Final Assessment Report of the
Augmented Review of Earth Science
(BSc, MSc and PhD)
March 2013

Review Process

The self-study was commenced by the former graduate officer, included input from colleagues, staff assistance, and was finalized by the Chair and Associate Chair following a review by certain faculty, staff, and representatives of the undergraduate and graduate student societies.

The previous review of both undergraduate and graduate programs occurred in 2004/05, when the same reviewers provided separate reports on both the undergraduate and graduate programs. They did not have major concerns, other than recommending that the fields at the graduate level (which had been collapsed into two) should be expanded in number.

The current review was originally scheduled for 2011/12, but due to some extenuating circumstances was delayed one year. Eight years is the maximum that a program is permitted to continue without review by the Ontario Universities Council on Quality Assurance.

Characteristics of the Program

Program Objectives

The objective of the undergraduate plans is to provide high-quality training in the Earth Sciences that prepares graduates to enter directly into formal employment as professional geoscientists or to undertake advanced training and research in the geosciences as graduate students.

The objective of the two departmental graduate programs (MSc and PhD) is to provide advanced training in the geosciences to superior candidates in five fields: Foundation Earth Sciences, Hydrogeology, Aqueous and Organic Geochemistry, Isotope Hydrology and Geochemistry, and Atmospheric and Water Cycle Modelling. MSc Earth Sciences graduates are prepared for professional geoscience employment or further study at the doctoral level. PhD Earth Sciences graduates are prepared for professional geoscience employment or academic careers.

Specific Learning Outcomes

Detailed learning outcomes for the undergraduate program have been developed, along with a curriculum map. Detailed learning outcomes at the graduate level need to be developed.

Distinctiveness

The Department has a very strong research profile, as evidenced by the amount of grant funding received and the number of research chairs appointed. The Department has a
particular strength in groundwater research, and the recent arrival of a Canada Excellence Research Chair in Ecohydrology and the associated research group has further strengthened the national and international reputation in this area, such that there are few (if any) larger groups in this area in the world. The average annual external research funding received by the Department was $7.8m over the review period, with about half of this from Tri-Council and other peer-adjudicated sources, and the balance from contract and other sources. This is a very substantial record. The Department has substantial lab facilities, and the University of Waterloo Environmental Isotope Laboratory is one of the best-equipped such facilities in North America, with 12 highly qualified technicians.

In terms of student numbers the Department trained 6% of the Bachelors graduates in Earth Sciences in Ontario, but 20% of the Masters and 14% of the PhDs in Ontario (as measured by numbers of graduates in the eight years from 2004 to 2010). Ontario in turn trains 33% of the undergraduate and about 40% of the graduate students in this discipline, nationally.

**Academic Programs Offered**

The undergraduate programs were first offered in 1965; the MSc beginning in 1969, and the PhD beginning in 1972.

The Department offers the following *undergraduate* programs:

- Honours BSc Earth Sciences (co-op and regular); within this Plan, three different specializations are available (Geology, Hydrogeology and Geophysics). An Atmospheric specialization will be deactivated shortly.
- Honours BSc Environmental Science (Geoscience option) (co-op and regular);

The Department also participates in programs with other Departments, including the BASc in Geological Engineering (offered by the Department of Civil and Environmental Engineering) and the BSc in Geochemistry (offered by the Department of Chemistry).

At the *graduate* level, the Department offers an MSc and a PhD, with five fields (Foundation Earth Sciences, Hydrogeology, Aqueous and Organic Geochemistry, Isotope Hydrology and Geochemistry, and Atmospheric and Water Cycle Modelling).

**Students: Undergraduate**

During the review period 42 different courses were offered in the undergraduate program including the two honours thesis courses (all Honours graduates in the Department are required to complete either a thesis) or a senior research project. There have been online course offered in the past, but there are non currently. However, it is expected that a first year online course will be reintroduced, and possibly others in future. There is a required field course for all students which is usually taken at end of the third year.

On average about 50 students per year whose grades exceed the minimum required apply for the undergraduate program, with a little over half of these applying for the Co-op stream.
About 8 students on average per year entered first year in the program over the 8 year review period, of which four-fifths were in co-op. The vast majority of these come from Ontario. Women constituted about 45% of this group. Since 2005, the Department has accepted students from China on 2+2 arrangement (students come in with the equivalent of 20 courses, and complete an additional 20 at Waterloo). These students do not enter the co-op stream. The numbers of such students has risen, and 12 graduated from this stream in 2011. On average about 17 students per year graduate from regular and co-op programs combined, hence the international students form a significant fraction of graduates with the Bachelor’s degree.

Co-op employers are generally very satisfied with co-op students, and 90% of them rate the students as “very good” or better; 97% of the co-op students rate their co-op placements as 7 or higher on a scale of 10 (10 being the best). Two-thirds of co-op jobs are with the public sector or with professional, scientific and technical services.

Departmental faculty receive above-average scores on course evaluations (relative to other Departments in the Faculty of Science), and an alumni survey of the Faculty suggested that the Departmental faculty also received above-average scores regarding their availability outside class time, and the interest they display in the active learning of their students.

**Students: Graduate**

Twenty-seven different graduate courses were offered in the three year period analyzed; however the majority of the enrolment was in five core courses. Masters students are required to take four courses plus a thesis (or six courses plus a major research paper), and doctoral students an additional four. Since students are accepted from a variety of undergraduate backgrounds, incoming graduate students may be required to make up missing background training by taking up to five undergraduate courses prior to proceeding to graduate study.

The five core courses have enrolments from between 10 to 30 students; other courses have smaller enrolments, and some of the 600-level courses are also open to undergraduate students.

Over the 8 year period, the PhD program admitted on average 7 students per year, of whom 60% were Canadian, and the Masters program admitted on average 23, of whom 70% were Canadian. The proportion of female students has risen to 40%, and the proportion of international students has likewise been rising. Masters students complete their program after between 2.3 to 2.7 years, and Doctoral take on average 6 or 7 years. The Department argues that the need for fieldwork, the need for additional qualifying undergraduate courses (for students entering from other disciplines), and the accepting of employment prior to completion, explain these relatively long completion times. Funding for graduate students is comparatively generous, with the average for Masters students exceeding $21,000/year in the 8 years considered, and for PhD students exceeding $27,000/year.
Graduates obtain employment with consulting firms, government agencies, or industry, in addition to those pursuing academic careers. The job market for geosciences is very strong, depending both on the economy and also on looming retirements for many current geoscientists.

Faculty

In 2010, the Department listed 15 faculty members whose primary graduate focus was in the Department (category 1) and another six who taught in the graduate program (but whose primary graduate appointment was elsewhere). These faculty members include two tier 1 Canada Research Chairs, one Canada Excellence Research Chair (in 2011 outside review period), one University Research Chair and several Research Professors. In addition, faculty include four distinguished professors emeritus and numerous adjunct appointees.

Other awards won by members (or former members) of the Faculty include:

- Order of Canada
- Fellowships in the Geological Association of Canada (3)
- Fellowship in the Canadian Academy of Engineering
- 3M Teaching Fellowship
- University of Waterloo Distinguished Teaching Awards (2)
- University of Waterloo Excellence in Graduate Supervision Award
- University of Waterloo Excellence in Research Award
- M. King Hubbert Award from the National Ground Water Association (4)
- O. E. Meinzer Award from the Geological Society of America (2)
- PREAs (3)

Six of the faculty are professional geoscientists, and four are professional engineers. About a third of the faculty are journal editors or members of editorial boards.

The Department has four administrative staff and another staff member responsible for laboratory teaching in large courses. Additional staff members are funded from research support.

Reviewers’ Report

1. **Consistency with institution’s mission; are program requirements and learning outcomes clear?**

   | Undergrad: No concerns: rich and diverse program |
   | Grad: Quality of research environment and output of student research publications reaching the highest standards |

2. **Admission requirements: aligned with learning outcomes?**

   | Undergrad: No concerns re admission: see |
   | Grad: Recruitment of students outside |
### 3. Curriculum: current? Creativity? Mode of delivery appropriate?

**Undergrad:** Reviewers felt hydrology/hydrogeology/geochemistry is cutting edge; Foundational Geology is under-represented and should be a hiring priority; advised cutting Geophysics Specialization and perhaps Geochemistry program; advice re 2+2, undergraduate research opportunities; see Recommendations 2 through 10

**Grad:** Curriculum is ready for an overhaul (Rec 12) to meet desired learning outcomes (which need to be established). A new multidisciplinary techniques course should be considered (Rec 13)

### 4. Teaching and Assessment: methods of assessment appropriate? Do means of assessment demonstrate achievement of learning objectives and DLE’s?

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<tr>
<th>No concerns</th>
<th>No concerns: quality of student outcomes very high</th>
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### 5. Resources: effective use of human, physical and financial resources?

Labs in hydrogeology and geochemistry are exceptional; current teaching labs near capacity, but expansion is underway

“...quality of water-related research facilities is unparalleled nationally....exceptional training environment”

### 6. Quality Indicators: faculty, student and graduate?

Faculty are internationally recognized experts; possible renewal needed in foundational geosciences; see Rec 11 re. links with alumni

Courses very high quality; Rec 14 discusses allocation of graduate teaching/supervisory load

### 7. Quality of enhancement: initiatives to improve program quality, learning environment?

Support the transition which occurred whereby environmental science moved from Dean’s Office to Department of Biology and Department of Earth and Environmental Sciences

Reviewers did not receive information relevant to this area, but reviewed the quality of the current program (see items 5 and 6 immediately above)
8. Graduate program criteria: time to completion, quality/availability of supervision, program quality indicators for faculty, students, program, sufficiency of graduate-only courses

“lax administration of the students’ progress through their programs..”: see Rec 15 re earlier meetings of students with supervisory committees; see Rec 16 re reviewing program requirements and remedial courses.

9. Other issues (graduate)

Rec 17 re inefficiencies in graduate admissions process; Rec 18 re need for a new Graduate Student Handbook; Rec 19 re making students more aware of resources for instructional skills; Rec 20 re workforce review to reduce burden on staff

Reviewers’ Recommendations, and Departmental Responses

The review was very positive regarding the quality of training, but contained a number of recommendations. The Department felt that the report was thorough and fair, but noted that since the Self Study was completed, some additional changes had occurred. The specific recommendations and responses follow (recommendations are taken verbatim from the review report).

**REC 1**
It is recommended that the Department and the University explore opportunities for recruitment from the Ontario college system through credit transfer agreements.
Response: The Department is already engaged in evaluating transfer possibilities for Sir Sanford Fleming College, one of the few colleges with a geosciences program.

**REC 2**
It is recommended that the Department ensure alignment of minimum program requirements with [Association of Professional Geoscientists of Ontario] APGO standards for professional registration, and communicate APGO standards clearly to students.
It is only programs run outside the Department (e.g. Geochemistry) where there is the issue of not meeting APGO requirements. The Department invites in APGO representatives annually to talk directly with students about current licensure requirements.

**REC 3**
It is recommended that the Department ensure that all undergraduate courses are integrated, and that faculty undertake to maintain an ongoing process of collaborative course renewal that ensures continuity while eliminating gaps and redundancy.
Response: The Department is addressing these curricular issues in a thorough review of the undergraduate curriculum, scheduled to be completed in May 2013.

**REC 4**
It is recommended that the Department undertake to expand opportunities for undergraduate students to engage in undergraduate thesis, co-operative work terms, or other research or employment experiences within the analytical research facilities. Response: Agreed.

REC 5
It is recommended that the Geophysics [program] be discontinued if no additional faculty expertise can be recruited to support the program. Response: Unless additional faculty resources can be obtained, the Department agrees with this recommendation.

REC 6
It is recommended that the Geochemistry Specialization be discontinued. Response: The Department has ascertained that the program cannot be easily modified to fulfill CIC and APGO requirements, and accordingly is moving to discontinue the program.

REC 7
It is recommended that the Department identify essential core areas of foundational earth sciences as priorities in recruitment of faculty. Response: Four recent hires (three replacements and one net new) have been in the core areas of Earth Sciences. However continued attention is necessary with additional likely retirements.

REC 8
We recommend expanding collaborative delivery of courses that meet the needs of both Geoscience and Ecology specializations within the Environmental Science program. Response: Agreed, for discussion with Biology.

REC 9
It is recommended that all faculty be encouraged to take part in Honours Thesis supervision. Response: Agreed.

REC 10
It is recommended that the University Administration re-evaluate admission and student-preparation practices for the China-Canada 2+2 program. Response: Two of the relevant Associate Deans (International Programs, Undergraduate Studies) responsible for the 2+2 program are from Earth Sciences, which will help. However, as of April 1, 2013, there will only be the Associate Dean of Science, International Programs.

REC 11
It is recommended that the Department continue to build relationships with its alumni, development mechanisms for more effectively gathering student feedback on degree completion, and create a means for tracking careers of alumni. Response: The Department is actively building and nurturing relationships with its alumni, as show by a recently mounted first class reunion, fundraising for two endowments for
scholarships from alumni, and alumni mentoring current students, so this suggestion is welcomed.

**REC 12**
*Now is the time to realign graduate course offerings with the realities of existing Departmental complement and expertise, and with desired student learning outcomes.*
Response: The Department recognizes the need to undertake a comprehensive review of the graduate curriculum in 2013.

**REC 13**
*It is recommended that the new graduate curriculum include a multidisciplinary “techniques” course that exposes students to diverse, advanced analytical techniques in the earth and environmental sciences.*
Response: The Department will consider carefully this suggestion. It is noted that a course on GIS and data analysis will be developed and offered in the near future.

**REC 14**
*Graduate course delivery needs to be more equably distributed across the department.*
Response: The graduate curriculum review will provide a basis to affirm that all faculty have the opportunity to teach courses, and to encourage the redesign of courses where enrolment has been low.

**REC 15**
*It should be absolutely a requirement that students meet with their complete supervisory committee within weeks of arrival, in order to lay out the necessary program of study, courses and research.*
Response: The Department undertakes to make sure all student committees meet at least once a year (but makes no specific response to the recommendation that this occur earlier during the student’s period of study).

**REC 16**
*It is recommended that the requirement for remedial undergraduate training in Earth sciences [for new graduate students] be re-evaluated at this time in order to allow for consideration of the context of a student’s specific research plans, recognizing the increasingly interdisciplinary nature of earth science research and faculty specializations within the Department.*
Response: For further examination.

**REC 17**
*It is recommended that the graduate admissions processes be investigated, with a view to elimination of unnecessary procedures and inefficiencies, and to rapid turnaround of offers of admission.*
Response: This is largely beyond control of the department. Expansion of support staff in the Dean of Science office is underway and will serve us greatly to alleviate any issues with admissions.
**REC 18**

*It is recommended that the Department place a high priority on preparing a new, comprehensive Graduate Student Handbook.*

Response: An updated handbook has been distributed in hard copy to students, and will soon be online.

**REC 19**

*It is recommended that the Department foster awareness of instructional support services available at the UofW, and work with the Centre for Teaching Excellence to create opportunities for graduate students to increase their instructional skills.*

Response: These materials will be handed out to incoming students.

**REC 20**

*It is recommended that the Department undertake a workforce review in order to seek efficiencies and eliminate unnecessary complexities in order to ease the burden on a dedicated and hard-working staff.*

Response: The department will endeavor to streamline activities as best it can with the resources it currently has.

**Two-Year Plan**

By August 31 2015, the Department will report on the following steps/issues:

**UNDERGRADUATE PROGRAM**

1. Any steps taken with regard to entry of students from cognate programs at colleges;
2. Outcomes of the undergraduate curriculum review scheduled to end in May 2013 (e.g. new courses, courses discontinued, fate of the Geophysics Specialization, fate of the Geochemistry program);
3. Numbers of co-op students employed in the Department in research positions in 2011/12, 2012/13, 2013/14 and 2014/15 years (individual academic year data, to see any trend);
4. Any decision taken regarding discontinuing the Geophysics specialization;
5. Since the program cannot readily be modified to meet CIC/APGO accreditation requirements, the specialization will be discontinued;
6. The number of retirements from July 2013 onwards, and how the areas of replacement faculty match with the essential core requirements of Earth Science;
7. The number of undergraduate projects/theses for each of the faculty members listed as Category 1 in the graduate program, for academic years 2012/13, 2013/14 and 2014/15 combined; and
8. Progress regarding the Alumni Reunion scheduled for the 2015 50th Anniversary.

**GRADUATE PROGRAM**

9. The Learning Outcomes established for the Masters and PhD programs; and following the curriculum review the number of courses which are discontinued, and the number of new courses/major course changes;
10. The Department's decision regarding whether or not to establish a techniques course;
11. The proportion of Masters students who meet with their full committee by end of term 2;
   the proportion of PhD students who meet with their full committee by end of term 3; and
   whether or not the Department wishes to change the PhD requirement to the end of term 2.
12. The average processing time for graduate applications for fall 2013 entry, compared to that
   for fall 2015 entry (data can be obtained from GSO or OnBase).
13. The URL for the Graduate Student Handbook

Timelines

Review visit by Dr. Jim Basinger (University of Saskatchewan) and Dr. Andrew Miall (University
of Toronto) December 4-5 2012
Review report received by GSO December 7, 2012
Departmental response received by GSO February 21, 2013
Discussed at Senate Undergraduate Council April 24, 2013
Discussed at Senate Graduate and Research Council April 23, 2013
Received by Senate May 21, 2013