

- achievement of, or significant progress toward, professional licensure
- achievement of, or significant progress toward, an advanced degree
- publication of research results and/or field reports
- advancement to leadership roles within an engineering organization
- professional participation in international engineering activities
- participation with organizations, agencies, or companies who offer solutions to major societal and environmental issues

Outcomes:

Upon graduation, graduates of EEE will show:

(a) an ability to apply knowledge of mathematics, science, and engineering

(b) an ability to design and conduct experiments, as well as to analyze and interpret data

(c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability

(d) an ability to function on multidisciplinary teams

(e) an ability to identify, formulate, and solve engineering problems

(f) an understanding of professional and ethical responsibility

(g) an ability to communicate effectively

(h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context

(i) a recognition of the need for, and an ability to engage in life-long learning

(j) a knowledge of contemporary issues

(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

(l) a knowledge of the roles and responsibilities of public institutions and private organizations pertaining to environmental and ecological engineering

(m) a knowledge of sustainability tools used in all engineering thought, and an ability to use these tools in the design process.

Degree Requirements:
The BSEEE degree program will include a minimum of **128** credit hours[a], including the courses or course options listed below. Minimum GPA requirements include: (a) 2.0 overall; and (b) 2.0 in College of Engineering courses at the 20000-level and above. Course requirements, distributed into topic area, are listed below. In some cases, alternative courses may exist; the Academic Programs Office of EEE maintains a list of approved substitutions.

First-Year Engineering: Students should complete the current first-year engineering requirements. Restrictions: COM 11400 and CHM 11600 (or equivalent) are required, so these courses will need to be taken after FYE if the student chooses a different General Education Elective and/or Science Selective course while in FYE. A maximum of 8 credits of Mathematics from FYE can be counted toward the BSEEE degree.	**typically requires 29-32 credits**
Mathematics: first-year engineering mathematics courses, plus: — MA 26100 — [MA 26200] or [MA 26500 and MA 26600]	**8-10 credits**
Sciences: first-year engineering science courses, plus: — Advanced Chemistry: CHM 22400, CHM 25700, CHM 33300, or BCHM 30700 — Biology: BIOL 12100 — Ecology: BIOL 28600 and [BIOL 48300 or BIOL 58500]	**10-12 credits**
General Education: General Education Electives: 18 credits, following College of Engineering guidelines for General Education. At least one course in economics (e.g., ECON 25100 or ECON 25200) is recommended. At least one course at the intersection of society and the environment is required.[b]	**18 credits**
Engineering Core: Recommended courses or course options are listed. Approved substitutions are given in parentheses.[c] — Statics and Dynamics: [ME 27000 or CE 29700] and [ME 27400 or CE 29800] (approved sub: [AAE 20300 and AAE 20400]) — Thermodynamics/Mass and Energy Balances: ABE 21000 (approved subs: ME 20000, CHE 21100, or MSE 35000) — Hydraulics: [CE 34000 and CE 34300] (approved subs: ME 30900 or [AAE 33300 and AAE 33301]) — Probability and Statistics: IE 23000 (approved subs: CHE 32000, STAT 35000, STAT 51100, IDE 49500 (variable title: statistics))[d]	**16 credits**
Environmental and Ecological Engineering Core: — EEE 25000: Environmental, Ecological, and Engineering Systems — EEE 30000: Environmental and Ecological Systems Modeling — EEE 39000: EEE Professional Practice Seminar — EEE 43000: Industrial Ecology and Life Cycle Analysis — Senior Design: Three credits of EEE 48000; or three credits (total) of EPCS 41100 or EPCS 41200. — CE 35000: Introduction to Environmental Engineering, or ABE 32500: Soil and Water Resources Engineering — CE 35500: Engineering Environmental Sustainability	**20-22 credits**

Electives and Selectives: — EEE Selectives: At least six courses, comprising at least 18 credits from the EEE Selective List, with the following constraints: …at least nine credits must be from the College of Engineering at the 20000+ level; of these, at least three credits must be 40000+.[d] …at least nine credits from a single "EEE Selective Theme" list.[e] …one course focusing on advanced environmental science.[f] …one course classified as including "engineering design"[g] — Technical Electives: two courses, comprising at least five credits.[d,h]	**at least 23 credits**

Footnotes:

[a] Depending on course options, it is possible to complete the list of requirements with fewer than 128 credits; in this case, a student must take additional free elective course or courses to reach the minimum total of 128 credits.

[b] Generally courses in environmental law, environmental policy, environmental history, environmental humanities, or environmental education. A list of accepted courses will be maintained by EEE.

[c] Many of the approved substitutions carry significant pre-requisites. It is likely that students entering EEE from FYE will not be able to take approved substitutions, but they are listed here to facilitate flexibility of students entering EEE from a different professional school after FYE.

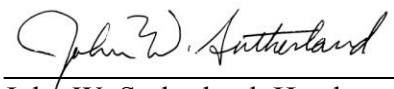
[d] If Statistics course is taken outside of the College of Engineering, one of the two following must be met: either (a) EEE Selectives must include at least 12 credits (rather than the normal requirement of 9 credits) of Engineering at 20000+ level; or (b) Technical Electives must include at least 3 credits of Engineering at 20000+ level.

[e] The EEE Selective List and EEE Selective Theme lists are maintained by EEE. Students may petition the EEE Curriculum Committee to allow EEE-related or environment-related courses not currently on the approved lists.

[f] Advanced environmental science courses are typically 30000+ level courses from the Colleges of Science or Agriculture (likely AGRY, BIOL, EAS, CHM, or FNR). A list of potential courses is maintained by EEE. Students may petition the EEE Curriculum Committee to allow environmental science courses not currently on the approved list.

[g] This requirement may also be met by courses in Technical Electives, or other courses taken that do not satisfy any requirement above. A list of acceptable engineering design courses is maintained by EEE. Students may petition the EEE Curriculum Committee to allow engineering design courses not currently on the approved list.

[h] Technical Electives are defined as any course in a technical field, typically from the Colleges of Engineering, Technology, Science, or Agriculture. ENTR courses are allowed. CGT courses may be particularly appropriate for some students. Remedial courses are not allowed.



John W. Sutherland, Head
Division of Environmental and Ecological Engineering

Supporting Documentation for EFD 38-11:
Degree Requirements for BSEEE
(Bachelors of Science in Environmental and Ecological Engineering)

The extensive supporting documentation provided here includes the following:

In addition, the following planning documents are available on the EEE Intranet. To access, go to:
https://engineering.purdue.edu/Intranet/Groups/Schools/DEEE
These documents are in the right-hand column, titled "Internal documents (restricted)." All faculty and staff of the Purdue College of Engineering should have access; users will need to log in on the left hand side of the screen. These documents will be available at least one year beyond the end of the EFD review and approval process.

1. One-page overview statement for the BSEEE, including mission of the degree and a summary of justification and approach of the degree.
2. Alternative sample plans of study: nine-semester, ten-semester, three-term co-op, four hypothetical students (all electives filled in assuming common student interests).
3. Advisory documents for EEE Selective themes: recommended courses based on typical pre-requisites and regularity of offering.
4. One-page figure with graphical comparison of proposed BSEEE to existing related programs in the Purdue CoE.
5. Planning and implementation timeline, with contingency plans.
6. BSEEE Enrollment goals, 2009-2015 and steady state.
7. Continuous improvement plan: medium-term and long-term planned initiatives and improvements.

Interested people who are unable to access these documents on the Purdue CoE Intranet may contact the EEE Assistant Head, Stephen Hoffmann, at srh@purdue.edu to request access.

Sample Plan of Study:

Recommended or preferred courses are listed below. If substitute options exist, the course number is marked with an asterisk. Students should consult the published degree requirements or the EEE office for approved substitutions, and restrictions and approved course lists for the EEE Selective and Technical Elective courses.

FIRST YEAR

Fall Semester			*Spring Semester*		
ENGR 13100	Ideas to Innovation I	2	ENGR 13200	Ideas to Innovation II	2
MA 16100 / MA 16500	Calculus I	4-5	MA 16200 / MA 16600	Calculus II	4-5
CHM 11500	General Chemistry I	4	CHM 11600	General Chemistry II	4
ENGL 10600	First-Year Composition	4	PHYS 17200	Modern Mechanics	4
			COM 11400	Fund'ls of Speech Comm.	3
		14-15			17-18

SECOND YEAR

Fall Semester			*Spring Semester*		
EEE 25000	Env. Ecol. Eng. Systems.	3	CE 35500	Engr. Env. Sustainability	3
MA 26100	Multivariable Calculus	4	MA 26200*	Linear Alg. + Diff. Eqns.	4
	Advanced Chemistry	3-4	CE 29700 / ME27000	Basic Mechanics I (Statics)	3
	Technical Elective	2-3			
	General Education Elective	3	ABE 21000*	Mat'l and Energy Balance	3
				General Education Elective	3
		15-17			16

THIRD YEAR

Fall Semester			*Spring Semester*		
EEE 30000	Environ. Ecol. Modeling	3	EEE 39000	EEE Professional Preparation	1
CE 35000*	Intro. Environ. Engineering	3	IE 23000*	Statistics	3
CE 29800 / ME27400	Basic Mechanics II	3	CE 34000 and CE 34300*	Hydaulics (+ lab)	4
BIOL 12100*	Biol. I: Div., Ecol., Behav.	2	EEE 43000	Industrial Ecology and LCA	3
	EEE Selective	3	BIOL 28600	Intro. Ecology & Evolution	2
	General Education Elective	3		EEE Selective	3
		17			16

FOURTH YEAR

Fall Semester			*Spring Semester*		
EEE 48000*	EEE Senior Design	1	EEE 48000*	EEE Senior Design	2
	EEE Selective	3		EEE Selective	3
	EEE Selective	3		EEE Selective	3
BIOL 48300 / BIOL 58500	advanced ecology course	3		General Education Elective	3
	General Education Elective	3		General Education Elective	3
	Technical Elective	3			
		17			14

Total Credits Required for Graduation = 128

"Curricular Aspects" of the BSEEE Degree

As part of the curricular planning process, the EEE Curriculum Committee created a list of 36 "curricular aspects" — topics, skills, proficiencies, areas, etc. — that should be included in the major. Several documents from professional societies and accrediting bodies were of great help in the creation of this list, as they list the characteristics of engineering graduates.

These are not official approved outcomes or objectives of the program; they are a preliminary planning tool that was used to make sure that important ideas were not accidentally omitted. To aid in the use of these aspects, they have been tentatively mapped to the official BSEEE Program Outcomes listed in EFD 38-11 — see the right-hand column of Table 1, and also Table 2 at the end of this section. The EEE Faculty and Curriculum Committee intend to assess the attainment of the official program outcomes, not these curricular aspects.

These curricular aspects or student competencies have been organized into three types, and given codes accordingly: Knowledge (K), Skill (S), and Professional (P) outcomes.

The third column lists external documents that include items related to each aspect. Abbreviations for these table include:
—ABET: General ABET accreditation outcome criteria, from 2009-2010 criteria.
—ABET EnvE: specific requirements for Environmental Engineering, from 2009-2010 criteria.
—AAEE BOK = American Academy of Environmental Engineering Body of Knowledge.
—FYE = First Year Engineering requirements
—PE2020 = Purdue Engineer of 2020 Attributes

Table 1: Proposed curricular aspects for the BSEEE Degree

Code	Aspect	Related to (in brackets if partial or implicit, no brackets if explicit)	Mapping to program outcomes
K1	Math proficiency	[ABET 3a], [PE2020], AAEE BOK 1, ABET EnvE 1 (through DiffEq), [FYE]	(a)
K2	Chemistry proficiency	[ABET 3a], [PE2020], AAEE BOK 1, ABET EnvE 1, FYE	(a) and (b)
K3	Calculus-based physics proficiency	[ABET 3a], [PE2020], AAEE BOK 1, ABET EnvE 1, FYE	(a)
K4	Biological science proficiency	AAEE BOK 1, ABET EnvE 1	(a)
K5	Earth science proficiency	AAEE BOK 1, ABET EnvE 1	(a)
K6	Engineering fundamental tools, philosophy, identity	[ABET 3a], [ABET 3e], [PE2020],	(e)
K7	Thermodynamics: mass, energy balancing and conservation	[ABET 3a], [PE2020], AAEE BOK 1, ABET EnvE 1	(a)
K8	Mass transport principles and fluid mechanics	[ABET 3a], [PE2020], AAEE BOK 1, ABET EnvE 1	(a)

Table 1: Proposed curricular aspects for the BSEEE Degree

Code	Aspect	Related to (in brackets if partial or implicit, no brackets if explicit)	Mapping to program outcomes
K9	Engineering materials	[ABET 3a], [PE2020]	(a)
K10	Engineering mechanics: statics and dynamics	[ABET 3a], [PE2020]	(a)
K11	Probability and statistics	ABET EnvE 1	(b)
K12	Sustainability in analysis and design	AAEE BOK 8, ABET 3c?	(m)
K13	"Advanced" knowledge and skills	AAEE BOK 4, ABET EnvE 5	(k)
K14	Societal impact of public policy affecting EnvE issues	ABET 3h, ABET EnvE 6b, PE2020, AAEE BOK 10	(j) and (l)
K15	Understanding of global and contemporary issues	ABET 3j, ABET EnvE 2, AAEE BOK 11	(h) and (j)
K16	Fate and transport of substances in environmental media	AAEE BOK 9	(b) and (e)
K17	Ecology		(a)
K18	Advanced chemistry		(a) and (b)
K19	Systems analysis and thinking		(d) and (m)
K20	Assessment of risks, uncertainty and reliability	AAEE BOK 5	(c) and (e)
S1	Experimental Design; and Data Analysis/Interpretation	ABET 3b, ABET EnvE 3 (specifies "in a focus area"), AAEE BOK 2	(b)
S2	Techniques, skills, and modern engineering tools	ABET 3k, AAEE BOK 3	(c) and (k)
S3	Problem formulation and conceptual analysis, problem solving analytical skills	ABET 3e, AAEE BOK 6, PE2020	(c) and (e)
S4	Design skills and experience	ABET 3c, ABET EnvE 4, AAEE BOK 7, PE2020	(c) and (d)
S5	Entrepreneurship	PE2020	(l)
S6	Ability to work in global/ multicultural environment	PE2020	(d)
S7	Strong work ethic	PE2020	(d) and (i)
S8	Innovation	PE2020	(e)
S9	Use of primary literature		(b), (e), and (k)
P1	Multidisciplinary teamwork	ABET 3d, AAEE BOK 12, PE2020	(d)
P2	Professional ethics	ABET 3f, AAEE BOK 13, PE2020, ABET EnvE 6a	(f)
P3	Effective communication	ABET 3g, AAEE BOK 14, PE2020	(g)

Table 1: Proposed curricular aspects for the BSEEE Degree

Code	Aspect	Related to (in brackets if partial or implicit, no brackets if explicit)	Mapping to program outcomes
P4	Life-long learning	ABET 3i, AAEE BOK 15, PE2020	(i)
P5	Project management	AAEE BOK 16, PE2020	(f)
P6	Business management and public administration	AAEE BOK 17, PE2020	(f) and (l)
P7	Leadership	AAEE BOK 18, PE2020	(f)

Table 2: How these aspects map to the proposed Program Outcomes:

Outcome	Description	Related aspects
(a)	An ability to apply knowledge of mathematics, science, and engineering	K1, K2, K3, K4, K5, K7, K8, K9, K10, K17, K18
(b)	An ability to design and conduct experiments, as well as analyze and interpret data	K2, K11, K16, K18, S1, S9
(c)	An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability	K20, S2, S3, S4
(d)	An ability to function on multidisciplinary teams	K19, S4, S6, S7, P1
(e)	An ability to identify, formulate, and solve engineering problems	K6, K16, K20, S3, S9
(f)	An understanding of professional and ethical responsibility	P2, P5, P6, P7
(g)	An ability to communicate effectively	P3
(h)	The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context	K15
(i)	A recognition of the need for, and an ability to engage in life-long learning	S7, P4
(j)	A knowledge of contemporary issues	K14, K15
(k)	An ability to use techniques, skills, and modern engineering tools necessary for engineering practice	K13, S2, S9
(l)	A knowledge of the roles and responsibilities of public institutions and private organizations pertaining to environmental and ecological engineering	K14, S5, P6
(m)	A knowledge of sustainability tools used in engineering thought, and an ability to use these tools in the design process	K12, K19

EEE Selective Themes:

A significant number of credits in the proposed curriculum form the "EEE Selectives." These are necessary due to the breadth of the field of EEE, and the likelihood that students will want to specialize in a particular area within EEE. This structure allows the flexibility to do so.

To ensure both breadth and depth within advanced EEE topics, several rules and restrictions have been placed on the EEE Selective courses:

Rules for EEE Selectives (an individual course may satisfy several of these rules)

a. At least six courses, comprising at least 18 credits, are required.
b. At least nine of the 18 credits must be in the College of Engineering at the 20000-level or above. Of these, at least three credits must be at the 40000-level or above.
c. At least one of the courses must be classified as an "engineering design" course. Participation in the EPICS program or a Global Design Team project (at least three credits and two semesters, excepting "senior design" participation in EPICS or GDT) may satisfy this requirement.
d. At least one course must focus on advanced environmental science from the Colleges of Science or Agriculture (likely from AGRY, BIOL, EAS, CHM, or FNR). A list of potential courses will be available in the EEE office.
e. At least nine credits must come from a single "EEE Selective Theme" list. Current theme lists are maintained in the EEE office.

As per rule (e), students are required to choose a "theme" for at least nine credits of EEE and related courses; this theme would allow them to define an area of specialty within the broad range of the EEE field, and would also require students to gain advanced skills through the progression of a series of related upper-level courses (helping to meet curricular aspect K13).

Within the themes, students may choose to have a disciplinary focus, so that they gain some significant experience with a traditional field of engineering. The initial plan is to structure a small set of themes around current strengths and disciplinary areas of EEE faculty, with a long-term plan (continuous improvement) to add more themes as the Division, its courses, and the number of affiliate faculty, grow to support them.

When the BSEEE is first offered, three themes will be available:

— water, soil, air, and natural resources engineering
— energy systems and energy conservation engineering
— urban systems and sustainability engineering

The initial course lists for each theme will include:

Water, soil, air, and natural resources engineering

ABE 32500: Soil and Water Resources Engineering*
ABE 48500: Agricultural Engineering Design
ABE 52200: Ecohydrology

ABE 59100 (variable title): Nonpoint Source Pollution Engineering
AGRY 33700: Environmental Hydrology
CE 35000: Introduction to Environmental Engineering*
CE 35200: Biological Processes of Environmental Engineering
CE 35300: Physico-Chemical Processes of Environmental Engineering
CE 44000: Urban Hydraulics
CE 45600: Water and Wastewater Treatment
CE 45700: Air Pollution Control and Design
CE 55000: Physico-chemical Processes of Environmental Engineering
CE 55900: Water Quality Modeling
CE 59700 (variable title): Water Resources Sustainability
CE 59700 (variable title): Water Chemistry

*Note ABE 32500 and CE 35000 are a required option – if a student takes both courses, the second can count as an EEE Selective within this theme.

Energy systems and energy conservation engineering

ABE 58000: Process Engineering of Renewal Resources
CHE 59700 (variable title): Advanced Solar Energy Conversion
CE 59700 (variable title): Global Sustainable Engineering
CE 59700 (variable title): Building Energy Audits
EAS 37500: Great Issues: Fossil Fuels, Energy, and Society
EEE 5xxxx: Alternative Energy Systems (course in development)
EEE/ME 4xxxx: Environmental Impacts of Alternative Energy (course in development)
ME 49700 (variable title): Energy in a Global Context
ME 52500: Combustion
ME 59700 (variable title): Fundamentals of Wind Engineering
ME 59700 (variable title): Solar Energy
ME 59700 (variable title): Sustainable Energy Options and Analysis
MET 42200: Power Plants and Energy Conversion
NUCL 30000: Nuclear Structure and Radiation
NUCL 47000: Fuel Cell Engineering
NUCL 50300: Radioactive Waste Management

Urban systems and sustainability engineering

AGRY/FNR 59800 (variable title): Ecological Footprints: Designing a Community Tool for Sustainable Living
CE 3xxxx: Introduction to Architectural Engineering
CE 44000: Urban Hydraulics
CE 51200: The Comprehensive Urban Planning Process
CE 59700 (variable title): Global Sustainable Engineering
CE/EEE 5xxxx: Critical Urban Infrastructure Systems (course in development)
ME 59700 (variable title): Indoor Environmental Analysis and Design

Several of these courses have significant pre-requisites or a limited frequency of offering that may make them difficult to take for some students. An advising document showing recommendations of courses with reasonable pre-requisite requirements and a regular offering schedule is available in the EEE office, and is included on the EEE Intranet site accompanying this proposal.

Initial approved elective and selective course lists

For several elective and selective requirements, lists of acceptable courses will be maintained by the EEE Assistant Head, with approval of changes by the EEE Curriculum Committee. In addition, students will be able to petition the EEE Curriculum Committee to have other courses (including one-time special offerings) count for one of the requirements. These lists are therefore considered incomplete, and it is anticipated that small changes will be made to the lists regularly.

General Education restriction: "course at the intersection of society and the environment"

AGEC 40600: Natural Resources and Environmental Economics
AGEC 41000: Agricultural Policy
AGEC 41500: Community and Resource Development
AGEC 52500: Environmental Policy Analysis
PHIL 55100: Philosophy of the Natural Sciences
POL 22300: Introduction to Environmental Policy
POL 42300: International Environmental Policy
POL 42800: Politics of Regulation
POL 42900: Environmental Law
POL 52300: Environmental Politics and Public Policy
SOC 53300: Environmental Sociology

Complete EEE Selective List

This list includes several sub-lists, each related to the sub-requirements of the EEE Selectives:

— CoE200 = College of Engineering at 200+ level (9 cr. required)
— CoE400 = College of Engineering at 400+ level (3 cr. required)
— Design = Engineering design course (3 cr. required)
— EnvSci = Advanced environmental science (3 cr. required)

EEE Selective List	CoE200	CoE400	Design	EnvSci
ABE 32500: Soil And Water Resource Engineering*	x		x	
ABE 48500: Agricultural Engineering Design	x	x	x	
ABE 52200: Ecohydrology	x	x		
ABE 52700: Computer Models in Env. and Natural Resources	x	x		
ABE 56000: Biosensors: Fundamentals and Applications	x	x		
ABE 58000: Process Engineering Of Renewal Resources	x	x		
ABE 59100: Biomass feedstock systems engineering	x	x		
ABE 59100: Instrumentation and Data Acquisition	x	x		
ABE 59100: Non-point Source Pollution	x	x		
AGRY 33700: Environmental Hydrology				x
AGRY 38500: Environmental Soil Chemistry				x
AGRY 45000: Soil Conservation and Water Management				x
AGRY 53600: Environmental Biophysics				x

EEE Selective List	CoE200	CoE400	Design	EnvSci
AGRY 54000: Soil Chemistry				x
AGRY 54400: Environmental Organic Chemistry				x
AGRY 54500: Remote Sensing of Land Resources				x
AGRY 56000: Soil Physics				x
AGRY 58000: Soil Microbiology				x
AGRY 58200: Environmental Fate of Pesticides				x
AGRY 58500: Soils and Land Use				x
AGRY 59800: Ecological Footprints				
ASM 33600: Environmental Systems Management				
ASM 54000: GIS Applications				x
BIOL 43800: General Microbiology				x
BIOL 48300: Environmental and Conservation Biology*				x
BIOL 54900: Microbial Ecology				x
BIOL 58500: Ecology*				x
BME 52100: Biosensors: Fundamentals and Applications				
CE 35000: Environmental Engineering*	x			
CE 35200: Biological Princ. Of Environmental Engineering	x			
CE 35300: Physico-Chemical Princ. of Environ. Engr.	x		x	
CE 40800: Geographic Information Systems in Engineering	x	x		
CE 44000: Urban Hydraulics	x	x	x	
CE 44300: Introductory Environmental Fluid Mechanics	x	x		
CE 45600: Water and Wastewater Treatment	x	x	x	
CE 45700: Air Pollution Control And Design	x	x	x	
CE 49700: Introduction to Architectural Engineering	x			
CE 51100: GPS surveying	x	x		
CE 54000: Open Channel Hydraulics	x	x		
CE 54100: Design Of Hydraulic Structures	x	x		
CE 54200: Hydrology	x	x		
CE 54300: Coastal Engineering	x	x	x	
CE 54400: Subsurface Hydrology	x	x		
CE 54500: Sediment Transport Engineering	x	x		
CE 54600: Computational River Hydraulics	x	x	x	
CE 54900: Computational Watershed Hydrology	x	x	x	
CE 55000: Physico-Chemical Processes In Environ. Engr.	x	x		
CE 55400: Aquatic Chemistry in Environmental Engineering	x	x		
CE 55500: Microbial Degradation of Pollutants	x	x		
CE 55700: Air Quality Management	x	x		
CE 55900: Water Quality Modeling	x	x		
CE 59300: Environmental Geotechnology	x	x		
CE 59700: Global Sustainable Engineering	x	x	x	
CE 59700: Water Chemistry	x	x		

EEE Selective List	CoE200	CoE400	Design	EnvSci
CE 59700: Water Resources Sustainability	x	x		
CE 59700: Building Energy Audits	x	x		
CE 49700/59700: Critical Urban Infrastructure Systems	x	x	x	
CHE 34800: Chemical Reaction Engineering	x		x	
CHE 54000: Transport Phenomena	x	x		
CHE 59700: Advanced Solar Energy Conversion	x	x		
CHM 48100: Environmental Chemistry				x
CHM 58100: Atmospheric Chemistry				x
CHM 58200: Chemistry of the Earth's Upper Atmosphere				x
EAS 32000: Physics of Climate				x
EAS 37500: Great Issues: Fossil Fuels, Energy, and Society				x
EAS 42000: Global Change Modeling				x
EAS 44000: Geochemistry of Earth Elements				x
EAS 51900: Applications of Analytical Geosciences				x
EAS 52100: Atmospheric Chemistry				x
EAS 52200: Chemistry of the Earth's Upper Atmosphere				x
EAS 58300: Geology of Landfills				x
EAS 58400: Hydrogeology				x
EAS 58500: Hydraulic Analysis of Groundwater Systems				x
EAS 58600: Engineering Geology				x
EAS 58700: Chemical Evolution of Groundwater				x
EAS 58800: Analytical Hydrogeochemistry				x
EAS 58900: Numerical Modeling of Groundwater Systems				x
EAS 59100: Instrumental Methods in Environ. Geochemistry				x
EEE xxxxx: Critical Urban Infrastructure Systems	x	x	x	
EEE xxxxx: Environmental Impacts of Alternative Energy	x	x		
EDCI 50600: Environmental Education				
EPCS xxxxx: Participation in EPICS (min. 3 cr, max 6 cr before Sr. Design, must be environment-related project)			x	
ENTM 46000: Aquatic Entomology				x
FNR 48100: Environmental Interpretation				
FNR 48800: Global Environmental Issues				x
FNR 54000: Wetlands Ecology				x
FNR 54300: Conservation Biology I				x
FNR 54500: Fisheries Management				x
FNR 55800: Digital Remote Sensing and GIS				x
FNR 56400: Environmental Education				
FNR 59800: Human Dimensions in Natural Resources				
FNR 59800: Landscape Ecology GIS				x
HSCI 52600: Principles of Health Physics and Dosimetry				x
HSCI 54500: Advanced Topics in Exposure Assessment				x

EEE Selective List	CoE200	CoE400	Design	EnvSci
HSCI 54700: Environmental Epidemiology				x
HSCI 56000: Toxicology				x
IDE 49500: Manufacture and Assembly	x	x		
MCMP 56000: Toxicology				x
ME 41300: Noise Control of Acoustic Waves	x	x		
ME 41800: Engineering of Environ. Systems and Equipment	x	x		
ME 49200: Technology and Values	x	x		
ME 49700: Energy in a Global Context	x	x		
ME 52500: Combustion	x	x		
ME 59700: Fundamentals of Wind Energy	x	x		
ME 59700: Indoor Environment Analysis and Design	x	x	x	
ME 59700: Sustainable Design and Manufacturing	x	x	x	
ME 59700: Sustainable Energy Options and Analysis	x	x		
ME 59700: Solar Energy				
ME 59700/49700: Environ. Impacts of Alternative Energy	x	x		
MET 42200: Power Plants and Energy Conversion				
MET 49000: Green Manufacturing and Sustainability				
MSE 49700: Manufacture and Assembly	x	x		
MSE 59700: Energy Conversion Materials	x	x		
NRES 38500: Environmental Soil Chemistry				
NRES 45000: Soil Conservation and Water Management				
NUCL 30000: Nuclear Structure and Radiation Interactions	x			
NUCL 40200: Engineering of Nuclear Power Systems	x	x	x	
NUCL 47000: Fuel Cell Engineering				
NUCL 50300: Radioactive Waste Management	x	x		
NUCL 54400: Nuclear Fuel Systems	x	x		

* Courses with an asterisk can count for EEE Selective only if they are not used to satisfy required options.

Course Descriptions for All Required Courses in the Program:

Note that there are at least an additional 41 credits of elective courses.

Mathematics:

MA 16100/16500: **(Plane) Analytic Geometry and Calculus I.** Introduction to differential and integral calculus of one variable, with applications. Conic sections.

MA 16200/16600: **(Plane) Analytic Geometry and Calculus II.** Continuation of MA 161/165. Vectors in two and three dimensions, techniques of integration, infinite series, conic sections, polar coordinates, surfaces in three dimensions.

MA 26100: **Multivariate Calculus.** Planes, lines, and curves in three dimensions. Differential calculus of several variables; multiple integrals. Introduction to vector calculus.

MA 26200 (option): **Linear Algebra and Differential Equations.** Linear algebra, elements of differential equations.

MA 26500/26600 (option): **Linear Algebra (and) Ordinary Differential Equations.** Introduction to linear algebra. Systems of linear equations, matrix algebra, vector spaces, determinants, eigenvalues and eigenvectors, diagonalization of matrices, applications. **(and)** First order equations, second and n'th order linear equations, series solutions, solution by Laplace transform, systems of linear equations.

Sciences:

BCHM 30700 (option): **Biochemistry.** Introduction to the chemistry, function, and metabolism of compounds found in the living organism.

BIOL 12100: **Biology I: Diversity, Ecology, and Behavior.** Creates a framework for ordering biology by examining the unity and diversity of life on earth with an emphasis on ecology, genetics, population biology, evolution, and behavior.

BIOL 28600: **Introduction to Ecology and Evolution.** Evolutionary processes and ecological principles associated with individuals, populations, communities, and ecosystems. Topics include genetic drift, natural selection, adaptation, life tables, population dynamics, competition, predation, biodiversity, and ecological stability, with emphasis on natural systems.

BIOL 48300 (option): **Environmental and Conservation Biology.** Concerned with the application of ecological principles to environmental issues, the course introduces fundamental ecology, emphasizing the interplay of theoretical models, natural history, and experimentation. New research developments are stressed, with the outlook for application to environmental management and restoration. Whole-biosphere issues, such as the loss of biological diversity, frame a focus at the population level to understand local and global extinction and community stability. In-depth case studies of endangered ecosystems (both temperate and tropical), with computer modeling, field trips, and discussions of policy formulation, demonstrate the range of tools and information necessary to accomplish coexistence of humans with the rest of nature.

BIOL 58500 (option): **Ecology.** Ecological processes and dynamics of populations, communities, and ecosystems; physical, physiological, behavioral, and population genetic factors regulating population and community structure; case studies; field studies, and simulation models of life history attributes, competition, predation, parasitism, and mutualism.

CHM 11500/11600: **General Chemistry.** Stoichiometry; atomic structure; periodic properties; ionic and covalent bonding; molecular geometry; gases, liquids, and solids; crystal structure; thermochemistry; descriptive chemistry of metals and non-metals. (and) Solutions; quantitative equilibria in aqueous solution; introductory thermodynamics; oxidation-reduction and electrochemistry; chemical kinetics; qualitative analysis; further descriptive chemistry of metals and nonmetals.

CHM 22400 (option): **Introductory Quantitative Analysis.** Introduction to titrimetric, gravimetric, and instrumental methods of analysis.

CHM 25700 (option): **Organic Chemistry.** Introductory organic chemistry. Emphasis is on structure, nomenclature, reactions, and theory as applied to simple organic compounds.

CHM 33300 (option): **Principles of Biochemistry.** Structure and function of biologically important molecules.

PHYS 17200: **Modern Mechanics.** Introductory calculus-based physics course using fundamental interactions between atoms to describe Newtonian mechanics, conservation laws, energy quantization, entropy, the kinetic theory of gases, and related topics in mechanics and thermodynamics. Emphasis is on using only a few fundamental principles to describe physical phenomena extending from nuclei to galaxies. 3-D graphical simulations and numerical problem solving by computer are employed by the student from the very beginning.

Humanities, Social Sciences, and Communication:

ENGL 10600: **First Year Composition.** Extensive practice in writing clear and effective prose. Instruction in organization, audience, style, and research-based writing.

COM 11400: **Fundamentals of Speech Communication.** A study of communication theories as applied to speech; practical communicative experiences ranging from interpersonal communication and small group process through problem identification and solution in discussion to informative and persuasive speaking in standard speaker-audience situations.

Engineering Core:

ABE 21000: **Biological Applications of Material and Energy Balances.** Applications of material and energy balances to biological and engineering systems; development of a framework for the analysis of biological systems from an engineering perspective. Introduction to applications of the first and second laws of thermodynamics to biological and mechanical engineering systems. Topics include refrigeration systems, power cycles, energy conversion systems, and environmental impacts of energy production.

CE 29700 (option): **Basic Mechanics I (Statics).** Statics of particles. Rigid bodies: equivalent systems of forces, equilibrium. Centroids and centers of gravity. Static analysis of trusses, frames, and machines. Friction. Area moments of inertia.

CE 29800 (option): **Basic Mechanics II (Dynamics).** Kinematics of particles. Kinetics of particles and systems of particles. Kinematics of rigid bodies. Mass moments of inertia. Kinetics of rigid bodies. Mechanical vibrations.

CE 34000: **Hydraulics.** Fluid properties; hydrostatics; kinematics and dynamics of fluid flows; conservation of mass, energy, and momentum; flows in pipes and open channels. Formal laboratory experiments.

CE 34300: **Elementary Hydraulics Laboratory.** The laboratory covers basic concepts in analysis of experimental data and methods in hydraulic measurements. A variety of simple laboratory experiments illustrating the principles of hydraulics are performed.

ENGR 13100: **Transforming Ideas to Innovation I.** A partnership between Schools and Programs within the College of Engineering, introduces students to the engineering professions using multidisciplinary, societally relevant content. Developing engineering approaches to systems, generating and exploring creative ideas, and use of quantitative methods to support design decisions. Explicit model-development activities (engineering eliciting activities, EEAs) engage students in innovative thinking across the engineering disciplines at Purdue. Experiencing the process of design and analysis in engineering including how to work effectively in teams. Developing skills in project management, engineering fundamentals, oral and graphical communication, logical thinking, and modern engineering tools (e.g., Excel and MATLAB).

ENGR 13200: **Transforming Ideas to Innovation II.** A partnership between Schools and Programs within the College of Engineering continues building on the foundation developed in ENGR 13100. Students take a more in depth and holistic approach to integrating multiple disciplines perspectives while constructing innovative engineering solutions to open-ended problems. Extending skills in project management engineering fundamentals, oral and graphical communication, logical thinking, team work, and modern engineering tools (e.g., Excel and MATLAB).

IE 23000: **Probability and Statistics in Engineering I.** An introduction to probability and statistics. Probability and probability distributions. Mathematical expectation. Functions of random variables. Estimation. Applications oriented to engineering problems.

ME 27000 (option): **Basic Mechanics I.** Vector operations, forces and couples, free body diagrams, equilibrium or a particle and of rigid bodies. Friction. Distributed forces. Centers of gravity and centroids. Applications from structural and machine elements, such as bars, trusses, and friction devices. Kinematics and equations of motion of a particle for rectilinear and curvilinear motion.

ME 27400 (option): **Basic Mechanics II.** Review and extension of particle motion to include energy and momentum principles. Planar kinematics of rigid bodies, including equations of motion and principles of energy and momentum. Three-dimensional kinematics and kinetics of rigid bodies. Linear vibrations, with emphasis on single-degree-of-freedom systems.

Environmental and Ecological Engineering Core:

EEE 25000 (proposed): **Environmental, Ecological, and Engineering Systems.** An overview of systems thinking and examples, and applications to environmental, ecological, and engineering systems. Students will develop an understanding of complex and global systems, along with the tools and analysis methods required to deal with them. Basic environmental and ecological science concepts are also included.

EEE 30000: **Environmental and Ecological Systems Modeling.** Introduction to computational methods for describing physical, chemical, and microbiological processes that occur in natural and engineered aqueous systems, including rivers and lakes, and within water and wastewater treatment systems. Emphases on understanding and conceptualizing important processes, data analysis, algorithm development, and competency in the use of programming tools.

EEE 39000 (proposed): **EEE Professional Preparation Seminar.** Seminar lectures and discussion to introduce students to aspects of professional practice within Environmental and Ecological Engineering. Topics include career planning and placement skills, professional responsibility and ethics, functioning as a professional, and other current important topics in the profession. Students will interact with several practicing Environmental and Ecological Engineers.

EEE 43000 (proposed): **Industrial Ecology and Life Cycle Analysis.** The outputs and processes associated with industrial systems are examined, with special emphasis placed on interactions of these systems with environmental and ecological systems, and on computer-based dynamic modeling of these systems. A full product life cycle perspective is stressed, including energy and material flows, processes used to produce materials and realize products, and the management of end-of-life of products.

EEE 48000 (proposed): **EEE Senior Design.** Senior-level environmental and ecological design projects. Projects will integrate knowledge and skills gained earlier in the degree program and stress the application of the design process to interdisciplinary environmental and/or ecological engineering systems. May be repeated for a maximum of three credits.

ABE 32500 (option): **Soil and Water Resource Engineering.** Interrelationships of the plant-water-air-soil system; hydrologic processes; protection of surface and ground water quality; GIS targeting of soil and water protection measures; and design of subsurface and overland drainage systems, irrigation systems, and soil erosion control practices.

CE 35000 (option): **Environmental Engineering.** Introduction to water pollution, air pollution, noise, hazardous and solid wastes, and their control. Environmental impact statements and global pollution issues. Field trips required.

CE 35500: **Engineering Environmental Sustainability.** An introduction to the examination of global-scale resource utilization, food, energy and commodity production, population dynamics, and their ecosystem impacts.

Benchmarking the Proposed Program:

The analysis presented here compares the proposed EEE major program with ten similar programs. The comparison programs were chosen based on the following criteria:

- *Specificity of the degree:* programs of Environmental Engineering (or some very similar title), not Civil and Environmental Engineering are included. Several major peer universities (UC-Berkeley, Illinois, Michigan, Wisconsin, Carnegie Mellon) are not included in this comparison because each university's degree, offered by a Department of Civil and Environmental Engineering, has several traditional components of CE (e.g., course requirements for structures, transportation systems, geotechnical, construction, etc.). Many of these programs lead to degrees of BSCE or BSCEE and are accredited by ABET under the CE rules. These programs are more comparable to the Environmental option in CE at Purdue, and therefore inappropriate for direct comparison to the EEE degree.
- *ABET Accreditation:* all programs included are accredited by ABET, under the Environmental Engineering rules (in some cases, the awarded degree is BSCE, but the options within the degree program make it eligible for ABET under EnvEng rules.)
- *Program reputation:* most of the comparison programs are similar or higher in the *US News* rankings as Purdue Environmental Engineering.
- *Focus:* programs with an unusual focus that does not translate well to Purdue's context (e.g., Penn State's Environmental Systems Engineering program within the College of Earth and Mineral Sciences) were not included.

The comparison programs are:

University	Degree Name	ABET in EnvEng	Top 10 EnvEng
Cal Poly – San Luis Obispo	BSEnvEng	yes	
Cornell	BSEnvEng	yes	yes
Georgia Tech	BSEnvEng	yes	yes
Johns Hopkins	BSEnvEng	yes	yes
MIT	BSCE	yes	yes
North Carolina State	BSEnvEng	yes	
Northwestern	BSEnvEng	yes	
Ohio State	BSCE	yes	
Oregon State	BSEnvEng	yes	
Stanford	BSEnvEng	yes	yes

The table on the next page shows the number of courses required in each of the programs for each topic/field. Note that five of the universities are on a quarter system (shaded light grey and placed on the right part of the table), so they will naturally be about 50% higher in total number of courses. The far right column of the table indicates areas where the proposed Purdue program is distinctive; that is, where the Purdue EEE program does not match the consensus of the ten comparison programs.

Finally, courses required by the other programs but not included in the proposed Purdue EEE program are listed at the bottom.

Table: Comparison of proposed Purdue EEE program with existing peer programs.

		semester system					quarter system					
Courses required in the proposed EEE curriculum	**Purdue EEE**	Cornell	Georgia Tech	Johns Hopkins	MIT	NC State	Cal Poly	Northwestern	Ohio State	Oregon State	Stanford	**Areas of distinction**
Math												
— calculus	**3**	3	3	3	2	3	4	3	4	4	3	
— diff. eqns / linear alg.	**1**	1	1	1	1	1	1	1	1	1	1	
Basic science												
— general chemistry	**2**	2	2	2	1	2	3	3	3	3	2	
— advanced chemistry	**1**		1		1	1	1	1	3	2		
— calculus-based physics	**1**	2	2	2	2	2	3	1	3	3	1	←
— biology (except ecology)	**1**		1	1	1	1						
— ecology	**2**			1	1							←
— earth science	**0**	1	1			1		3		1	2	
— statistics	**1**	1	1	1	S	1	1	1			1	
Core engineering												
— intro to engineering	**2**	1				1		4		1		
— thermodynamics	**1**	S		1		1	2	1		4	1	
— mechanics (statics/dynamics)	**2**		2	1	2	2	2		1	2		
— fluid mechanics/hydraulics	**1**	1	2	1		1	1	2	1	3	2	
— major design experience	**1**		1	1	1	1	1	1	1	1	1	
— professional preparation	**1**	1										←
Required Env/Ecol Eng												
— intro to environ. engineering	**1**	1	1	2		1	1	1	1	1	3	
— systems modeling	**1**						1		1		1	←
— environ. engr. systems	**1**	1	1	1				1		1		
— engineering sustainability	**1**	1			1					1		←
— LCA and industrial ecology	**1**											←
Advanced EEE												
— advanced EEE elective	**6**	8	6	4				4	2		3	
— technical electives	**2**	1	2	4	1	1	3				3	
— advanced EEE specified*					1	4	10	1	1	4	3	
General education												
— humanities and social sciences	**6**	6	6	6	6	6	8	7	9	7	9	
— writing and communication	**2**	2	1			2	3	3	1	4		
— other					1			5				
Common courses not in proposed Purdue BSEEE curriculum:**												
— intro to computers/programming		1		1	S	2	1	1		1	1	
— microbiology		1					1	1	1	1		
— engineering economics			1	1					1	1	1	
— lab/field in environ. engineering			1	1		1		1	1	2		
— water/wastewater				1		2	3	2	3	1	1	
— hydrology				1	1	1				1	1	
— intro to CE/CEE; CE systems			1		1				1		1	

* = the list of these specified courses, for each university, is included on the next page.

** = these course, while not required, are available at Purdue and generally can count toward EEE Selectives.

S = Selective from a short list (usually choose 1 of 2, or choose 2 of 3)

Table continued:
Courses under "advanced EEE specified" for each program:

Cal Poly:
Circuits
Geotech engineering
Noise and vibrations
Air pollution (x3)
Hazardous waste
Solid waste
Pollution prevention
Environmental health

MIT:
Environmental health

Northwestern:
Air and Land Resources

NC State:
Geotech. engineering
GIS
Air pollution
Solid waste

Oregon State:
Soil science
Air pollution
Solid waste
Bioremediation

Stanford:
Air pollution (x2)
Environ. planning methods

Comments on comparisons to established programs:

1. The engineering core of the degree (as per ABET requirements) is largely the same in all programs, including this proposal. This includes math, chemistry, physics, design, statistics, engineering core (thermo, mechanics, fluids, etc), and general education.
2. No other program explicitly includes a course in "professional preparation" (which would explicitly address many of the non-technical skills and competencies). However, we are proposing only a single-credit seminar-type course, which does not place difficult constraints on student schedules and may help us meet and assess non-technical ABET outcomes. Also, a course of this sort has precedent in other programs in the College – e.g., ABE 490, BME 390, IDE 301.
3. Upper-level EEE courses (those which distinguish the EnvEng programs from the other engineering disciplines) follow one of three general approaches for the approximately 10-12 (semester equivalent) courses:
    a. specify all required courses (ex: Oregon State, NC State, Cal Poly)
    b. split in half: specify a core and allow half to electives. Use environmental media (air, water, soil, waste) to structure the core. (ex: Johns Hopkins, Stanford)
    c. split in half: specify a core and allow half to electives. Use a broad systems approach (sustainability, LCA, systems thinking, ecology) to structure the core.

    Purdue EEE is the only program in set c; this is a distinguishing feature of the program.
4. Common courses that Purdue EEE is not requiring – note that students may still take these as part of the EEE selectives, and will be encouraged to take them as appropriate for their interests and career objectives:
    a. an introduction to computer programming
    b. microbiology
    c. engineering economics
    d. a field/lab methods in environmental engineering
    e. an explicit focus on traditional water/wastewater treatment and engineering