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A Graduate Capability Framework for Environmental Engineering Degree Programs

A GUIDE FOR AUSTRALIAN UNIVERSITIES

Define Your Discipline > Stakeholder Consultation Process

Defining Your Discipline to facilitate curriculum renewal in undergraduate programs

David Dowling – Roger Hadgraft

MARCH 2013

MELBOURNE SCHOOL OF ENGINEERING

ENGINEERS AUSTRALIA

UNIVERSITY OF SOUTHERN QUEENSLAND

RMIT UNIVERSITY

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The members of the Environmental Engineering Reference Group

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FOREWORD

Foreword

When environmental engineering started as a separate discipline of engineering, it was based on aspects of civil engineering, chemical engineering and environmental science. Later, when the Environmental College of Engineers Australia was formed, guidelines were developed to help define the discipline of environmental engineering.

Over time, the Environmental College Board felt that a more detailed definition was required, one that had national support. This was because it was found that some of the programs submitted by universities to Engineers Australia for accreditation as environmental engineering programs were not, in fact, environmental engineering programs but environmental engineering streams within programs from other disciplines, such as civil or chemical engineering. Some of these programs had not been developed using a holistic, systems thinking approach and only covered some aspects of what the industry considers as core environmental engineering skills.

In 2009, the College Board made the decision that the original guidelines for environmental engineering programs needed to be updated and that more detail should be included to provide suitable guidance for Australian universities in developing and running environmental engineering programs. Consequently, in late 2009, when the College was invited to participate in the *Defining Your Discipline* project, the College Board was very keen to be involved.

With the funding support of the Australian Learning and Teaching Council (ALTC), now the Office for Learning and Teaching (OLT), and the leadership and contribution of the DYD Project Team, the DYD Environmental Engineering project enabled a much larger and more detailed national consultation process to occur than the College would have been able to undertake on its own. The involvement of the DYD Project Team has enabled consultation to take place at a national level with both academics and environmental engineering industry professionals (both experienced professionals and recent graduates). As College Chair, I took the opportunity to attend the Stakeholder Consultation Workshops and this enabled me to meet with College members face-to-face in their home cities. Many commented that this was the first time they were offered an opportunity to be involved with one of the learned Colleges of Engineers Australia.

The only shortcoming was the College's inability to get a good turnout of members at the workshops in some locations. It appears that some practitioners did not see that this project was something that they should get involved with, but rather something that the universities should be concerned with. The low overall participation rate was one of the reasons why, at the end of 2010, the DYD Project Team decided to continue to consult with stakeholders during 2011 and then develop the Environmental Engineering Graduate Capabilities in late 2011. Their plan had been to publish the Graduate Capabilities in early 2011 and then work with another engineering discipline to develop a set of graduate capabilities for that discipline.

The extension of the original project scope enabled the draft set of Graduate Capabilities developed during the first year of consultations to be taken back to the stakeholder groups for confirmation, clarification and the addition of further detail. We also took the opportunity to visit and consult with staff from five universities that were preparing for future accreditation visits. They welcomed the opportunity to provide input into this process and to talk to some of the College Board members who are involved with accreditations.

Towards the end of 2011, all of the data was synthesised to develop drafts of each of the tables. These were then considered and refined by the Environmental Engineering Reference Group during a two-day meeting in late November 2011. The tables were then incorporated into the first draft of this Guide. During February 2012, the Guide was sent to all Environmental College members across Australia and to all of the universities delivering environmental engineering programs. This enabled comment and input from the widest range of stakeholders into the last stage of the DYD process.

To conclude this final phase of the consultation process, a workshop was held in Melbourne on 17 February 2012 for university environmental engineering program coordinators to discuss the use of the Guide, particularly for accreditation purposes. The Project Team then reviewed the responses, updated the Guide and tabled it at the March 2012 meeting of the College Board for comment and endorsement.

The Guide will provide valuable input into curriculum renewal at the universities that deliver environmental engineering programs. It will also be used by the Accreditation Board of Engineers Australia to inform the accreditation of environmental engineering programs. The Graduate Capabilities in the Guide will also be used to inform the National Professional Engineering Register (NPER) (Engineers Australia, 2008) requirements for environmental engineers. Subsequently, these Graduate Capabilities will be used to assess eligibility for the NPER, and the auditing of existing NPER (Environmental) members.

I would like to personally thank the many industry representatives who provided extremely valuable information into this process. In particular, I would like to thank the members of the Environmental Engineering Reference Group who advised the DYD Project Team during the development of the Guide. Finally, I would like to thank the DYD Project Team, for their hard work, dedication and commitment to a quality outcome. The results presented in this Guide have made a major contribution to defining the field of environmental engineering. It has been an absolute pleasure working with the DYD Project Team on this project.

Dr Julia Lamborn
Chair, Environmental College Board, Engineers Australia (2010-2011)

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Defining Your Discipline to facilitate curriculum renewal in undergraduate programs

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PURPOSE

This Guide is designed to inform environmental engineering stakeholders about the profession's expectations regarding the capabilities of graduates during their first two or three years of practice. It is expected that each group of stakeholders will use the Guide in different ways

Environmental College members will use the Guide as a companion resource to the Engineers Australia Stage 1 Competency Standard when they review environmental engineering programs for Professional Engineers as part of the Engineers Australia accreditation process.

Engineering schools will use the Guide to support the review and revitalisation of the curriculum in their environmental engineering programs, and to prepare for accreditation reviews by Engineers Australia.

Environmental Engineering students can use the Guide to gain a better understanding of environmental engineering and to inform their decisions about specialisations and career choices. They may also use the Guide to help manage their learning so that they acquire the knowledge and skills required for them to commence practice in their chosen specialisations.

Employers may use the Guide to define graduate roles in their organisation, to assess capabilities during the recruitment process, and to prepare staff development and training activities.

The Guide will therefore help members of the environmental engineering profession to develop a shared understanding of environmental engineering.

BACKGROUND

Government standards

The Federal Government, employers, and accrediting bodies, such as Engineers Australia, are all calling for more clearly defined 'program outcomes' or 'exit standards' for tertiary education programs. The aim of defining these exit standards is to improve:

- graduate employability skills;
- the quality of both vocational and higher education programs;
- the international transferability of graduates and qualifications; and
- the marketability of Australia as a provider of high quality tertiary education.

Therefore, engineering schools face increasing pressure to more clearly define what graduates from four or five year undergraduate engineering programs should know and be able to do.

The DYD Project

The aims of the DYD Project were:

1. *To identify and develop an efficient, effective, and inclusive consultation process that can be used by discipline stakeholders to define graduate capabilities for their discipline.*
2. *To use the consultative process to deliver nationally agreed graduate capabilities for at least two disciplines.*

During 2010 and 2011 the DYD Project Team worked with members of Engineers Australia's Environmental Engineering College to produce a set of Graduate Capabilities for Environmental Engineering programs. This Guide is the result of that work.

During 2012, the DYD Stakeholder Consultation Process was used in three other disciplines.

The educational context

The educational context of the Graduate Capabilities defined in this Guide is shown in Figure 1 which shows the four phases of a policy-driven cyclical process for the review, design and delivery of the curriculum for a program. The cycle may be completed annually, or it may be aligned with an accreditation cycle, which in the case of Engineers Australia is five years. The four phases in the cycle are:

1. Review an existing set of graduate capabilities, or develop a new set of graduate capabilities.
2. Review existing curriculum and embed the graduate capabilities, or use the graduate capabilities to inform the development of the curriculum for a new program.
3. Teach the curriculum.
4. Assess student learning and evaluate program outcomes.

The DYD Stakeholder Consultation process can be used in Phase 1 of the cycle.

Figure 1: *(Source: Adapted from Dowling, 2005)*
A graduate capability-driven curriculum design and delivery process

The engineering context

Engineers Australia's Stage 1 Competency Standard for Professional Engineer represents 'the profession's expectations of the knowledge and skill base, engineering application abilities, and professional skills, values and attitudes that should be evident at the point of entry to practice' (Engineers Australia, 2011).

Engineers Australia first published the Stage 1 Competency Standard in 2004. Following an extensive review, a new version of the Stage 1 Competency Standard was published in 2011 (Engineers Australia, 2011). It lists three clusters of competencies under the headings: (1) Knowledge and Skill Base; (2) Engineering Application Ability; and (3) Professional and Personal Attributes (See Table 1).

The Elements of Competency included in the Standard are generic, as they apply to graduates from all engineering disciplines. In this sense, an 'engineering discipline is defined as a broad branch of engineering (civil, electrical, mechanical, etc.) as typically represented by the Engineers Australia Colleges' (Engineers Australia, 2011). All six of the Elements of the first Competency (*Knowledge and Skill Base*) now define separate requirements relating to the engineering discipline, compared to just the one Element (1.3) in the 2004 version of the Standard, which required graduates to demonstrate 'in-depth technical competence in at least one engineering discipline' (Engineers Australia, 2004).

The aim of the DYD Environmental Engineering Project was to define the capabilities of an environmental engineering graduate who would meet these requirements.

Overview of Environmental Engineering

Environmental engineering is a broad field and is described by Engineers Australia (2012) as follows:

Environmental Engineers are concerned with protecting the environment by assessing the impact a project has on the air, water, soil and noise levels in its vicinity. This is done by studying the project's design, construction and operation and minimising any adverse effects that it may have on the environment. Environmental Engineers are also involved in removing problems caused by past activity, such as cleaning contaminated industrial land so it can be used for housing. Environmental Engineers predict what problems may be caused by accidents, such as oil spills for example, and assess what may cause problems for the environment in the long term. They also plan and design equipment and processes for the treatment and safe disposal of waste material and direct the conservation and wise use of natural resources. They are involved in research and development of alternative energy sources, water reclamation, waste treatment, and recycling.

Areas of practice

The following areas of practice in environmental engineering are listed in the National Engineering Registration Board (NPER) Guideline (NPER, 2008):

- water and waste water treatment and management (including application of reuse, recycling, etc.)
- waste management (including eco-efficiency, cleaner production concepts, life-cycle assessment, etc.)
- surface and groundwater system environmental management (including water quality management, and contaminated land assessment and remediation)
- natural resource management
- environment protection, management and pollution control
- environmental management system design (including environmental management planning, auditing, etc.)
- environmental impact assessment and environmental management planning
- environmental information systems
- natural system accounting (including economic evaluation)
- social impact analysis, community consultation, dispute resolution, etc.
- sustainable energy planning and design, greenhouse gas mitigation and management
- environmental risk assessment and management
- environmental policy formulation.

Developing the Graduate Capability Framework for environmental engineering programs

The Graduate Capabilities are defined by ***clusters of tasks*** that together define what an environmental engineering graduate should be able to do in their first two or three years after graduation, including supervised tasks. The definition of a task was based on that provided by Brannick et al. (2007, pp. 6-7) when describing the hierarchy of components associated with a job (Elements, Activities, Tasks, Duties and Position): 'Task: A collection of activities that are directed toward the achievement of a job objective. Example: Talks to parties to settle disputes.'

Twenty-two DYD Stakeholder Consultation Workshops were held during the period March 2010 – October 2011, with at least one workshop being held in each of the mainland states. The 111 people (61 academics, 42 practitioners and 8 recent graduates) who participated in the workshops provided more than 1000 task descriptions and comments. These were synthesised by the members of the Project Team and then refined by the members of the Environmental Engineering Reference Group. Their role in this process was critical, as they also ensured that the focus was on the skills graduates may need in 10 or 20 years as well as current requirements.

The Project Team had expected that clusters would form around the specialisations in environmental engineering, such as soil, water, energy, noise, and air pollution, with the resulting capability statements forming a more detailed layer in the graduate outcomes hierarchy, one step below, and expanding on, Engineers Australia's Stage 1 Competency Standard. However, the clustering process undertaken by the participants at each workshop yielded quite unexpected results.

The clusters consistently formed around six major work processes: *Investigation; Modelling and analysis; Integrated design and implementation; Assessment of impact, risk and sustainability; Environmental planning and management; and Audit, compliance and review*. Of these, half are quite generic skills (Investigation; Integrated design and implementation; and Modelling and analysis) while the remaining three have a distinctly environmental feel (Assessment of impact, risk and sustainability; Environmental planning and management; and Audit, compliance and review).

The final stages in the stakeholder consultation process were undertaken in February 2012 when the following review activities were undertaken:

- all of the members of the Environmental Engineering College, and the Heads of the relevant Engineering Schools, were invited to comment on a draft of the Guide; and
- a workshop was held in Melbourne on 17 February 2012 for university environmental engineering program coordinators to discuss the use of the Guide, particularly for accreditation purposes.

The Project Team then considered all of the comments received during this process and, after receiving advice from the Environmental Engineering Reference Group and the Environmental College Board, refined and published the Guide.

THE ENVIRONMENTAL ENGINEERING GRADUATE CAPABILITY FRAMEWORK

The Four Underpinning Principles

The major outcome from the DYD Environmental Engineering Project was the development of a ***Graduate Capability Framework*** that defines the Environmental College's requirements for a graduate to be able to claim in-depth technical competence in the environmental engineering discipline.

The Graduate Capabilities are underpinned by four principles that inform environmental engineering practice:

- **Sustainability**: Environmental engineers produce outcomes based on the principles of sustainable development including, but not limited to: Applying the precautionary principle; Undertaking full life-cycle analyses; Minimising impacts; Using resources economically and efficiently, particularly non-renewable resources; Appreciating the effect of climate change; Ensuring socially equitable outcomes; and Evaluating engineering outcomes using triple bottom line techniques.
- **Systems thinking**: Environmental engineers use holistic systems thinking and approaches to understand, investigate, model and design natural, constructed and engineering systems, and the interactions between those systems, while accounting for the interconnected social and economic systems that lie within the scope of a project. This understanding enables them to explicitly acknowledge inherent uncertainties and risks and ensure that the benefits of a project on natural and constructed environments are maximised and negative impacts are minimised.
- **Integrated approach**: Environmental engineers often play a leading role in integrating the work of the members of multi-disciplinary teams. They have a 'big picture' perspective that enables them to analyse, evaluate and synthesise inputs from a range of disciplines to achieve integrated outcomes.
- **Critical thinking**: Environmental engineers use critical thinking skills to resolve complex and multi-disciplinary problems.

These four principles are explicitly included in some of the 'Evidence of Attainment' statements associated with the Elements in Engineers Australia's Stage 1 Competency Standard for Professional Engineers. They also appear in many of the 'Tasks' in the Environmental Engineering Graduate Capability Tables in the appendices in this Guide. The following examples, each from a different field, illustrate how these four principles may be applied in environmental engineering practice:

1. **Clean and efficient resource utilisation and recovery:** For example, the ability to apply these principles to reduce water and energy consumption, and waste production.
2. **Green infrastructure:** For example, the ability to assess and specify priorities for green infrastructure in buildings; communications systems; eco-technologies; energy systems; transport systems; and urban environments.
3. **Sustainable communities:** For example, the ability to apply their knowledge of how the following cycles, frameworks and principles interact and impact on the processes which sustain life and healthy communities: Biochemical; Carbon, nutrient and water cycles; Ecological impacts of development proposals; Economic, legal and regulatory frameworks; Social justice and social science principles; and Urban and regional planning principles.

The Graduate Capabilities

The Stage 1 Competency Standard for Professional Engineer defines the expectations for all engineering graduates, including Environmental Engineering graduates (see Table 1). It is important to note that the Environmental Engineering Graduate Capabilities ***do not replace*** the Stage 1 Competency Standard. Rather, the Graduate Capabilities are to be used in conjunction with the Stage 1 Competency Standard as they provide an insight into how Stage 1 Competency may be assessed in the Environmental Engineering discipline.

The Graduate Capabilities have been grouped into ***three sets of capabilities***, with the Technical Capabilities being accompanied by a ***set of practice contexts***:

1. **Technical Capabilities**: Seven environmental engineering Technical Domains were identified: Water resources and supply; Stormwater management and reuse; Water and wastewater treatment; Soils and geology; Resource and waste management; Air and noise; and Energy systems and management.
2. **Environmental Engineering Contexts:** Seven environmental engineering Practice Contexts were identified: Natural environments and systems; Agricultural environments and systems; Industrial environments, processes and systems; Built environments and systems; Natural resources and extraction systems; Utility infrastructure and systems; and Transport infrastructure and systems.
3. **Process Capabilities:** Six environmental engineering Processes were identified: Investigation; Modelling and analysis; Integrated design and implementation; Assessment of impact, risk and sustainability; Environmental planning and management; and Audit, compliance and review.
4. **Generic Capabilities:** Seven Generic Domains were included: Project management; Ethics; Communication; Innovation; Information; Self-management; and Teamwork.

Table 1 shows the relationship between the three sets of Graduate Capabilities and the three competencies in the Stage 1 Competency Standard.

Table 1: Environmental Engineering Graduate Capabilities and the Stage 1 Competency Standard

STAGE 1 COMPETENCY STANDARD	ENVIRONMENTAL ENGINEERING GRADUATE CAPABILITIES
1. Knowledge and skill base	***Technical Capabilities***
1.1 Comprehensive, **theory-based understanding** of the underpinning natural and physical sciences and the engineering fundamentals applicable to the engineering discipline. 1.2 **Conceptual understanding** of the mathematics, numerical analysis, statistics, and computer and information sciences which underpin the engineering discipline. 1.3 **In-depth understanding** of specialist bodies of knowledge within the engineering discipline. 1.4 **Discernment** of knowledge development and research directions within the engineering discipline. 1.5 **Knowledge** of contextual factors impacting the engineering discipline. 1.6 **Understanding** of the scope, principles, norms, accountabilities and bounds of contemporary engineering practice in the specific discipline.	The graduate capabilities are listed in seven *technical domains:* 1. Water resources and supply 2. Stormwater management and reuse 3. Water and wastewater treatment 4. Soils and geology 5. Resource and waste management 6. Air and noise 7. Energy systems and management
2. Engineering application ability	***Process Capabilities***
2.1 **Application** of established engineering methods to complex engineering problem solving. 2.2 **Fluent application** of engineering techniques, tools and resources. 2.3 **Application** of systematic engineering synthesis and design processes. 2.4 **Application** of systematic approaches to the conduct and management of engineering projects.	The graduate capabilities are listed under six *processes:* 1. Investigation 2. Modelling and analysis 3. Integrated design and implementation 4. Assessment of impact, risk and sustainability 5. Environmental planning and management 6. Audit, compliance and review
3. Professional and personal attributes	***Generic Capabilities***
3.1 Ethical conduct and professional accountability. 3.2 Effective oral and written communication in professional and lay domains. 3.3 Creative, innovative and pro-active demeanour. 3.4 Professional use and management of information. 3.5 Orderly management of self, and professional conduct. 3.6 Effective team membership and team leadership.	The graduate capabilities are listed in seven *generic domains,* each closely aligned with a Stage 1 Element: 1. Project management 2. Ethics 3. Communication 4. Innovation 5. Information 6. Self-management 7. Teamwork

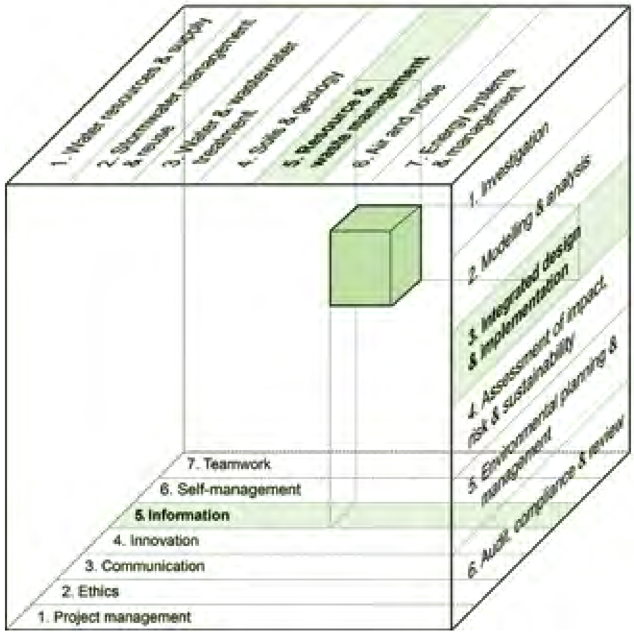

Figure 2: The Environmental Engineering Capability Cube

The Environmental Engineering Graduate Capability Cube shown in Figure 2 shows the interrelationships between the three sets of Capabilities which make up the axes of the Cube. When undertaking a project, a graduate uses ***Generic Capabilities*** when applying a ***Process*** in one or more ***Technical Domains***. For example, as shown in Figure 2, a graduate may be gathering information (a *Generic Capability*) to prepare a design (*a Process*) for a resource management and remediation project (a *Technical Domain*) at a mine site (a *Practice Context*).

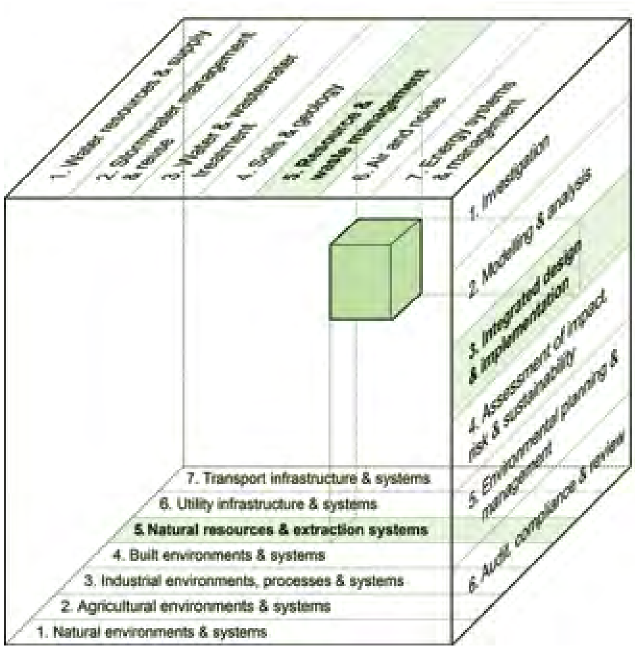

Figure 3: The Environmental Engineering Practice Cube

The Environmental Engineering Practice Cube shown in Figure 3 was adapted from Figure 2 by replacing the seven Generic Domains with the seven Practice Contexts. This Figure can be used to show the scope of the work undertaken by an individual environmental engineering practitioner, i.e. their ***specialist practice domain***, which is '*is a specific area of knowledge and practice within an engineering discipline'* (Engineers Australia, 2011). A person's *specialist practice domain* is a combination of their *Process* and *Technical Capabilities*, and their knowledge and skills of the *Practice Contexts* in which they are applied.

THE ENVIRONMENTAL ENGINEERING GRADUATE CAPABILITIES

The three sets of Environmental Engineering Graduate Capabilities are described in detail the following sections and the Graduate Capability tables are included as Appendices

The Technical Capabilities

Accreditation requirement
It is expected that Environmental Engineering graduates would normally have basic knowledge and skills in all seven Technical Domains, and in-depth understanding of the bodies of knowledge in at least three of the Technical Domains.

Generally environmental engineers practice in one or more *specialist practice domains*. Their work in these domains is underpinned by:

- The breadth and depth of their knowledge of core environmental engineering and science fundamentals;
- Their in-depth knowledge and skills in a number of Technical Domains; and
- Their knowledge of, and experience of working in one or more Practice Contexts.

Engineering and science fundamentals

The fundamental engineering and science domains normally studied by environmental engineering students include: Biology, bio-chemistry, bio-technology, bio-energy, chemistry, ecology, fluid mechanics, geology, hydraulics, hydro-geology, mass-balance, micro-biology, physics, soil science, soil mechanics, and statics (See Elements 1.1 and 1.2, Stage 1 Competency).

The Technical Domains

The Technical Domains are indicative as environmental engineers may work across two or more of these domains and new domains will emerge from time to time. The fields included within each of the Technical Domains are:

T1. Water resources and supply: Surface water systems; water supply systems; integrated catchment management, flood management systems; groundwater systems; coastal and marine systems; irrigation systems; retrofitted systems; and smart water grids.

T2. Stormwater management and reuse: Water sensitive urban design; hydrology, stormwater systems; design of wetlands and sediment ponds; and retention basins.

T3. Water and wastewater treatment: Water treatment; water quality; water quality management; environmental toxic effect of water contaminants; water pollution assessment and control; design of wetlands; wastewater treatment; sediment ponds; and agricultural waste.

T4. Soils and geology: Acid-sulphate soils; hydrogeology; de-watering; soil productivity and properties; contaminated land assessment and remediation; geological contexts; groundwater isolation; management of contamination plumes; agricultural chemicals and by-products; erosion and sediment control; soil conservation; soil pollution and control; salinity; sodicity; and cracking clays.

T5. Resource and waste management: Eco-efficiency; clean production; industrial ecology; life-cycle assessment; solid and liquid waste minimisation, recovery, treatment, reuse and disposal; radioactive waste and protection; recycling processes; biogas generation; hazardous waste; hazardous material storage; spill bunding; landfill design, containment, liners and management; leachate control; waste transfer station design and management; infrastructure waste; and transport waste.

T6. Air and noise: Air quality; air pollution assessment and control; air pollution control devices (e.g. filters, electro-static precipitators); application of climate change assessments/forecasts; climate change mitigation; noise pollution (industrial, transport, residential, commercial, agricultural, etc.); vibration; light pollution; indoor air pollution; industrial ventilation; particulate control (e.g. baghouse, cyclones); pollutant dispersal; and prediction of pollutant transport.

T7. Energy systems and management: Energy production, utilisation, and optimisation; energy recovery, processing and impact assessment; embodied energy; sustainable energy planning and design; greenhouse gas mitigation and management; renewable energy; energy efficiency; bio-energy; and carbon reduction.

A Graduate Capability table for each of these Technical Domains is included in Appendix A.

The Environmental Engineering Practice Contexts

Environmental engineering projects are situated in one or more of the Practice Contexts listed below. Therefore, Environmental Engineers need to understand these contexts and the factors that may impact on their projects (See Element 1.5, Stage 1 Competency). The seven *Environmental Engineering Practice Contexts* are:

1. Natural environments and systems
2. Agricultural environments and systems
3. Industrial environments, processes and systems
4. Built environments and systems
5. Natural resources and extraction systems
6. Utility infrastructure and systems
7. Transport infrastructure and systems

The Process Capabilities

Accreditation requirement
It is expected that Environmental Engineering graduates would, under appropriate supervision, be able to apply each of these processes in their practice.

The Processes

Environmental engineers apply their knowledge and skills using one or more environmental engineering processes, all underpinned by integrated systems thinking and critical analysis skills. The six inter-connected Processes are briefly described below:

P1: Investigation: Environmental engineers undertake investigations to understand the characteristics of natural and constructed environments and systems, how they operate, and the interrelationships between them.

P2: Modelling and analysis: Environmental engineers develop and apply modelling and analysis tools to understand existing natural and constructed systems, and proposed engineering systems. They identify controlling variables, compare the spatial and temporal scales on which they act, and assess the implications of feedback and interactions within the systems. Models are also used for scenario assessment and to identify potential impacts of proposed changes to the systems.

P3: Integrated design and implementation: Environmental engineers use their understanding of natural and constructed systems to bring together multi-disciplinary teams to develop integrated designs, and implementation strategies, that together result in sustainable outcomes.

P4: Assessment of impact, risk and sustainability: Environmental engineers conduct studies to assess the sustainability of proposals, the potential risks of implementing those proposals and the impacts they may have on natural, constructed and community environments and systems.

P5: Environmental planning and management: Environmental engineers prepare plans to manage natural, constructed and community environments and systems to achieve sustainable outcomes.

P6: Audit, compliance and review: Environmental engineers collect appropriate data and information to critically review the status of natural and constructed systems, to evaluate their compliance with regulations or Environmental Management Statements, and to identify opportunities to enhance sustainable outcomes.

A project may consist of a single process, or two or more processes. A large, ongoing project may include all of the processes. This highlights the inter-connectedness of the processes, which together represent a life-cycle approach to environmental engineering.

A Graduate Capability table for each of these Processes is included in Appendix B.

The Generic Capabilities

Accreditation requirement
It is expected that Environmental Engineering graduates would, under appropriate supervision, be able to demonstrate competency in each of these generic domains.

The Generic Domains

Environmental Engineering graduates are expected to have acquired the knowledge and skills required to be able to demonstrate Stage 1 Competency in seven Generic Capability domains (See Element 2.4 and Elements 3.1–3.6, Stage 1 Competency Standard). The seven Generic Domains are:

G1: Project Management

G2: Ethics

G3: Communication

G4: Innovation

G5: Information

G6: Self-management

G7: Teamwork

A Graduate Capability table for each of these Generic Capability domains is included in Appendix C.

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APPENDICES

Appendix A: The Technical Capability tables

Appendix B: The Process Capability tables

Appendix C: The Generic Capability tables

Tasks

The indicative tasks included in the tables provide an insight into the practice of environmental engineering and thus the potential capabilities of graduates. Graduates would be expected to perform these tasks after two or three years of experience and, where appropriate, under supervision. Therefore, these tasks refer to mature practice and are appropriate for Stage 2 assessment, i.e. assessment for Chartered status.

Acronyms

The following table lists the meaning of the acronyms used in the capability tables.

ACRONYM	MEANING
EIA	Environmental Impact Assessment: In this guide EIA includes environmental impact statements (EIS) and reports
EMS	Environmental Management System
EMP	Environmental Management Plan
OH&S	Occupational Health and Safety
GIS	Geographic Information System
WSC	Water sensitive cities
WSUD	Water sensitive urban design

APPENDIX A: THE TECHNICAL CAPABILITY TABLES

Seven Technical Domains were identified and a set of indicatives tasks is listed in a table for each Domain. The division of the tasks into these domains was informed by the employment market and current practice.

An '**X**' is used in the tables to indicate the Practice Contexts that are relevant for each task.

T1: Water resources and supply

	INDICATIVE TASKS	PRACTICE CONTEXTS						
		NATURAL ENVIRONMENTS & SYSTEMS	AGRICULTURAL ENVIRONMENTS & SYSTEMS	INDUSTRIAL ENVIRONMENTS, PROCESSES & SYSTEMS	BUILT ENVIRONMENTS & SYSTEMS	NATURAL RESOURCES & EXTRACTION SYSTEMS	UTILITY INFRASTRUCTURE & SYSTEMS	TRANSPORT INFRASTRUCTURE & SYSTEMS
1.	Undertakes watershed and catchment studies	✗	✗	✗	✗	✗	✗	✗
2.	Undertakes catchment scale water balance studies to facilitate changes in land use	✗	✗	✗	✗	✗	✗	✗
3.	Assesses changes in catchment runoff yield over time – noting land use changes and impact on infiltration	✗	✗	✗	✗	✗	✗	✗
4.	Assesses geological contexts of sites	✗	✗	✗	✗	✗	✗	✗
5.	Predicts groundwater movements	✗	✗	✗	✗	✗	✗	✗
6.	Monitors groundwater movements	✗	✗	✗	✗	✗	✗	✗
7.	Models catchment runoff to study the impact of changing land uses on peak and total flows	✗	✗	✗	✗	✗	✗	✗
8.	Models the likely fate of river sediments discharged into an estuary/coastal region	✗						
9.	Uses flood models to develop predictions for flooding and to design mitigation measures	✗	✗	✗	✗	✗	✗	✗
10.	Completes assessments of water use in cropped and native vegetated areas to understand the water balance for the site	✗	✗					
11.	Undertakes assessment of water demand management measures		✗	✗	✗	✗		
12.	Analyses freshwater, estuarine and ocean aquatic resources	✗						
13.	Analyses long-term stream flow records to help determine environmental requirements and set allowable diversion limits	✗	✗	✗		✗		
14.	Identifies and reviews a suite of options for a water supply scheme (e.g. stream flow, groundwater, recycling, augmentation)	✗	✗	✗	✗	✗		
15.	Designs flood mitigation measures using flood or rainfall design methods	✗	✗	✗	✗	✗		✗
16.	Prepares preliminary estimates for water supply system components including reservoir sizing, pipe sizes, pump station power and specification, treatment requirements, etc.		✗	✗	✗	✗		
17.	Designs efficient water supply infrastructure for small communities, including storage reservoirs, trunk design, water treatment facilities, and distribution networks		✗	✗	✗	✗		
18.	Uses hydraulic analysis techniques to determine pipe and channel sizes	✗	✗	✗	✗	✗	✗	✗
19.	Uses computer simulation techniques to develop and test an operating strategy for a dam or treatment plant		✗	✗	✗	✗		
20.	Determines impacts of agricultural, mining and urban water discharge on natural water systems	✗	✗	✗	✗	✗		
21.	Assists in planning smart water grids			✗	✗			
22.	Develops water management plans for proposed developments and existing buildings, industrial plants, etc.			✗	✗	✗		✗
23.	Develops policy related to water resource use, including social and economic impacts	✗	✗	✗	✗	✗	✗	

T2. Stormwater management and reuse

	INDICATIVE TASKS	PRACTICE CONTEXTS						
		NATURAL ENVIRONMENTS & SYSTEMS	AGRICULTURAL ENVIRONMENTS & SYSTEMS	INDUSTRIAL ENVIRONMENTS, PROCESSES & SYSTEMS	BUILT ENVIRONMENTS & SYSTEMS	NATURAL RESOURCES & EXTRACTION SYSTEMS	UTILITY INFRASTRUCTURE & SYSTEMS	TRANSPORT INFRASTRUCTURE & SYSTEMS
1.	Uses WSC and WSUD principles to develop stormwater strategies for residential, industrial and commercial developments		✗	✗	✗	✗	✗	✗
2.	Uses WSC and WSUD principles to prepare preliminary plans for detention basin placement and design		✗	✗	✗	✗	✗	✗
3.	Uses stormwater modelling and design software to design stormwater systems	✗	✗	✗	✗	✗	✗	✗
4.	Prepares conceptual stormwater design sketches to enable members of the team to prepare final drawings	✗	✗	✗	✗	✗	✗	✗
5.	Designs culvert structures by considering inlet/outlet controls, and calculating headwater levels, tail water levels, and velocities	✗	✗	✗	✗	✗	✗	✗
6.	Designs stormwater structures to manage water quantity and control water quality	✗	✗	✗	✗	✗	✗	✗
7.	Designs diversion and detention schemes for construction sites		✗	✗	✗	✗	✗	✗
8.	Prepares maintenance plans and manages stormwater systems		✗	✗	✗	✗	✗	✗

T3. Water and wastewater treatment

	INDICATIVE TASKS	PRACTICE CONTEXTS						
		NATURAL ENVIRONMENTS & SYSTEMS	AGRICULTURAL ENVIRONMENTS & SYSTEMS	INDUSTRIAL ENVIRONMENTS, PROCESSES & SYSTEMS	BUILT ENVIRONMENTS & SYSTEMS	NATURAL RESOURCES & EXTRACTION SYSTEMS	UTILITY INFRASTRUCTURE & SYSTEMS	TRANSPORT INFRASTRUCTURE & SYSTEMS
1.	Assesses wastewater to determine the levels of nutrients, organisms and pollutants		✗	✗	✗	✗	✗	✗
2.	Identifies and reviews relevant regulations and licence conditions		✗	✗	✗	✗	✗	✗
3.	Identifies legal point of discharge for treated liquid waste	✗	✗	✗	✗	✗		✗
4.	Identifies suitable biological and/or physical treatment processes		✗	✗	✗	✗		✗
5.	Uses modelling software to assess the performance and suitability of proposed wastewater treatment systems		✗	✗	✗	✗		✗
6.	Identifies opportunities for grey/black water recycling and use		✗	✗	✗	✗		✗
7.	Prepares preliminary estimates for sewerage system components including gravity pipe sizes and grades, pump station locations and specifications, treatment requirements and effluent management		✗	✗	✗	✗		✗
8.	Designs reticulated sewerage for small communities including raw sewage transport, sewage treatment and effluent management			✗	✗	✗		✗
9.	Designs components of a sewage treatment plant based on influent quality and required effluent standard		✗	✗	✗	✗		✗
10.	Designs on-site effluent management systems		✗	✗	✗	✗		✗
11.	Contributes to the design of components of wastewater treatment processes including pipes, pump stations and treatment systems		✗	✗	✗	✗		
12.	Develops an operating strategy for a wastewater treatment plant			✗	✗	✗		
13.	Uses computer simulation techniques to test an operating strategy for a water treatment plant		✗	✗	✗	✗		✗
14.	Uses modelling and plume dispersion simulation techniques to contribute to the design of ocean outfalls	✗				✗		
15.	Works with other disciplines to assess the impacts on marine flora and fauna of treated waste from ocean outfalls	✗				✗		
16.	Identifies sources of contamination of groundwater resources	✗	✗	✗	✗	✗		
17.	Proposes physical, chemical or bioremediation processes to remove contamination	✗	✗	✗	✗	✗		
18.	Develops water sampling strategies to address water quality concerns	✗	✗	✗	✗	✗		✗
19.	Assesses water quality in a runoff event	✗	✗	✗	✗	✗	✗	✗
20.	Analyses water quality parameters and develops recommendations to improve water quality	✗	✗	✗	✗	✗		
21.	Collects and analyses water samples from proposed sources to determine physical, chemical and biological composition	✗	✗	✗	✗	✗		✗
22.	Assesses the quality of water supply and uses guidelines to determine what treatment is needed so the water can be used for the desired purpose (e.g. drinking water or irrigation, etc.)	✗	✗	✗	✗	✗		
23.	Collates reservoir water quality data to determine possible causes of poor water quality (e.g. algal blooms, manganese, suspended solids, colour, etc.)	✗	✗	✗	✗	✗		
24.	Designs components of a water treatment plant based on water quality data		✗	✗	✗	✗		
25.	Assesses the toxicity of the impacts of water contaminants on the environment	✗	✗	✗	✗	✗	✗	✗
26.	Designs water and wastewater quality monitoring systems	✗	✗	✗	✗	✗		✗
27.	Assesses wastewater treatment system performance	✗	✗	✗	✗	✗		✗

T4. Soils and geology

	INDICATIVE TASKS	PRACTICE CONTEXTS: NATURAL ENVIRONMENTS & SYSTEMS	AGRICULTURAL ENVIRONMENTS & SYSTEMS	INDUSTRIAL ENVIRONMENTS, PROCESSES & SYSTEMS	BUILT ENVIRONMENTS & SYSTEMS	NATURAL RESOURCES & EXTRACTION SYSTEMS	UTILITY INFRASTRUCTURE & SYSTEMS	TRANSPORT INFRASTRUCTURE & SYSTEMS
1.	Develops detailed soil profiles referenced to a relevant classification system	✗	✗	✗	✗	✗	✗	✗
2.	Classifies soils and assesses their properties such as salinity, sodicity, cracking, acid-sulphate, etc.	✗	✗	✗	✗	✗	✗	✗
3.	Assesses soil and land contamination	✗	✗	✗	✗	✗	✗	✗
4.	Undertakes acid-sulphate assessments	✗	✗	✗	✗	✗	✗	✗
5.	Designs soil remediation systems	✗	✗	✗	✗	✗	✗	✗
6.	Prepares soil and water management and monitoring plans for construction sites that comply with regulatory requirements		✗	✗	✗	✗	✗	✗
7.	Reads and interprets geological maps	✗	✗	✗	✗	✗	✗	✗

T5. Resource and waste management

	INDICATIVE TASKS	PRACTICE CONTEXTS: NATURAL ENVIRONMENTS & SYSTEMS	AGRICULTURAL ENVIRONMENTS & SYSTEMS	INDUSTRIAL ENVIRONMENTS, PROCESSES & SYSTEMS	BUILT ENVIRONMENTS & SYSTEMS	NATURAL RESOURCES & EXTRACTION SYSTEMS	UTILITY INFRASTRUCTURE & SYSTEMS	TRANSPORT INFRASTRUCTURE & SYSTEMS
1.	Assesses the compliance of hazardous waste from industrial facilities			✗	✗	✗		
2.	Designs a waste classification survey for a new waste collection contract			✗	✗	✗		
3.	Contributes to the development of contract documentation for a kerb side collection and recycling system for household and green waste				✗			
4.	Develops process flow charts for various waste processing technologies, including inputs, outputs and the main processes			✗	✗	✗		
5.	Recommends waste recycling options (e.g. composting, energy capture, and recycling)			✗	✗	✗		
6.	Scopes the environmental impact of any engineering intervention in terms of its waste management practices, solutions and outcomes	✗	✗	✗	✗	✗		
7.	Locates potential landfill sites for local government authorities, assesses their suitability by reviewing factors such as topography, odour, transport, and geology	✗		✗	✗	✗	✗	✗
8.	Prepares Environmental Management Statements for new landfill sites	✗		✗	✗			
9.	Assesses solid waste treatment system performance			✗	✗			
10.	Assesses the toxicology and risks associated with solid waste		✗	✗	✗	✗		
11.	Applies techniques such as life-cycle analysis and cleaner production to process design			✗	✗		✗	✗

T6. Air and noise

	INDICATIVE TASKS	PRACTICE CONTEXTS						
		NATURAL ENVIRONMENTS & SYSTEMS	AGRICULTURAL ENVIRONMENTS & SYSTEMS	INDUSTRIAL ENVIRONMENTS, PROCESSES & SYSTEMS	BUILT ENVIRONMENTS & SYSTEMS	NATURAL RESOURCES & EXTRACTION SYSTEMS	UTILITY INFRASTRUCTURE & SYSTEMS	TRANSPORT INFRASTRUCTURE & SYSTEMS
1.	Designs air quality monitoring programs to assess whether the levels of key pollutants are within environmental guidelines		✗	✗	✗	✗		
2.	Uses models to predict or assess pollutant dispersal		✗	✗	✗	✗		
3.	Collects and analyses air pollution data		✗	✗	✗	✗		
4.	Develops inventories of emissions including the key physical, chemical or spatial characteristics of the sources		✗	✗	✗	✗		
5.	Manipulates and combines air quality data to define and assess aggregate effects		✗	✗	✗	✗		
6.	Models air pollution dispersion to determine ground level concentrations of stack pollutants		✗	✗	✗	✗		
7.	Supervises construction of small projects such as the installation of monitoring ware and weather stations	✗	✗	✗	✗	✗		
8.	Determines environmental noise impacts from proposed developments and existing facilities		✗	✗	✗	✗	✗	✗
9.	Develops noise management plans for construction sites			✗				
10.	Designs noise amelioration measures for developments and redevelopments		✗	✗	✗	✗	✗	✗
11.	Assists in specifying development conditions for proposed developments such as residential developments, rail or road corridors, industrial facilities, etc.		✗	✗	✗	✗	✗	✗

T7. Energy systems and management

	INDICATIVE TASKS	PRACTICE CONTEXTS						
		NATURAL ENVIRONMENTS & SYSTEMS	AGRICULTURAL ENVIRONMENTS & SYSTEMS	INDUSTRIAL ENVIRONMENTS, PROCESSES & SYSTEMS	BUILT ENVIRONMENTS & SYSTEMS	NATURAL RESOURCES & EXTRACTION SYSTEMS	UTILITY INFRASTRUCTURE & SYSTEMS	TRANSPORT INFRASTRUCTURE & SYSTEMS
1.	Undertakes energy audits		✗	✗	✗	✗	✗	✗
2.	Analyses energy data and calculates carbon footprints		✗	✗	✗	✗	✗	✗
3.	Reports on energy use and incorporates graphs of trends in energy use over time, etc.		✗	✗	✗	✗	✗	✗
4.	Assesses alternative energy supplies		✗	✗	✗	✗	✗	✗
5.	Designs and plans for the installation of alternative energy systems		✗	✗	✗	✗	✗	✗
6.	Develops plans for energy and carbon reduction initiatives		✗	✗	✗	✗	✗	✗
7.	Calculates short- and long-term carbon footprints of approved project proposals		✗	✗	✗	✗	✗	✗
8.	Conducts energy and emission life-cycle assessments in the built environment			✗	✗	✗	✗	✗

APPENDIX B: THE PROCESS CAPABILITY TABLES

Each table includes a set of indicative tasks, listed in order, for each phase of the process

P1: Investigation

PROCESS PHASE	INDICATIVE TASKS
1. Defines the scope of the investigation and identifies systems	a. Reaches agreement with client on the goals, objectives, constraints, deliverables and acceptance criteria for the investigation b. Identifies, defines and reaches agreement with the client on the system boundaries – particularly space, time and cost c. Identifies the likely stakeholders and their areas of interest d. Documents the preliminary scope of the investigation
2. Plans the investigation	a. Selects appropriate investigation methods after considering current, new and emerging methods b. Identifies data and information needs, and any knowledge gaps c. Identifies sources of appropriate knowledge and information d. Identifies relevant regulatory frameworks, codes and standards e. Identifies data to be gathered f. Develops sampling strategies, methods, locations and sizes and any specialist input required g. Assesses the resources that may be required for the investigation h. Performs a risk assessment for the investigation (e.g. environmental, financial, legal and OH&S) i. Plans communication strategies for interactions with stakeholders j. Produces a program of activities for the investigation k. Costs the investigation l. Confirms the scope and cost of the investigation and acceptance criteria with the client
3. Gathers information	a. Gathers plans, maps and existing data sets b. Obtains relevant codes, guidelines and standards c. Obtains reports, articles and research papers to assess the state of knowledge and opinion on environmental issues d. Consults relevant regulatory bodies and stakeholders e. Reviews findings against the scope of the investigation defined in Phase 1
4. Collects data	a. Establishes quality control procedures for data collection and storage b. Selects appropriate equipment and instruments to collect field data c. Identifies OH&S and quality issues prior to fieldwork and manages them during data collection d. Conducts, or arranges for, sampling, monitoring, and measuring activities to gather data (e.g. air, flora, fauna, noise, soil, water or waste) e. Accurately records field observations and metadata f. If appropriate, manages field staff during data collection activities
5. Critically analyses and synthesises information	a. Assesses the quality of data and information b. Collates and analyses data from diverse sources c. Identifies, develops and uses models to inform analysis d. Analyses data using appropriate techniques e. Uses GIS systems to spatially analyse information f. Critically analyses data and information to gain an in-depth understanding g. Tests the reality of the results against knowledge of the underlying processes h. Assesses levels of uncertainty of results
6. Uses predictive models	a. Refines computer models of environmental systems and events b. Uses models to predict system performance c. Undertakes sensitivity analysis of assumptions and recognises the limitations in modelled outputs
7. Draws conclusions and makes recommendations	a. Develops conclusions after considering all aspects of the investigation b. Costs the recommendations c. Provides recommendations to the client including ongoing monitoring d. Seeks feedback on deliverables to ensure that the brief is satisfied e. Reviews the conclusions and recommendations with stakeholders f. Arranges for independent checks of findings or results
8. Reports investigation outcomes	a. Prepares investigation report in accordance with client requirements b. Presents data in a concise, logical and neat manner using tables, charts and other graphics c. Presents findings to clients and other stakeholders in meetings and workshops d. With the client's permission, disseminates findings to extend current knowledge base

P2: Modelling and analysis

PROCESS PHASE	INDICATIVE TASKS
1. Defines the scope of the investigation and the systems involved	a. Reaches agreement with client on the goals, objectives, constraints, deliverables and acceptance criteria for the modelling project b. Documents key assumptions c. Identifies, defines and reaches agreement with the client on the system boundaries (e.g. space, time and cost) d. Documents the preliminary specifications for the model
2. Assembles information and data	a. Sources data and information b. Identifies key data and assesses the quantity of data c. Interrogates the data to become familiar with it (e.g. plot data, etc.) d. Assesses the quality of data and information (e.g. gaps, outliers, etc.) e. Identifies and reports on any assumptions or limitations associated with the data f. Pre-processes data (e.g. data infilling, data transformation, etc.) g. Splits data into calibration and validation subsets
3. Selects model type	a. Reviews relevant model types (e.g. statistical/data-driven, conceptual, process-driven) b. Assesses advantages and disadvantages of different modelling types for the project (e.g. data requirements, range of applicability) c. Selects appropriate model type
4. Specifies model	a. Determines appropriate model complexity (e.g. number of processes, degree of non-linearity, etc.) b. Determines the range of model complexities to be investigated c. Determines the appropriate software platform and, if required, develops the platform (e.g. Fortran, C++, Excel) and formalises modelling agreement with client
5. Calibrates model	a. Selects calibration method, such as manual or optimisation approach (e.g. gradient, evolutionary, etc.) b. Selects error measure (e.g. root mean squared error, etc.) c. Selects stopping criterion (e.g. error measure, number of iterations, etc.)
6. Validates model	a. Tests structural validity of the model (e.g. checks whether calibrated model parameters make physical sense, etc.) b. Tests replicate validity of model (e.g. residual analysis to check for normality, structure, etc.) c. Tests predictive validity of model (e.g. checks predictive performance of model on independent validation data set)
7. Considers uncertainty/sensitivity and defines limitations	a. Identifies potential sources of uncertainty/sensitivity (e.g. inputs, model structure, parameters, etc.) b. Characterises uncertainties for uncertainty analysis (e.g. determine distribution or inputs, etc.) or ranges for sensitivity analysis c. Applies appropriate methods of uncertainty or sensitivity analysis (e.g. Monte Carlo methods) d. Develops comparisons with other relevant model outputs and obtains appropriate risk-based performance measures (e.g. reliability) e. Defines the key assumptions that underpin the model and identifies the conditions where these will be violated and the implications for predictions f. Ensures data legacy by properly documenting the steps used in the modelling process so they can be replicated in the future g. Identifies and documents key areas for model improvement
8. Applies model and analyses systems	a. Applies model to the agreed scenarios b. Conducts scenario analysis and evaluates the results against the critical system issues and the constraints and limitations of the model
9. Reports outcomes	a. Prepares appropriate documentation to report the outcomes of the modelling process b. Discusses outcomes with the client and other relevant stakeholders

P3: Integrated design and implementation

PROCESS PHASE	INDICATIVE TASKS
1. Documents current status of project and identifies systems	a. Gathers and documents background information and context of project b. Documents the current stage of the design project. For example: completed investigation, preliminary design, EIA design, Development Consent, an old but approved design c. Documents Approval Stage of Project including all Approval Conditions from the EIA/ Development Consent stage if applicable and any necessary regulatory licences required for the project d. Within the Approval Conditions, identifies opportunities for variations and/or design changes to reduce costs, enhance the claimed economic, environmental and social benefits and to improve sustainability. Agree on variations with client e. Seeks formal confirmation of the client's design contract including: the project budget, the design budget, the designer's role in any remaining approval process; any documentation required to facilitate budget monitoring; the project delivery timetable; the project delivery method; the clients representative, quality assurance procedures, dispute resolution procedures, and the number of concept designs required for discussion; the design stages of the agreed concept to be subject to documentation and client's approval (e.g. Preliminary say 50%, Near Final say 90% and Final); and the designer's role during construction f. Assists in preparing proposal documentation
2. Interprets clients brief and scopes design requirements	a. Analyses the design criteria to ensure that all appropriate specifications and regulatory requirements are included in the design requirements b. Helps to select and apply the design process or method, uncertainty bounds, and engineering standards and specifications to formalise technical specifications to meet the agreed design requirements c. Identifies and communicates sustainability implications for the project d. After discussion and agreement, documents the final acceptance criteria and incorporates the agreement in the design contract documents e. When requested, helps to develop communication strategies to engage with the local community, government authorities (particularly those associated with any approval conditions), and other professional stakeholders f. Develops a quality assurance plan to reflect the agreements with the client g. Assists with the selection of staff and the establishment of management procedures to effectively deliver the design project h. If appropriate, seeks the client's approval for a nominated peer reviewer for the design project
3. Prepares integrated concept proposal	a. Mobilises the core design team for the concept stage b. Participates in developing the agreed range of potential solutions c. Develops the agreed number of concepts for start-up projects and discusses them with the client d. Evaluates alternative concepts against relevant criteria such as: engineering specifications; operating and capital costs; feasibility of construction/implementation/operation/ maintainability; sustainability (including resource recovery and recycling); agreed environmental criteria; and criteria arising from community consultations e. Uses best practice and innovative approaches to develop a final design concept that meets project and regulatory requirements, and approval conditions f. During the development of the integrated concept design, seeks advice from specialists where necessary on issues such as architecture, traffic control, OH&S, operating requirements, noise, and air quality g. Discusses and reaches agreement with client and relevant approval authorities on the final design concept h. Incorporates final design concept in the design contract documentation i. Assists client with the preparation of a project summary for the local paper or newsletter to advise the community about the final design concept j. If required, arranges with specialists to build a scale model of the final design concept k. Establishes documentation management procedures

PROCESS PHASE	INDICATIVE TASKS
4. Implements planning and design process	a. Mobilises the design team and briefs them on the timetable, deliverables, budget hours and the design leaders' responsibilities b. Carries out the agreed and staged design tasks to document the final design concept c. Meets with the client and, where appropriate, the contractor on a regular basis to review progress, discuss any issues that have arisen, and incorporates their construction and operational knowledge into the design process d. Meets regularly with quality assurance staff to maintain a 'cleared project' through all design stages e. Documents any agreed changes f. Ensures the necessary specifications and contract documentation keeps pace as the design drawings approach completion g. Prepares a design report that checks the design solution against the agreed design specification h. Seeks sign-off from the peer reviewer if required
5. Reviews the design to achieve acceptance	a. Reviews the design and specification with the client to ensure that the client's design criteria have been satisfied b. Incorporates any final changes and finalises the design documentation c. Arranges for the client to sign-off on the design package
6. Prepares & maintains documentation during construction/ implementation	a. Ensures that all of the supporting documentation required to effectively construct/implement the design is timely, accurate, concise, complete and clear (specialist reports and agreed changes) b. Ensures the agreed documentation control process is followed when making changes to the design
7. Provides design services during construction/ implementation	a. Responds promptly to any design questions raised during construction or implementation b. Reaches an agreement with the client on: the tasks for any site inspectors and their budget; site reporting schedule; rules for any stakeholder and community involvement; and provisions for site accommodation and support c. Sets out these agreements in a site supervision contract d. If required in contract, develops a time schedule to monitor construction/implementation progress and to facilitate the timely and effective completion of corrective actions by the contractor e. Finalises the set of 'as constructed' drawings
8. Validates design	a. Arranges and manages with the client for any necessary commissioning tests to be undertaken b. If required during the construction stage, documents and manages the completion of any defective work orders c. Prepares a report that verifies that the completed physical work meets the agreed acceptance criteria d. Evaluates the performance of the new project against any earlier environmental impact assessment claims and/or the client's environmental goals e. Seeks and evaluates community reaction to the new project

P4: Assessment of impact, risk and sustainability

PROCESS PHASE	INDICATIVE TASKS
1. Preparation	a. Reviews the EIA process and methodology appropriate for the project type b. Establishes appropriate project management systems
2. Identifies systems and reviews project scope and relevant legal, regulatory and code requirements	a. Reviews the feasibility study for the project b. Defines the scope, limits and boundaries of the project c. Identifies what economic, environmental and social changes will result from the project d. Identifies the potential impacts of those changes e. Gathers and reviews relevant legislation, guidelines, regulations and legal judgements f. Identifies relevant sections of codes, guidelines, regulations and legal judgements g. Assists in the preparation of tender documentation for the EIA and liaises with the relevant stakeholders h. Identifies any specific discipline expertise that will be required to deliver the project
3. Gathers relevant baseline environmental data	a. Identifies and understands the affected environments (e.g. natural, social, economic) and constructed systems b. Identifies and defines potential contaminants and their sources c. Identifies stakeholders d. Consults with relevant community groups and statutory authorities about the project and the scope of the study e. Undertakes a literature review f. Researches historical data sets to establish the history of the site, including contamination information g. Gathers existing environmental and other relevant data (e.g. air quality, flora, fauna, groundwater, soils, traffic, water, etc.) h. Defines the scope of any measurements required to fill information gaps i. Identifies and engages specialists to undertake measurements, modelling and studies j. Coordinates and facilitates the work of specialists from multiple disciplines
4. Identifies potential impacts and opportunities	a. Analyses a range of field and laboratory data to develop a conceptual model to describe the environmental systems being assessed b. Identifies the range of impacts, both short and long term, direct and indirect, and selects a suitable ranking method c. Synthesises and integrates information from a range of specialists to form an overall understanding of the impacts d. Identifies amelioration measures that may reduce or eliminate impacts
5. Assesses the significance of impacts	a. Assesses the significance of potential environmental impacts b. Assesses the risks associated with the identified impacts
6. Reviews the proposed development to minimise impacts	a. Reviews the impacts with the client to identify opportunities to change the proposal to minimise or eliminate impacts b. Advises the design team on recommended changes to designs
7. Reassesses impacts	a. Reassesses the significance of the potential environmental impacts
8. Recommends final management measures to avoid or minimise environmental impacts	a. Prepares draft impact report that summarises input from specialists b. Develops mitigation measures to manage residual impacts and considers whole-of-life costs associated with those measures c. Develops monitoring plans and programs d. Develops environmental management plans as required e. Prepares final report on environmental impacts of project f. Reviews the report with the client
9. Prepares and disseminates documentation	a. Prepares relevant documentation for required formal approval processes, dissemination to stakeholders and, where necessary, public display b. Finalises documentation for environmental assessment report, including summary c. Where appropriate, participates in community consultations

P5: Environmental planning and management

PROCESS PHASE	INDICATIVE TASKS
1. Determines the existing environmental condition	a. Establishes stakeholder list with client and then consults relevant stakeholders to establish issues and expectations b. Reviews relevant environmental regulations for the activity c. Identifies best practice and industry standards d. Identifies client/company policies and procedures e. Evaluates existing environmental conditions
2. Responds to environmental conditions and identifies risks	a. Identifies knowledge gaps and priorities b. Initiates briefs for environmental studies which adequately reflect the extent of required work c. Reviews the environmental, economic and social aspects of the proposed activity d. Records/reports on the findings of the initial assessment, including compliance e. Identifies opportunities for environmental improvement
3. Reviews existing environmental conditions against stakeholders' expectations	a. Determines variations between environmental and sustainability goals and the current condition of the environment b. Establishes the possibilities and options for the ongoing minimisation of environmental impacts, environmental regeneration and the development of sustainability c. Determines existing directions of project requirements against expectations d. Assesses the risks of non-compliance and consequences for each environmental aspect
4. Develops environmental management plan (EMP)	a. Develops short- and long-term management strategies for each of the individual environmental aspects b. Develops a draft EMP that is aligned with stakeholder expectations, regulations and best practice c. Consults client to gain acceptance of the plan d. Modifies plan to take account of client feedback e. Obtains approval to seek input from external stakeholders f. Consults external stakeholders, including regulators and members of the community g. Modifies plan to take account of stakeholder feedback h. Submits plan to relevant statutory authorities for approval
5. Implements, monitors and evaluates EMP	a. Implements strategies in consultation with appropriate stakeholders and communities b. Integrates relevant aspects of the environmental management plan and procedures into all aspects of engineering design, construction and operational activities c. Collects and reviews data on implementation of strategies d. Evaluates progress and reviews strategies e. Reviews outcomes with stakeholders
6. Integrates EMP into existing environmental management system (EMS)	a. Integrates environmental management plan into any existing EMS using relevant standards (e.g. ISO 14000) where appropriate
OR	
6. Assists in the development of an environmental management system	a. Reviews relevant sections of the ISO 14001 framework if required for project b. Assists with the development of an EMS using relevant standards (e.g. ISO 14000) where appropriate

P6: Audit, compliance and review

PROCESS PHASE	INDICATIVE TASKS
1. Reviews scope and purpose of the audit	a. Consults with the client to confirm the purpose of the audit and the reporting requirements b. Determines if the audit is a desktop or physical audit c. Identifies and reaches agreement with the client on the audience for the report d. Identifies the timelines for the audit e. Reviews and evaluates previous audits f. Defines the scope of the audit including the number of sites, activities, environmental aspects (e.g. air, water, etc.) g. Determines the resources required to undertake the audit
2. Identifies relevant policies, regulations and procedures	a. Identifies relevant national, state and local authority regulations b. Identifies relevant industry standards c. Reviews existing company Environmental Management System (EMS) to determine applicable requirements
3. Develops audit work plan	a. Identifies assumptions and develops plans and checklists for the audit b. Develops draft audit schedule c. Consults with stakeholders to arrange access to site staff and data d. Finalises schedule e. Forwards list of audit information requirements to site managers f. Develops OH&S plan for site visits
4. Undertakes environmental audits	a. Undertakes desktop review of submitted information b. Refines work plan and schedule c. Participates in site induction d. Interviews site staff e. Undertakes physical inspections f. Collects samples and measurements as required
5. Reviews and reports on audit outcomes	a. Collates observations b. Assesses and analyses results, and checks assumptions c. Identifies any non-compliances d. Develops recommendations to mitigate non-compliances, including the identification of necessary resources e. Develops monitoring and follow-up schedule f. Critically reviews data and identifies opportunities to improve performance g. Prepares draft audit report h. Forwards draft report to the client for comment i. Forwards draft report to the agreed audience for comment j. Prepares final audit report
6. Oversees compliance	a. Undertakes follow-up audits and inspections b. Assesses compliance of Environmental Management System

APPENDIX C: THE GENERIC CAPABILITY TABLES

A set of indicatives tasks is listed for each domain

G1. Project management

	INDICATIVE TASKS
1.	Contributes to the development of project strategies, milestones and timelines considering regulatory and approval requirements
2.	Assists project manager with the management of multi-disciplinary studies
3.	Manages small projects and project tasks
4.	Liaises with sub-consultants and manages the flow of information and deliverables to and from them
5.	Prepares preliminary cost estimates for projects based on standard rates
6.	Develops costing models to compare project implementation options, including net and present values based on capital and operational cost estimates
7.	Manages time, cost and quality outcomes within the constraints established in project plans and specifications and/or contracts
8.	Assesses, limits and manages cost and time risks associated with project overruns
9.	Assesses and helps to manage the health and environmental risks associated with engineering projects
10.	Supervises or inspects on-site activities to ensure fieldwork or construction is being performed safely

G2. Ethics

	INDICATIVE TASKS
1.	Demonstrates commitment to the Code of Ethics and professional standards
2.	Recognises their professional limitations and, where appropriate, seeks advice from others
3.	Complies with legal and other regulatory requirements associated with their work
4.	Considers the wider implications of their work to achieve project outcomes that maintain or enhance the health and well being of the environment, members of the community and workers
5.	Promotes sustainable engineering practices and outcomes

G3. Communication

	INDICATIVE TASKS
1.	Communicates effectively with clients, contractors and members of the engineering team
2.	Clearly articulates concepts, issues, and project objectives to stakeholders
3.	Engages and consults with other professionals
4.	Communicates effectively with people from other disciplines (e.g. chemical, civil and structural engineers; botanists; chemists; geologists; and microbiologists)
5.	Demonstrates sound listening and observation skills
6.	Asks questions to obtain information and opinions, and to understand issues, perspectives and stances
7.	Assists in resolving environmental disputes
8.	Uses appropriate language and techniques to present project information to community groups, business organisations and school groups
9.	Manages community consultation processes and social interactions
10.	Reports on the outcomes of community consultations
11.	Prepares and delivers educational sessions on environmental engineering issues
12.	Develops checklists to capture project requirements and specifications during meetings with clients
13.	Records and prepares draft minutes and notes of meetings
14.	Prepares drafts of project correspondence
15.	Writes up results of engineering studies
16.	Assists in preparing proposals and tender documents
17.	Writes reports that clearly, accurately and logically present the findings and outcomes of engineering projects
18.	Under guidance, compiles reports for large projects
19.	Assists with the preparation of reports on multi-disciplinary studies
20.	Accurately proof reads draft reports and provides feedback on clarity, grammar, logic and spelling
21.	Compiles, formats and facilitates the printing, binding, and delivery of reports
22.	Assists with the development and maintenance of environmental and sustainable development policies
23.	Prepares engineering drawings and plans
24.	Interprets maps, plans and architectural and engineering drawings
25.	Prepares posters to communicate specific environmental aspects of a project to community and other stakeholders

G4. Innovation

	INDICATIVE TASKS
1.	Proactively uses self-learning skills to identify and acquire new knowledge and skills
2.	Mentors and helps to train other members of the team
3.	Thinks laterally to create innovative solutions
4.	Develops innovative concepts for environmental sustainability and remediation outcomes
5.	Suggests new ideas and approaches with confidence
6.	Reports on innovative and creative solutions and processes to add to the environmental engineering body of knowledge

G5. Information

	INDICATIVE TASKS
1.	Sources and reviews documents, reports, journal articles and background information for a project
2.	Interprets and compiles summaries of technical reports and journal articles
3.	Coordinates the information-gathering process for multi-disciplinary projects including identifying and contacting key people, and sourcing and requesting information
4.	Compiles and integrates information from a range of sources to prepare initial drafts of tender documents or project reports

G6. Self-management

	INDICATIVE TASKS
1.	Willingly uses self-learning skills to build knowledge and skills
2.	Asks relevant and timely questions to seek information
3.	Systematically maintains currency of knowledge of relevant Acts, Regulations, Standards and Codes of Practice
4.	Manages own time and tasks effectively and efficiently
5.	Works independently to achieve defined project outcomes
6.	Uses critical thinking skills to evaluate process and project outcomes
7.	Defines decision indicators to enhance outcomes of performance-based engineering projects
8.	Makes decisions confidently and in a timely manner
9.	Responds to emerging situations by developing and implementing appropriate reaction plans and communication strategies
10.	Maintains effective and professional relationships with clients, project managers and other members of the project team
11.	Presents a professional image and contributes to the enhancement and promotion of the environmental engineering profession

G7. Teamwork

	INDICATIVE TASKS
1.	Uses knowledge of team roles and processes to contribute effectively to project team activities
2.	Works effectively in multi-disciplinary project teams
3.	Recognises limits of knowledge and skills and collaborates with team members and others to fill identified gaps in knowledge and experience
4.	Develops leadership and management capabilities to be able to operate in complex multi-disciplinary environments

Define
Your
Discipline

Stakeholder
Consultation
Process

A Graduate Capabilities Framework for Environmental Engineering Degree Programs: A Guide for Australian Universities

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