BODY OF KNOWLEDGE
for
WATER RESOURCES ENGINEERING

Defined by Outcomes

The Body of Knowledge (BOK) for water resources engineering is defined by outcomes. The required outcomes are the knowledge, skills, and attitudes necessary to become a certified as a Diplomate, Water Resources Engineer. The required fifteen outcomes are defined without consideration of the specific courses, semesters, cooperative education, pre- and post licensure professional experience, access and delivery systems, and other administrative and logistical aspects of learning and mastering the outcomes. For example, topics listed in the outcomes could appear in more than one course, one course could contain many of the outcomes, and, conceivably, one outcome could encompass an entire course. Similarly, topics listed in the outcomes could have been learned and mastered in a particular project or assignment, one project or assignment could contain many of the outcomes, and one outcome could encompass a series of increasingly difficult and complex projects or assignments.

The required outcomes are consistent with and fulfill the intent of ASCE Policy 465. Each outcome is supported by a commentary that elaborates on and illustrates the outcome's intent for the practice of water resources engineering. Commentaries and competency levels are essential parts of the outcomes.

Levels of Competence Definitions

BOK fulfillment begins with the premise that professional licensure lays the foundation for all outcomes and builds the superstructure for some. Beyond licensure, Experience and Ethics build the superstructure for the other outcomes. Therefore, for certification, all candidates must reach the minimum level recommended for licensure for all fifteen outcomes. In addition, the candidate must reach the highest or fourth level in one or more of the fifteen outcomes.

Knowledge, skills, and attitudes can exist at many different levels of capability and usefulness. The BOK distinguishes the following four broad levels of competence for individuals intending to become certified:

- Level 1 (Recognition) represents a reasonable level of familiarity with a concept. At this level, the engineer is familiar with a concept, but lacks the knowledge to specify and procure solutions without additional expertise. For example, a water resources engineer might *recognize* that a particular design plan poses significant construction difficulties without having the expertise to devise improved construction or to design alternative solutions.

- Level 2 (Understanding) implies a thorough mental grasp and comprehension of a concept or topic. Understanding typically requires more than abstract knowledge. For example, an engineer with an *understanding* of professional and ethical responsibility should be able to identify and to communicate ethical issues arising from a practical case study.

- Level 3 (Ability) is a capability to perform with competence. An engineer with the ability to design a particular system can take responsibility for the system, identifying all the necessary aspects of the design, and match objectives with appropriate technological solutions. As an engineer develops, the engineer's abilities also develop. so that more challenging and difficult problems can be solved.

- Level 4 (Mastery) represents that the engineer has reached the level of expert and that the more challenging, complex, and difficult problems may be solved.

Given the importance of the post-licensure BOK to maintaining competence and achieving career success, certified water resources engineers are encouraged to continuously enhance their mastery of the BOK by improving abilities in some outcomes and moving from demonstrated ability and beyond with other outcomes. In addition, new outcomes may be appropriate as careers evolve.

The Fifteen Outcomes

The BOK is presented in the form of outcomes and commentaries. The purpose of the commentaries is to elaborate on and illustrate each outcome's intent. The commentaries are not intended to be prescriptive. The outcome-commentary format provides a desirable deliverable for stakeholders, a list of succinct outcomes, each linked for illustrative purposes to an explanatory commentary. Outcomes are viewed as being applicable over a long period of time (years, not weeks or months). In contrast, some illustrative topics mentioned in the commentaries will be ephemeral, requiring modification as technologies advance, society matures, and other changes appear.

The outcomes collectively prescribe the necessary depth and breadth of knowledge, skills, and attitudes required of an individual aspiring to become certified as a Diplomate, Water Resources Engineer. Relative to today's requirements for entry at the professional level as a licensed engineer, the outcomes prescribe additional breadth and more technical depth. The water resources engineer must demonstrate the required level of competence in all of the following fifteen outcomes.

1. Knowledge of mathematics, science, and engineering.

Commentary: A technical core of knowledge and breadth of coverage in mathematics, science and water resources engineering topics is stressed in this outcome. Underlying the professional role of the water resources engineer as the master integrator and technical leader are most of the following: mathematics through differential equations, probability and statistics, calculus-based physics, biology, chemistry, ecology, geology and geomorphology, engineering economics, mechanics, hydrology, hydraulics, water quality, material properties, systems, geo-spatial representation, and information technology.

2. Design and execution of experiments, and data analysis and interpretation.

Commentary: Water resources engineers frequently design and conduct field and laboratory studies, gather data, create numerical and other models, and then analyze and interpret the results. Candidates should be able to do this in at least one of the evolving or current major water resources engineering areas. Examples include flume studies, rainfall-runoff monitoring, BMP performance monitoring, TMDL analyses, and water quality investigations.

3. Design of systems, components, or processes to meet desired needs.

Commentary: Critical design methodology and process elements include problem definition, scope, analysis, risk assessment, environmental impact statements, creativity, synthesizing alternatives, iteration, regulations, codes, safety, security and constructability, sustainability, and multiple objectives and various perspectives. Other important design or design procurement elements are bidding versus qualifications-based selection; estimating engineering costs; interaction between planning, design and construction; design review; owner-engineer relationships; and life-cycle assessment. Understanding large-scale systems is important, including the need to integrate information, organizations, people, processes, and technology. Design experiences should be integrated throughout the professional component of the curriculum.

4. Functioning on multi-disciplinary teams.

Commentary: Diplomates should be able to lead a design or other team as well as participate as a member of a team. This requires understanding team formation and evolution, personality profiles, team dynamics, collaboration among diverse disciplines, problem solving, and time management and being able to foster and integrate diversity of perspectives, knowledge, and experiences.

5. Identifying, formulating, and solving water resources engineering problems.

Commentary: Assessing situations in order to identify water resources engineering problems, formulate alternatives, and recommend feasible solutions is an important aspect of the professional responsibilities of the water resources engineer.

6. Professional and ethical responsibility.

Commentary: The water resources engineer is to hold paramount public safety, health, and welfare. A thoughtful and careful weighing of alternatives when values conflict is crucial to the responsible conduct of engineering. Therefore, water resources engineers practicing at the professional level need to demonstrate an understanding of and a commitment to practice according to the seven Fundamental Canons of Ethics and the associated Guidelines to Practice Under the Fundamental Canons of Ethics.

7. ***Effective communication.***

Commentary: Effective communication includes listening, observing, reading, speaking, and writing. It requires understanding of the fundamentals of interacting effectively with technical and nontechnical or lay individuals and audiences in a variety of settings. Professional water resources engineers need to be versatile with mathematics, graphics, the worldwide web, and other communication tools.

8. Impacts from engineering solutions in global and societal contexts.

Commentary: Professional water resources engineers need to appreciate, from historical and contemporary perspectives, culture, human and organizational behavior, aesthetics and ecology and their impacts on society including the history and heritage of the engineering profession.

9. Need for and commitment to engage in life-long learning.

Commentary: Life-long learning mechanisms available for personal and professional development include additional formal education, continuing education, professional practice experience, active involvement in professional societies, community service, coaching, mentoring, and other learning and growth activities.

Personal and professional development can include developing understanding of and competence in goal setting, personal time management, communication, delegation, personality types, networking, leadership, the socio-political process, and effecting change.

In addition to the preceding, professional development can include career management, increasing discipline knowledge, understanding business fundamentals, contributing to the profession, self-employment, additional graduate studies, and achieving licensure and specialty certification.

10. Contemporary issues.

Commentary: To be effective, Diplomates should appreciate the relationship of engineering to critical contemporary issues such as multicultural globalization of engineering practice; raising the quality of life around the globe; the growing diversity of society; and the technical, environmental, societal, political, legal, aesthetic, economic, and financial implications of engineering projects.

11. Techniques, skills, and modern engineering tools necessary for engineering practice.

Commentary: This includes the role and use of appropriate information technology, contemporary analysis and design methods, and applicable design codes and standards as practical problem-solving tools to complement knowledge of fundamental concepts. Also included is the ability to select the appropriate tools for solving different types and levels of problems.

12. Knowledge in a specialized area of water resources engineering.

Commentary: For a Diplomate, specialized technical coursework (or the equivalent) is necessary. Examples of specialized technical areas include hydrology, hydraulics, sediment transport, water quality management, water resources regulation, master planning, construction engineering and management, public works management, water resource protection, irrigation, water supply, numerical or physical modeling, system planning, operation, and maintenance, etc.

13. Elements of project management, construction, and asset management.

Commentary: Efforts of the professional water resources engineer often lead, in the context of projects, to construction of structures, facilities, and systems that, in turn, must be operated and maintained.

Project management essentials include project manager responsibilities, defining and meeting client requirements, risk assessment and management, stakeholder identification and involvement, contract negotiation, project work plans, scope and deliverables, budget and schedule preparation and monitoring, interaction among engineering and other disciplines, quality assurance and quality control, and dispute resolution processes.

Important construction elements are owner-engineer-contractor relationships; project delivery systems (e.g., design-bid-build, design-build); estimating construction costs; bidding by contractors; labor and labor management issues; and construction processes, methods, systems, equipment, planning, scheduling, safety, cost analysis and cost control.

Asset management seeks effective and efficient long-term ownership of capital facilities via systematic acquisition, operation, maintenance, preservation, replacement, and disposition. Goals include optimizing life-cycle performance, minimizing life-cycle costs, and achieving maximum stakeholder benefit. Tools and techniques include design innovations, new construction technologies, materials improvements, geo-mapping, database management, value assessment, performance modeling, web-based communication, and cost accounting.

14. Business, public policy, and administration fundamentals.

Commentary: The water resources engineer typically functions within both the public and private sectors. That requires at least an understanding of business, public policy, and public administration fundamentals. Important business fundamentals topics as typically applied in the private, government and non-profit sectors include legal forms of ownership, organizational structure and design, income statements, balance sheets, budgets and procurement systems, decision (engineering) economics, finance, marketing and sales, billable time, overhead, and profit.

Essential public policy and administration fundamentals include the political process, public policy, laws and regulations, funding mechanisms, public education and involvement, government-business interaction, and the public service responsibility of professionals.

15. Role of the leader and leadership principles and attitudes.

Commentary: Leading, in the private and public arena – which differs from and complements managing – requires broad motivation, direction, and communication knowledge and skills. Attitudes generally accepted as being conducive to leadership include commitment, confidence, curiosity, entrepreneurship, high expectations, honesty, integrity, judgment, persistence, positiveness, and sensitivity. Desirable behaviors of leaders, which can be taught and learned, include earning trust, trusting others, formulating and articulating vision, communication, rational thinking, openness, consistency, commitment to organizational values, and discretion with sensitive information.

Attitudes

As stated earlier, the BOK is defined as "the knowledge, skills, and attitudes necessary to become a Diplomate, Water Resources Engineer." Knowledge, skills and attitudes are the essential components of the *what* dimension of the BOK. Attitudes are the ways in which one thinks and feels in response to a fact or situation. Attitudes reflect an individual's values, how he or she "sees" the world, not in terms of sight, but in terms of perceiving, interpreting and approaching.

Some potential attitudes might be considered skills or be heavily dependent on skills. Examples are creativity and assertiveness that often are viewed as skills. Attitudes are explicitly mentioned in Outcome 15 ("an understanding of the role of the leader and leadership principles and attitudes"). Many desirable attitudes are listed in the associated commentary. Attitudes are one of the three essential components of the BOK.