

# Multidisciplinary Civil Engineering Education through Environmental Impact Analysis

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## Abstract

The development of civil engineering projects incorporates a broad range of constituents, issues, and regulatory concerns. These issues encompass both traditional engineering topics such as structural engineering and construction management as well as topics often referred to as “soft” topics such as public policy and environmental regulation. Because civil engineering graduates often take jobs with consulting firms or government agencies, understanding the complete spectrum of these topics is becoming an essential requirement for civil engineering professionals. This paper introduces an engineering course developed by the authors entitled “Evaluation of Environmental Impact Statements” that provides students with a multidisciplinary educational experience in the context of environmental assessment. From transportation and construction to hazardous waste and water quality, students are exposed to the environmental, legal, and regulatory requirements associated with civil engineering projects. Finally, the field-oriented course assignment is introduced that emphasizes the examination of regulatory and construction processes throughout the life-cycle of a constructed facility.

## Environmental Analysis Background

Historically, major civil engineering projects have had significant positive and negative impacts on the human environment. Dams, highways, power plants, landfills and other major infrastructure systems provide significant urban environmental benefits. However, these same systems can significantly impact the natural environment in terms of air quality, water quality, and permanent removal of local ecosystems.

Environmental impact assessments have become an integral component of the civil engineering design process since the passage of the National Environmental Policy Act (NEPA) in 1970. Under the current regulatory framework, all major federal projects that have a significant impact on the human environment require the preparation of an environmental impact statement (EIS) by a responsible federal agency. The document must state the need for the project, describe the affected environment, and outline the impacts of the proposed project and the impacts of alternatives to the proposed project (including the no-action alternative).

The actual requirements associated with performing environmental impact assessments are found in a variety of laws, regulations, and supporting documents. Figure 1 illustrates the hierarchy of environmental impact assessment law, regulations, and policy. The underlying legal requirements of NEPA are somewhat vague, requiring that a general statement be prepared and the agency take into consider the impacts on the environment. In 1978, the Council on Environmental Quality issued regulations clarifying the requirements of NEPA and outlining much more detailed contents for EISs. Federal agencies were also required to develop and implement regulations designed to implement NEPA requirements. Each federal agency’s regulations are contained in the Code of Federal Regulations and outline even more specific requirements that must be met by agencies when preparing EISs. Finally, because agency regulations often require supplemental interpretation, each agency intermittently issues clarifying guidance documents. Agency regulations and guidance documents typically require specific actions, EIS content, and impact mitigation requirements that are not required by the underlying law (NEPA).

To prepare adequate environmental impact assessments for major projects, one must identify and understand the

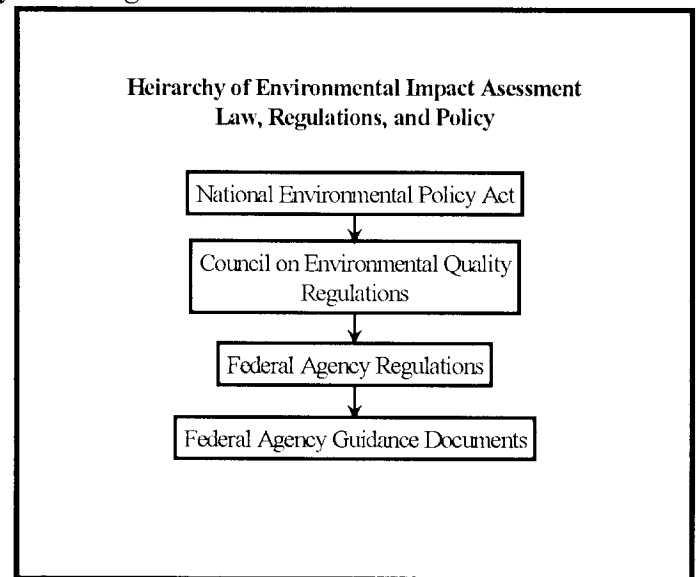


Figure 1: Hierarchy of regulations directing development of Environmental Impact Statements

requirements outlined in all four general sets of legal, regulatory, and policy documents. Because civil engineering graduates often take jobs with consulting firms or government agencies, understanding these environmental requirements is important. Many university programs do not provide courses that emphasize the policy and regulatory aspects of engineering [1]. Hence, there is often a lack of classroom focus on the interpretation of government regulations that guide civil engineering design and construction process.

## **Environmental Impact Project Course**

During the Spring quarter of 1997, the authors developed an engineering course entitled "Evaluation of Environmental Impact Statements" which is designed to take students a large step beyond the basic understanding of environmental assessment. The elective course was open to senior level undergraduate students and graduate students in civil engineering. From transportation and construction to hazardous waste and water quality, students are exposed to the environmental, legal, and regulatory requirements associated with civil engineering projects. Students receive classroom instruction on basic regulatory structure and complete required readings on environmental impact assessment. The course is designed to expose students to the key policy, planning, and modeling issues involved in the environmental impact assessment process that are often considered "soft" topics by traditional civil engineering educators [2, 3]. However, the instructors believe that the most effective learning experience comes from active, independent exploration of the multidisciplinary topics that constitute environmental assessment.

Creating an environment that encourages civil engineering students to examine projects from a multidisciplinary point of view requires educators to provide students with case study examples that prompt discussions on issues that traverse traditional civil engineering divisions [4]. For example, the issue of wetland protection is not limited to environmental, transportation, or construction students, rather the wetland issue is one that exists from project planning through design and finally to construction. The Environmental Impact course provided civil engineering graduate students with the opportunity to examine these multidisciplinary issues through the in-depth analysis of completed environmental impact statements. Students explored the relationships between the law/regulations/policies, analytical work, the final written EIS, and the actual constructed project.

In addition to focusing on topics that exist throughout the project development process, the Environmental Impact course broke from traditional lecture formats to encourage student interaction and discussion. Specifically, the course required students to interact in a discussion format to identify the indirect and direct regulations that define, describe, and influence civil engineering projects. The discussion format required students to present these influences on particular components of selected projects each week. For example, early in the course, the emphasis was placed on examining the regulatory and permitting influences on environmentally sensitive projects such as managing wetland areas and controlling noise. In response, students presented summaries of the National Environmental Policy Act (NEPA), Federal Regulations, and Corps of Engineers jurisdictional determinations that directly governed these operations.

In contrast to traditional lecture formats, this focus on discussions and cases provided opportunities for students to engage in the process of self-discovery and communication that are currently being advocated by national research agencies [5]. Given an introduction to a topic such as NEPA, the students utilized government documents, World Wide Web sites, and Corps of Engineers interviews to supplement traditional textbook authorities. In this way, the students exchanged a broad spectrum of information for each topic covered in the course. Students also focused on interpretation of regulatory language and written agency guidance. The interpretation of these regulatory documents is often a difficult task for students as they wade through legal jargon, professional acronyms, and complex requirements. Assisting students in understanding the impact of regulations and other external project impacts requires a broad range of materials to provide an appropriate case context. Plans, project videotape, written regulations and third-party summaries are required to provide a scope and context from which students can put abstract regulations into the perspective of civil engineering projects.

### **Course Project**

Pedagogical research has demonstrated that the long-term comprehension of topics requires students to be actively involved in the learning process [6]. In contrast to traditional lecture formats, active learning promotes project-based activities to reinforce concepts and knowledge presented in the classroom. This pedagogical research formally set the foundation for the project-based approach adopted within the Environmental Impact course. Specifically, the authors combined this established education theory with their personal belief that students should analyze real projects to augment the classroom experience. In this way, the student viewpoint will not be limited to the idealized world of textbook scenarios. Rather, students will be exposed to the realities of conflicting requirements that arise from regulatory agencies, owners, design teams, and construction processes. Following this philosophy, the course was designed around a field-oriented assignment that emphasized the examination of regulatory and construction processes throughout the life-cycle of a constructed facility. The project required each student to complete the following requirements:

1. Select a facility that required an Environmental Impact Statement to be completed,
2. Select an individual environmental impact concern such as wetlands, noise, or air quality for analysis.
3. Prepare a regulatory checklist that outlines the steps that must be followed to obtain government approval in the selected area,
4. Interview a project participant to obtain the methodology used to prepare the Environmental Assessment (EA) or Environmental Impact Assessment (EIS), and
5. Analyze the EA or EIS, and the actual project if possible, to determine compliance with the regulatory checklist.

### **Select a Facility**

The first component of the course assignment focused upon selecting a facility that incorporated a significant element of environmental concern. Examples of student-selected projects included highway expansions, airport developments, water treatment facilities, and highway interchanges. Each of these cases contained a series of common elements. First, the cases contained unique elements that piqued the interest of the students. Second, the cases contained contextual information that allowed the students and educators to discuss the full scope of the design-construction process. Third, the cases included examples of conflicts that highlighted the reality of the design process. Finally, the cases illustrated the diverse input of internal and external project constituents.

An example of a representative project case is the Wolf Creek Shooting Complex in Atlanta, Georgia. The Wolf Creek site contained several unique elements that made it conducive to an educational field analysis. First, the Wolf Creek site hosted the 1996 Summer Olympics shooting events. This high visibility event ensured that both a significant amount of documentation would be available to compile illustrative materials and that a unique element surrounded the case. Second, the site included several types of wetlands and endangered plants to illustrate the concepts of wetlands and environmentally sensitive construction. Finally, the site incorporated several topological features that provided the opportunity to examine mitigation alternatives to the adopted design.

### **Select an Environmental Concern**

The analysis of an Environmental Impact Statement encompasses a broad range of topics as outlined by Federal, state, and local regulations. In preparation for the Environmental Impact course, the decision was made to have students do an in-depth analysis of a single study element rather than a broad analysis of an entire study. This decision was made to emphasize the detail required to completely address the concerns of any given impact area. As such, the students were assigned to select an individual EIS area for study from each of their selected facilities.

An example of this analysis focus can be taken from the previously described Wolf Creek project. In this project, the wetlands issue was selected as the EIS area of focus. Specifically, the Wolf Creek design required the reclassification and elimination of a stream that ran through the site, as well as the elimination of several acres of silt filtration areas that protected the Wolf Creek basin. Successfully analyzing this topic required a broad range of documents including both pre-design documents such as Corps of Engineers' permitting documents, county correspondence, and design inquiries, and design documents focusing on the drawings and specifications that outlined the proposed project solution. This diversity of influences provided the unique aspect that was desired for the remainder of the course project.

### **Prepare Regulatory Checklists**

The authors set a specific objective to provide students with the practical experience of interpreting government regulations. After selecting a particular focus area, the students were required to take the first step in transforming government regulations into engineering action plans by preparing evaluation checklists. Students were required to translate the NEPA regulations, CEQ regulations, relevant federal agency regulations for implementing NEPA (e.g. Corps of Engineers or Federal Highway Administration) and Federal Agency guidance documents associated with the media of concern into checklists that outline the actions required to obtain project approval. This exercise provided two important learning outcomes; (1) the students learned that the language used in Federal Regulations often requires secondary interpretation from the courts or other regulators, and (2) the students developed an analytical tool through which they could undertake a systematic interdisciplinary analysis of the environmental areas of concern in their selected projects.

### **Interview a Project Participant**

In traditional classroom settings, descriptions of example projects presented to students are often 3-4 people removed from the original project participants. At the minimum, projects presented in the traditional lecture format have passed through interpretation filters by both the textbook author and the professor. While this interpretation is appropriate when a specific project component such as a project schedule or design criterion is being presented, this filtration significantly hinders the understanding of the actual process that was followed to complete the overall facility. Although classroom presentations are adequate for presenting concepts, they cannot substitute for first-hand accounts from project participants for describing the decision making process.

As part of their assignment, students were required to interview an agency or employee or consultant that was directly involved in the project development or assessment process. To obtain first-hand project accounts, students contacted direct and indirect project participants including environmental consultants, Federal Highway Administration personnel, Corps of Engineers personnel, and owner representatives. To illustrate the benefit of this interview process in the context of the Wolf Creek project, the wetland issue can be revisited. Through interviews with Corps of Engineers personnel, the facts of political influence, Olympic pressures, and schedule concerns were put into the context of jurisdictional determination and permit classification. The interview participants provided the students with a broad range of project documentation that described the context, evolution, and individual processes of the project including pre-design documents, design documents, and construction videotape. While these influences do not change the final EIS studied by the students, it does significantly alter the understanding of why the document contained the final wetland analysis and design criteria in the form it appeared. Providing students with this process information does not conveniently fall into any segment of the civil engineering curriculum, however, this process is one of the fundamental components of the civil engineering profession and incorporates knowledge that is essential for future professionals.

### **EIS and Project Analysis**

Similar to the reduction in academic emphasis on regulatory interpretation is a reduction in classroom emphasis on project critiques. The engineering education curriculum is heavily weighted to emphasize design, and in most cases, original designs. This emphasis can be traced to many causes, but one that the authors believe is a primary cause is the compartmentalization of civil engineering education. While it is feasible to develop a design with emphasis on a single engineering topic, the analysis of a completed project requires a broader contextual view. The requirements of the multiple project constituents involved with the completion of a facility are often interwoven during the design-construction process to the point where it is difficult to determine the specific reasons behind individual decisions when looking at the final entity. Successfully analyzing the project requires an understanding of these interwoven requirements and an explicit decision to start the analysis process with a multidisciplinary perspective.

Providing students with this multidisciplinary analysis experience was the stated goal of the EIS analysis segment. The students were required to take the previously developed regulatory checklists and use them as an analytical framework for the completed project. For each element in the checklists, the students were required to identify whether the completed facilities met the requirements for these specifications during the design and construction process. Where the projects were deficient in meeting the regulatory requirements, the students were required to identify why the requirements were not met, the ramifications of the oversight, and the project players that were responsible for the project deficiency. The difficulty in this task is not in the identification of requirements that were not completely satisfied, but rather, lies in analyzing the ramifications of not meeting the requirements. This difficulty arises because the analysis of project results requires students to look at a project from a number of user and environmental perspectives rather than a single civil engineering discipline perspective.

To illustrate the requirement for multidisciplinary analysis, the wetland component of the Wolf Creek case may be examined. As described previously, the Wolf Creek site contained several wetland areas that required the cooperation of design and construction constituents to ensure that the wetlands were preserved. In accordance with the Federal Regulations, the project team conducted an Environmental Assessment that outlined the proposed project solution. A key component of these solutions was the inclusion of tree-save areas to ensure soil stabilization and filtration. However, when completed, the project team eliminated several of these tree-save areas that were considered an integral component of the silt filtration and control plan. The result of this elimination was a significant silt build-up in the Wolf Creek wetlands that was not anticipated during the design process. The reason for this potentially damaging decision is not limited to an individual discipline. Rather, this decision must be viewed in the context of many project participants. The regulatory checklists provided the basis for the students to conduct this broad project analysis and created the foundation on which the students developed the final project reports.

### **Conclusion**

While no single initiative will alter civil engineering education, the current trend toward academic downsizing and continued compartmentalization of disciplines needs to be addressed by engineering educators. This paper has introduced one approach to breaking down the barriers between civil engineering disciplines through the development of a course focusing on multidisciplinary project perspectives. The course has provided students with the opportunity to explore project responsibilities and development from perspectives that do not fall into traditional civil engineering categories. However, the development of this course represents a first step in enhancing the education process. Building upon this small step to develop engineers who are prepared for the multidisciplinary realities of the profession requires acceptance and commitment by a broader range of civil engineering educators.

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