FOR CONFIRMATION **PUBLIC** **CLOSED SESSION**

TO:	Executive Committee
SPONSOR:	Professor Susan McCahan, Vice-Provost, Academic Programs
CONTACT INFO:	(416) 978-0490, vp.academicprograms@utoronto.ca
PRESENTER:	Professor Cheryl Regehr, Vice-President & Provost
CONTACT INFO:	provost@utoronto.ca
DATE:	March 15, 2022 for March 22, 2022
AGENDA ITEM:	4 (b)

ITEM IDENTIFICATION:

New Graduate Program Proposal: Master of Science (MSc) in Environmental Science, University of Toronto Scarborough.

JURISDICTIONAL INFORMATION:

The Committee on Academic Policy and Programs has the authority to recommend to the Academic Board for approval new graduate programs and degrees. *(AP&P Terms of Reference, Section 4.4.a.ii)*

GOVERNANCE PATH:

1. UTSC Academic Affairs Committee [For Recommendation] (February 9, 2022)
2. Committee on Academic Policy and Programs [for recommendation] (February 17, 2022)
3. Academic Board [for approval] (March 10, 2022)
4. **Executive Committee [for confirmation] (March 22, 2022)**

PREVIOUS ACTION TAKEN:

The proposal for the Master of Science in Environmental Science received approval from the University of Toronto Scarborough Academic Affairs Committee on February 9, 2022.

HIGHLIGHTS:

This is a proposal for a research master's degree called Master of Science (MSc) in Environmental Science, to be offered by the Graduate Department of Physical and Environmental Sciences at the University of Toronto Scarborough (UTSC). The program is four sessions and full-time only. Students will complete 1.5 full-course equivalents (FCEs): 1.0 FCE in core courses and one

elective course (0.5 FCE). Students will also complete a thesis. The start date of the program is May (Summer session) which allows for the early immersion of students into research.

The purpose of the MSc in Environmental Science is to train Bachelor of Science or Engineering graduates in the design, execution and dissemination of research that is focused on the interfaces between traditional disciplines in dealing with fundamentally scientific, environment-focused issues. The MSc in Environmental Science will allow students to address major emerging research themes in the environment and pursue projects that make use of complementary research concepts, approaches and tools. Faculty members are cross-appointed from several graduate units including: Cell and Systems Biology; Chemical Engineering and Applied Chemistry; Chemistry; Earth Sciences; Ecology and Evolutionary Biology; Geography and Planning; Forestry; and Physics, which ensures the supervision of research projects across a broad range of expertise and research facilities. This program will engage these strengths in order to foster research that is critical for finding solutions to, or elucidating the root causes of, today's critical environmental challenges.

The program will be delivered in person. The program is expected to achieve a steady-state intake of 15 students per year within three years of launching.

Consultation outside UTSC occurred with the Faculty of Applied Science and Engineering; Faculty of Arts and Science; John H. Daniels Faculty of Architecture, Landscape, and Design; University of Toronto Mississauga; and the Tri-Campus Deans group. The feedback provided was incorporated into the proposal.

The program was subject to an external appraisal from October 21 to 25, 2021 by Professors Edward Hornibrook, Department of Earth, Environment and Geographic Sciences, University of British Columbia and Sara Hotchkiss, Department of Botany, University of Wisconsin-Madison. The appraisers made one suggestion, which has been adopted as described in the Dean's administrative response to the appraisal report.

FINANCIAL IMPLICATIONS:

The new financial obligations resulting from this program will be met at the divisional level.

RECOMMENDATION:

Be it confirmed by the Executive Committee

THAT the proposed degree program, Master of Science (MSc) in Environmental Science as described in the proposal from the University of Toronto Scarborough dated January 26, 2022 be approved effective May 1, 2023.

DOCUMENTATION PROVIDED:

- *Proposal for a Master of Science in Environmental Science*

UNIVERSITY OF TORONTO

University of Toronto
New Graduate Program Proposal

Full name of proposed program:	Master of Science in Environmental Science
Degree name and short form:	M.Sc.
Program name:	Environmental Science
Professional program:	No
Unit (if applicable) offering the program:	Graduate unit: Graduate Department of Physical and Environmental Sciences (GDPES)* *Note: this is an existing graduate unit. Budgetary academic unit: Department of Physical and Environmental Sciences (DPES)
Faculty/division:	University of Toronto Scarborough (UTSC)
Dean's Office contact:	• Mary Silcox; Vice-Dean Graduate & Postdoctoral Studies; vdgraduate.utsc@utoronto.ca • Annette Knott; Academic Programs Officer; annette.knott@utoronto.ca
Proponent:	Dr. George Archontitsis, Graduate Chair
Version date: (please change as you edit this proposal)	January 26, 2022

Development & Approval Steps	**Date**
New Program Consultation Meeting	March 29, 2019
Consultation Proponents/Dean's Office/Provost's Office	
Provost's Advisory Group	June 16, 2021
External Appraisal (Remote Site-Visit)	October 21, 25 and 29, 2021
Decanal signoff *In signing off I confirm that I have ensured appropriate:* ✓ compliance with the evaluation criteria listed in UTQAP section 2.3 ✓ consultation with the Office of the Vice-Provost, Academic Programs early in the process of proposal development ✓ Consultation with faculty and students, other University divisions and external institutions	Professor William A. Gough, Vice-Principal Academic and Dean, University of Toronto Scarborough: September 24, 2021
Provostial signoff *In signing off I confirm that the new program proposal:* ✓ Is complete ✓ Includes information on all the evaluation criteria listed in UTQAP section 2.3	Professor Susan McCahan, Vice-Provost, Academic Programs, University of Toronto: October 5, 2021
Unit-level approval (if required)	Departmental Curriculum Committee: October 8, 2020
Faculty/divisional governance – UTSC Academic Affairs Committee	Feburary 9, 2022
Submission to Provost's Office	
AP&P	February 17, 2022
Academic Board	March 10, 2022
Executive Committee of Governing Council	March 22, 2002
The program may begin advertising as long as any material includes the clear statement that, "No offer of admissions will be made to the program pending final approval by the Quality Council and the Ministry of Training, Colleges and Universities (where the latter is required)."	
Ontario Quality Council	April 1, 2022
Submitted to the Ministry (in case of a new graduate degrees and programs, new diplomas)	[date]

New Graduate Program Proposal

Master of Science (M.Sc.) in Environmental Science

Graduate Department of Physical and Environmental Sciences

University of Toronto Scarborough (UTSC)

Table of Contents

1 Executive Summary

Please provide a brief overview of the proposed program summarizing the key points from each section of the proposal. (You may wish to complete this section last.) This may need to be used on a stand-alone basis:

This is a proposal to introduce a new Master of Science (M.Sc.) in Environmental Science, which will be housed in, and administered by, the Graduate Department of Physical and Environmental Sciences (GDPES) at the University of Toronto Scarborough (UTSC). The M.Sc. in Environmental Science will be a 16-month program with a May start date, to allow for an early immersion in original research. This design feature of the program is essential because fieldwork is a critical component of many projects in Environmental Science, and in the Canadian context must often be completed in the spring and summer.

The planet is currently facing an environmental crisis. The nature of this crisis is multi-faceted, including global climate change, burgeoning population numbers, and threats to our forests, waterways, soil, and biodiversity resulting from human activities, such as natural resource extraction, pollution, biodiversity loss, and land-use change. The complex interactions between different earth systems require an integrated, inter-disciplinary approach to environmental science that creates bridges between traditional disciplines such as geography, biology, chemistry, and physics.

The University of Toronto follows a two-pronged approach to the study of the environment, which encompasses the development of both transdisciplinary and interdisciplinary programs. At UTSC, successful existing graduate offerings in GDPES include the professional Master of Environmental Science (M.Env.Sc.; 919 graduates, since the program start in 2006) and Ph.D. in Environmental Science (36 graduates, since the program start in 2010). The proposed M.Sc. in Environmental Science is a logical complement to these programs, offering a more research-intensive approach than the M.Env.Sc., but a shorter timeline and more compact structure than the Ph.D. It is anticipated that the M.Sc. will equip students to seek research positions in industry, but also train students to enter the Ph.D. program in Environmental Science with a strong foundation in performing original research.

Within the University of Toronto context, the proposed M.Sc. in Environmental Science is distinct from related graduate programs in its strong emphasis on original scientific data collection, requiring students to enter the program with some experience in applying scientific methods so that they can start doing original research in their first semester. Students will complete 1.5 full-course equivalents (FCEs) of coursework, including a new course in

Environmental Science Research Experience (EES 1200H), which is explicitly designed to give students a running start conducting research in their first semester. Students will also complete a master's thesis, with the intention that it will represent either a piece of publishable research or a contribution to a larger study that will be published.

Students in the M.Sc. in Environmental Science will benefit from access to more than 50 faculty (and 15 adjunct faculty) who will contribute to the delivery of the program, and from the high-quality facilities in the Environmental Science and Chemistry Building at UTSC. This includes, for example, the Teaching and Research in Analytical Chemistry and Environmental Sciences (TRACES) facility, which houses over 40 state-of-the-art instruments.

The proposed M.Sc. aims to meet the high demand for individuals trained in environmental research, evinced in the growing demand (approximately 8%) for environmental employees, translating to a forecasted need of more than 50,000 jobs in the next decade (ECO Canada 2020).

2 Effective Date & Date of First Review

Anticipated date students will start the program: May 2023.

First date degree program will undergo a UTQAP review and with which unit:[1]

In accordance with the University of Toronto Quality Assurance Process (UTQAP) all programs are reviewed on an eight-year cycle. The next review of the Department of Physical and Environmental Sciences (DPES) and Graduate Department of Physical and Environmental Sciences (GDPES) and their undergraduate and graduate programs is scheduled for 2023-24; the proposed M.Sc. will be included in that review process. Since the review will occur within four years of the May 2023 start date, the review will stand in for the monitoring report required through the UTQAP.

Graduate unit: Graduate Department of Physical and Environmental Sciences (GDPES)
Budgetary academic unit: Department of Physical and Environmental Sciences (DPES)

[1] Programs that are inter-and multidisciplinary must identify a permanent lead administrative division and identify a commissioning officer for future cyclical program reviews.

3 Academic Rationale

Please use the headings below:

- Identify what is being proposed and provide an academic rationale for the proposed program (what is being created and why?).
- Explain the appropriateness of the program name and degree nomenclature.
- If relevant, describe the mode of delivery (including blended or online, placement, etc.) and how it is appropriate to support students in achieving the learning outcomes of the program.
- Context
  - Discuss how the program addresses the current state of the discipline or area of study. (Identify pedagogical and other issues giving rise to the creation of this program. Where appropriate, speak to changes in the area of study or student needs that may have given rise to this development.)
  - Describe the consistency of the program with the University's mission as specified within the *Statement of Institutional Purpose* and unit/divisional academic plan and priorities.
- Distinctiveness
  - Identify any unique curriculum or program innovations or creative components.

Proposed Program

UTSC is proposing a new research-intensive Master of Science (M.Sc.) program in Environmental Science. This will be a 16-month program with a unique May start date that will allow students to collect substantive original data towards the completion of their M.Sc. thesis.

The purpose of the proposed program is to train students in the design, execution, and dissemination of research in environmental science. By definition, environmental science is an interdisciplinary, but natural science-based subject that falls outside of, or between, the boundaries of traditional academic disciplines, and which is applied to environmental problems. Based on experiences in the successful tri-campus graduate programs in Environmental Science offered by GDPES — the professional Master of Environmental Science (M.Env.Sc.), and the Ph.D. in Environmental Science — current issues and concerns surrounding environmental sciences attract students whose interests and backgrounds transcend traditional academic boundaries such as earth sciences, chemistry, biology, engineering, geography, or physics. The proposed M.Sc. will allow students to address major emerging research themes in the environment and pursue projects that make use of complementary

research concepts, approaches, and tools. This program will provide access to a broad range of faculty expertise, facilities, and courses, which have been cultivated explicitly to facilitate interdisciplinary environmental research. A key goal of the proposed M.Sc. is to engage these strengths in order to foster research that is critical for finding solutions to, or elucidating the root causes of, today's critical environmental challenges.

The pillars of the proposed program are: (i) cultivation of a synthetic perspective that effectively draws upon both the breadth of environmental science and the depth of knowledge required to specialize in a specific sub-discipline area; (ii) nurturing of critical thinking that impartially distinguishes between true knowledge produced and the multitude of sources of uncertainty typically characterizing environment systems; (iii) a unique timeframe that is conducive to successfully undertaking research in environmental science by providing two field seasons (terms 1 and 4), when students can create the required dataset(s) to address their research questions/hypotheses; (iv) a rich array of course offerings, taught by internationally renowned experts, through which students have the opportunity to delve into hydrology, environmental chemistry, ecology, geology, climatology, and mathematical/statistical modelling; (v) a high-profile colloquium that allows students to improve their communication/presentation skills and facilitate the dissemination of their research findings; and (vi) the intellectually stimulating environment that characterizes the Graduate Department of Physical and Environmental Sciences, which is a recognized research powerhouse within the University of Toronto system with outstanding annual research output (peer-reviewed publications, research grants, awards, etc).

The Graduate Department of Physical and Environmental Sciences has very successfully administered a large-enrolment, course-based Master's program (the M.Env.Sc.) since 2006 and a Ph.D. program in Environmental Science since 2010. These programs were reviewed under the UTQAP in 2015-16 and received very high praise from the review team. To date, 919 M.Env.Sc. and 36 Ph.D. students have successfully completed their programs. These graduates have gone on to successful careers with government, non-government organizations and charities, private companies such as consulting firms, academia, and as self-employed environmental entrepreneurs. The M.Env.Sc. program, in particular, boasts a 100% internship secure rate over its history, both due to dedicated staff and to close connections between faculty and the environmental sector/industry in Ontario and elsewhere. The undergraduate-focused Department of Physical and Environmental Sciences (DPES) also has a large contingent of environmental science Specialist, Major, and Minor programs. These programs have experienced significant growth over the past 5 years (>700 students), which is collectively the result of departmental efforts to improve their quality through, for example: i) gaining accreditation of the Specialist and Major programs from ECO Canada; ii) the creation of a set of

extremely rigorous Combined Degree Programs for the Specialist programs in Environmental Science with the Master of Engineering offered by the Faculty of Applied Science and Engineering (FASE) at the University of Toronto; iii) the revamping of the Specialist Program in Environmental Geoscience to meet the requirements of the Association of Professional Geoscientists of Ontario (APGO) for obtaining PGeo certification; iv) the revamping of the Specialist Program in Environmental Biology to establish it as one of the leading academic programs in Global Change Biology, planned for 2022-23; and v) the addition of a Minor program in Natural Sciences and Environmental Management. In short, the host graduate department (GDPES), sister undergraduate department (DPES), and division (UTSC) already demonstrate strong leadership in formulating and delivering interdisciplinary graduate and undergraduate programs in the environmental sciences at U of T. The proposed M.Sc. in Environmental Science is a logical next step in program development, and will be ideal for students seeking a more research-focused master's degree than can be achieved through the M.Env.Sc. It is anticipated that it will be a sought-after program for high-achieving undergraduates. It is also a natural complement to the existing tri-campus Ph.D. for those master's students looking to continue with their graduate studies.

Appropriateness of the Program Name and Degree Nomenclature

The program name and degree nomenclature is: Master of Science (M.Sc.) in Environmental Science.

The program is research-intensive and requires entering students to have the foundations of an undergraduate degree based in the sciences or engineering; hence, the Master of Science credential is most appropriate. In addition, students will complete courses and research focused on environmental science, which is an interdisciplinary, but natural science-based subject that seeks to provide science-based evidence for understanding and providing solutions to environmental issues.

The proposed M.Sc. is perfectly designed to address the needs of high-achieving students seeking a more intensive research-focused master's degree relative to the M.Env.Sc. program. This program is also a natural partner to the existing and successful tri-campus Ph.D. program in Environmental Science, for graduate students who are determined to invest additional time in research and continue their education at the doctoral level. Currently, there is no research-based M.Sc. program in support of the Ph.D. program. The addition of the M.Sc. to the existing offerings (M.Env.Sc., Ph.D.), will augment the GDPES's already strong offerings in environmental education and research.

For the reasons outlined above, there is national and international demand for research in environmental science. The proposed M.Sc. will:

- Provide an opportunity at the University for students who want to pursue a Master of Science degree program in environmental science. Currently, students seeking a M.Sc. program focused on environmental science are likely to go to other universities.
- Provide a shorter-term (16-month) opportunity that will be attractive to high-quality students wishing to pursue research in the environmental sciences, but who are not yet ready to make the financial and time commitments associated with a four- to five-year Ph.D. program. In this way, the proposed program will allow talented students that are trained in environmental research to make a more informed decision as to whether they wish to pursue doctoral-level studies.
- Allow graduate-level research in the environmental sciences at UTSC that facilitates progression into the Ph.D. in Environmental Science program, for students who choose to make the financial and time commitment.
- Foster interdisciplinary research project ideas among tri-campus graduate faculty. More specifically, to provide a viable option for shorter-term highly qualified personnel (HQP) training in research that is in especially novel, or emerging, environmental themes, and/or is associated with novel research funding calls, for example: requests for proposals related to Arctic research for emerging pollutants, cumulative impact of climate change on ecosystem phenology, the Great Lakes Sustainability Fund in Areas of Concern, the Great Lakes Protection Initiative, etc. The lifetime of these funding opportunities is relatively short (1–2 years) and is thus perfectly aligned with M.Sc. projects that allow students to delve into cutting-edge research that often reflects the priorities of the Federal or Provincial Government.
- Provide a unique approach to M.Sc. education wherein students begin the program with one-on-one mentoring in research.

The proposed M.Sc. is fully aligned with the University's mission, which says in its *Statement of Institutional Purpose*: "The University of Toronto is committed to being an internationally significant research university, with undergraduate, graduate, and professional programs of excellent quality." It will serve as an important addition to the University's expertise in environmental science by offering a research-intensive, science-focused, Master of Science program. It builds on, and broadens the range of, the excellent programs that already exist in environmental science at the wider University, including the M.Env.Sc. and Ph.D. in Environmental Science. Finally, it promotes high-quality research, and responds to new research in environmental science; as noted above, the purpose of the proposed M.Sc. is to train students in the design, execution, and dissemination of research in environmental science.

The proposed M.Sc. is also aligned with UTSC academic priorities. Indeed, the development of locally administered graduate programs has been at the forefront of campus academic planning for the past five years; in this regard, GDPES has been a campus/faculty leader. Under the *UTSC Strategic Plan: Inspiring Inclusive Excellence* (2020-2025), one of the campus imperatives is: "To augment U of T's global standing through scholarly prominence and exceptional learning in unique areas of established and emerging strength." The proposed program will support two key priorities of the *Strategic Plan*. The first priority is 'innovative, high-quality undergraduate and graduate student experience and success,' which includes this strategic direction: "Develop academic programs that make University of Toronto Scarborough an exemplar of life-long learning and expand opportunities for non-traditional students." The second priority is 'scholarly prominence in established and emerging areas,' which includes this strategic direction: "Enhance and grow current and emerging areas of research strength that will differentiate University of Toronto Scarborough as a global research leader in those fields."

Finally, the proposed M.Sc. is aligned with the departmental academic priorities of the GDPES, as they are outlined in the self-study for the 2015-16 external review of the graduate programs. In the self-study it states: "There is now a growing desire among the faculty to establish a research-based Master of Environmental Science that allows students to be trained in environmental research, free of the time commitment and career directions associated with the Ph.D. program."

The proposed M.Sc. will be an important addition to the suite of graduate programs focused on environmental issues at the University. It will fill an existing gap in the University's offerings by providing a science-focused and research-intensive graduate program in environmental science, which is distinct from other graduate programs at the University that are more focused on environmental studies, sustainability, and environmental management (see section 5, Table 1 and Appendix E). While environmental science encompasses an interdisciplinary research approach, it remains fundamentally rooted in the scientific method. In consultations with the directors of the other environment-related graduate programs at the University, there is collective agreement that the proposed program fills an important and distinct niche in graduate environment-related offerings at the University — an explicitly science-focused research program based on environmental issues. Further discussion of this issue can be found in section 5, below.

Distinctiveness

A distinctive design feature of the proposed M.Sc. is the May start, which allows for the early immersion of students into the research process. This early immersion will engage students to learn about research using a hands-on approach and a more prescribed supervisor-mentee relationship than would exist for a Ph.D. or in most other Master's programs. As part of this early immersion, faculty supervisors will collectively contribute to a workshop at the start of the M.Sc. program so that incoming students will receive additional direction regarding conducting environmental science research, which complements their individual mentor's supervision. The early start also allows environmental science students, many of whom rely on the May–August time period for new data collection, to collect one and possibly two season's worth of data to include in a scientifically rigorous thesis. This provides an open forum for students to learn from mistakes made early in the research process, while still leaving time to recover from them. To facilitate this early start, the program admission process will be rigorous and will aim to engage students truly interested in research by offering clear opportunities for early immersion into ongoing or new research projects led by graduate faculty; for more information see section 8 (Program Design), below.

The tri-campus Graduate Department of Physical and Environmental Sciences is uniquely prepared to support this program because it brings together the combined strengths of graduate faculty engaged in environmental science research from all three University of Toronto campuses to offer a full range of professional and doctoral-stream programs supported by critical facilities housed at UTSC.

4 Fields/Concentrations

- Description of fields/concentrations, if any. (Please note: graduate programs are not required to have fields/concentrations in order to highlight an area of strength or specialization within a program.)

None.

5 Need and Demand

- Provide a brief description of the need and demand for the proposed program and how this has been determined, focusing, as appropriate, on:
  - student interest

  - societal need
  - employment opportunities for prospective graduates
  - interest expressed by potential employers
  - professional associations
  - government agencies or policy bodies.
- How is the program distinct from other programs at U of T? (Address, if relevant, how this program might affect enrolment in other related programs offered here.)
- With specific reference to the impact on need and demand, describe how the proposed program relates to (is similar to or different from) existing programs offered by other universities in North America and Internationally (with specific reference to Canadian and Ontario examples). Please fill out and refer to the table in appendix E listing the comparator programs.

Societal Need

Highly trained employees in environmental science continue to be in high demand according to ECO (Environmental Careers Organization) Canada's job trends report for 2014-2017 (ECO Canada, 2018). While Canada saw an overall, year-to-year increase of 7% in the number of job ads, the increase in environment-related job ads was considerably greater at 17%. The ECO Canada report (2018) links these increases to: continued excellence in the Canadian job market overall; growth in industries that employ environmental workers, such as manufacturing (Manufacturing Technologists, Hazardous Waste Technicians); professional, scientific, and technical services (Corporate Sustainability Interns, Green Building Interns, Environmental Policy Analysts, Knowledge and Research Interns, Hazardous Air Pollutants Technicians, Junior Environmental GIS Specialists, Environmental Monitoring Technician/Officers, Landscape and Assessment Officers); public administration and construction (Assistant Auditors, Client Service Representatives, Junior Environmental Planners, Transportation Division Interns); and the implementation of climate change plans (Climate Action Interns, Adaptation Specialists, Climate Information Research Assistants) by all levels of government.

It is anticipated that students will apply to the proposed M.Sc. in Environmental Science from Bachelor of Science and Bachelor of Engineering degrees, across a number of natural and applied science fields. The program will enable two pathways post-graduation: one toward gaining employment in the professional environment sector, and the second leading to further graduate research and studies at the Ph.D. level, including the Ph.D. in Environmental Science located in the GDPES, which will be significantly facilitated by having had an experience in rigorous research at the master's level.

Student Demand

Demand for research opportunities in the environmental sciences is high, as evidenced by both the enrolment numbers in the Ph.D. in Environmental Science, as well as by the tremendous success of students in the program. Currently there is a steady-state of approximately 54 Ph.D. students and there have been 36 doctoral graduates since the start of the program in 2010. Student interest in novel scientific and technological solutions to pressing environmental issues is significantly on the rise. A research-based M.Sc. program will meet this demand for the large portion of graduates who are not seeking, or may not immediately be seeking, a five-year commitment to further study.

In addition to providing a preparatory experience for pursuing Ph.D. studies, the proposed M.Sc. in Environmental Science will meet demand for applied training needed for employment in several environmental fields. In particular, many research careers in government, industry, and environmental consulting now demand advanced, research-based degrees in environmental science. Some students may even become entrepreneurs if their research has involved marketable ideas. Graduates of the proposed M.Sc. will have in-depth, specific technical knowledge skills related to their area of expertise that will be applicable to a variety of technological innovations (e.g., bioremediation, analytical chemistry and monitoring, renewable energy, carbon sequestration, agroforestry, groundwater assessments, ecosystem monitoring and restorations).

An indication of the demand for the proposed M.Sc. can also be inferred from the large number of applications and significant competition for positions in the professional M.Env.Sc. program. Over the past five years for example, the M.Env.Sc. has received on average 240 applications per year, and on average 80 students have been admitted annually. This increasing interest in master's level environmental science education characterizes both the internship and research options in the M.Env.Sc. program.

To further assess student demand for the proposed M.Sc., both current undergraduate environmental science program students at UTSC and current Ph.D. in Environmental Science students at UTSC were surveyed; 57 responses from undergraduate students and 32 responses from current doctoral students were received (see Appendix F for survey results). Undergraduate students were overwhelmingly interested in a research-oriented M.Sc. degree in environmental science. 84% of undergraduate respondents said they were "possibly," "likely," or "definitely" interested in pursing a graduate degree after graduation; 91% of respondents were potentially interested ("possibly," "likely," or "definitely") in applying for the

proposed M.Sc., with 30% of respondents saying they would “definitely” be interested in applying. Importantly, despite a broad range of degree years among respondents, 25% of students describe having had the type of research experience that would be required for entry into the proposed M.Sc. program. This is a relatively high proportion, indicating a substantial probability of finding qualified students.

Current Ph.D. in Environmental Science students were also very positive about the proposed M.Sc. program. 50% of respondents said they likely would have applied to the proposed program, ahead of their Ph.D., had it been available at the time. This is a substantial proportion given most students already hold a M.Sc. For the formative questions on the survey about whether the proposed program structure allows for the achievement of the important learning objectives of a M.Sc., responses were overwhelmingly positive (80–90+ %) as “somewhat” or “entirely” agree.

Distinctiveness From Other Programs at U of T

The University of Toronto supports a strong a suite of graduate programs across the environment-related spectrum that specifically cater to distinct groups of students, including: the Master of Environmental Science (M.Env.Sc.) — University of Toronto Scarborough; the Master of Science in Sustainability Management (M.Sc.S.M.) — University of Toronto Mississauga; and the Master of Environment and Sustainability (M.E.S.) — Faculty of Arts and Science.

The proposed M.Sc. in Environmental Science will be an important, distinct offering within this suite of programs. It will serve students seeking natural sciences-based, research-intensive training related to environmental problems. It also has a highly-distinctive early research immersion model that sets it apart from the other environment-related programs at U of T. As a 16-month program with a May start, it recognizes the fact that many aspects of environmental science research are carried out and/or supported in the summer months.

This rich array of graduate offerings has been planned carefully to ensure that each program has distinct learning objectives, and targets distinct pools of prospective students. The directors responsible for the M.Env.Sc., M.Sc.SM., M.E.S., and the proposed M.Sc. have mapped the offerings to ensure that students can choose the program that best suits their learning objectives, academic background, and career plans (see Table 1, below). The key points of distinction between the proposed M.Sc. in Environmental Science and other environment-related master’s programs at U of T are highlighted below:

Masters of Environmental Science (M.Env.Sc. — UTSC)
This is a professional, course-based master's program that is research informed, but not research intensive. This is a large enrolment (80–100 students annually) program in which most students choose an "internship option" for the final 4 months of their 12-month program while approximately 6–10 students annually choose a 4-month "research option." The research option in the M.Env.Sc. has the primary goal of training students in one or two very specific research techniques. Students who already have significant work experience will typically choose the research option because it gives them the opportunity to learn a specific skill or technique; this is as compared to students wanting to secure a position who will typically choose the internship option. The "research option" in the M.Env.Sc. will be maintained because it serves an important, but fundamentally different purpose than the longer and more research-intensive experience that students will obtain in the proposed M.Sc. in Environmental Science.

Master of Science in Sustainability Management, Institute of Management Innovation, University of Toronto Mississauga (UTM) (M.Sc.S.M.)
This is a course-based program that provides training to act outside traditional disciplines, integrating knowledge from management, social, and natural sciences to address sustainability issues and to make advances in sustainability management. The program is intended to provide a strong foundation in sustainability management while offering an opportunity to specialize in a management or science concentration. The program admits students from diverse academic backgrounds and is aimed at individuals who want to pursue a management career in sustainability-related divisions and organizations. As such, it differs from the explicit research-intensive focus of the proposed M.Sc. in Environmental Science.

Master of Environment and Sustainability, School of the Environment, Faculty of Arts and Science (M.E.S.)
This is a research-based master's program focusing on transdisciplinary research in problems related to environment and sustainability. It is intended for students who wish to pursue a broad transdisciplinary research degree that explores issues related to the environment and sustainability through the multiple perspectives of the social sciences, humanities, and natural sciences. Admissions requirements are broader than the proposed M.Sc. in Environmental Science because graduates of either an Honours Bachelor of Science or a Honours Bachelor of Arts may be admitted. This program responds to a broader international trend to re-focus environmental studies programs to respond to the sustainability challenges of the 21st century. Learning objectives in this program differ from the proposed M.Sc. — most distinctively because the M.E.S. focuses on approaches and techniques for sustainability and the proposed

M.Sc. focuses on approaches and techniques for environmental science data generation and research. This program will launch in September 2022.

Master of Forest Conservation, Graduate Department of Forestry, John H. Daniels Faculty of Architecture, Landscape, and Design (M.F.C.)
This professional, course-based 16-month program has been accredited by the Canadian Forestry Accreditation Board and has a strong focus on field and laboratory practical training, field courses, practical internships, and individual and group research. The intention of the program is to provide a strong, coherent professional education in forest conservation to students from diverse educational backgrounds.

Master of Science in Forestry, Graduate Department of Forestry, John H. Daniels Faculty of Architecture, Landscape, and Design (M.Sc.F.)
In this research-stream program, students conduct focused research under the supervision of a faculty member. Faculty members' research is often interdisciplinary and applied in nature, distilling the utility and impact of discoveries and enabling partnerships with the public, private, and non-profit sectors. Research interests in the program include forest conservation biology, invasive species and threats to forest health, fire and ecosystem management, urban forestry, forest biomaterials science, and bioenergy.

Students entering both forestry programs have specific interests in forestry and forest conservation. We have not included either the M.F.C or M.Sc.F. programs in the graduate environment programs "map" in Table 1 because they are disciplinarily distinct from the offerings of the other programs.

In addition to these graduate programs, the University of Toronto offers two Collaborative Specializations. The Collaborative Specialization in Environmental Studies examines environmental-related issues from different disciplinary perspectives in order to gain insights about the importance of understanding and applying interdisciplinary approaches and methodological concepts and tools in environmental decision making. The Collaborative Specialization in Environment and Health focuses on understanding the human health implications of chemical, biological, and physical hazards in the environment, it encompasses topics such as the health impacts of air and water quality, climate change, contaminated lands, and urban design, and the need for interdisciplinary approaches to address them. Both Collaborative Specializations are offered through the Faculty of Arts and Science's School of the Environment. Collaborative Specializations provide an additional multidisciplinary experience for students enrolled in and completing a participating degree program. They offer

opportunities for students completing different degree programs to do some research and training in the area and do not lead to a separate degree in the area.

Comparator Programs: National and International

Institutionally U of T is recognized as having existing research strength in the area of environmental science; for example, U of T ranks 31 in the 2021 QS World University Rankings in Environmental Sciences (2021). The proposed program will leverage that existing strength in the more specific subfield of environmental science. Appendix E and the summary below provide a comparison, and highlight critical contrasts, to similar Canadian and international programs.

Ontario and Canada

In line with the importance of this subject area, there are multiple programs in Ontario and Canada that are focused on different aspects of sustainability and environmental studies. In Ontario, the University of Guelph, University of Windsor, and Nippissing University offer M.Sc. programs in Environmental Science. Trent University offers a M.Sc. in Environmental and Life Sciences. Finally, the University of Waterloo offers an interdisciplinary, environment-focused M.Sc. degree program in Environmental Science that is housed in the Department of Geography and Environmental Management. In Canada, Memorial University of Newfoundland, University of Lethbridge, Thompson Rivers University, and the University of Prince Edward Island offer M.Sc. degrees specifically in Environmental Science, while UBC-Okanagan offers a M.Sc. degree in Earth and Environmental Sciences. The UBC Vancouver campus offers a M.Sc. in Resources, Environment, and Sustainability. Finally, McGill University has a 'graduate option' in Environment, but they do not have a direct M.Sc. in Environmental Science.

Compared to other programs provincially and nationally, the proposed program distinguishes itself through its early immersion of students into the research process, strong academic rigour focused on scientific approaches to environmental problems, and unique timeline that allows for the completion of comprehensive research projects in 16 months. Similar to the programs identified above, the proposed M.Sc. in Environmental Science has a relatively similar course and thesis focus; however, it differs from these programs with respect to the specific research that can be supported by faculty, by the comparably large number of graduate courses available, by its unique research-focused timeline, and especially through its support from a strong doctoral-stream program that leverages advantages such as being situated within a large U of T community of cognate graduate programs. In addition to in-program offerings, this

offers even greater breadth and extensive opportunities for seminars, as well as access to diverse expertise and collaboration.

U.S. and International Universities

According to the QS rankings, Stanford University, Massachusetts Institute of Technology (MIT), and the University of California, Berkeley are the top-3 schools offering graduate programs in environmental science. Stanford's School of Earth, Energy, and Environmental Sciences offers a number of environment-related graduate programs, including a geosciences-focused M.Sc. in Earth Systems. MIT's Department of Earth, Atmosphere, and Planetary Sciences offers as a two-year Master of Science (S.M.) degree. The University of California, Berkeley offers a M.Sc. program in Environmental Health Sciences and a Ph.D. (but no M.Sc.) in Environmental Science, Policy, and Management. The Berkeley M.Sc. is not comparable to the proposed M.Sc., since Environmental Health Sciences is a primarily health sciences-rooted subdiscipline. ETH-Zurich, University of Oxford, and Wageningen University (Netherlands) are the top-3 international schools offering graduate programs in environmental science. ETH-Zurich offers a M.Sc. in Environmental Science, the University of Oxford offers a M.Sc. and MPhil in Environmental Change and Management, and Wageningen University offers a M.Sc. in Environmental Sciences.

Table 1: Comparison of U of T Environment-Related Graduate Programs

	Appeals to Students With	Program Structure	Key Themes	Commonalities	Career Trajectories
MScSM Sustainability Management (Mississauga Campus)	☐ Background in management science, engineering, or natural/social sciences; ☐ Interest in combining science and management perspectives.	**Professional program** ☐ 20-month program; ☐ 10- to 16-week internship; ☐ Capstone project; ☐ Year-long research paper course.	☐ Integration of business management, natural sciences, and social sciences; ☐ Environmental, economic, and social sustainability; ☐ Management principles and strategies; ☐ Environmental law and policy.	Interdisciplinary approaches; Integrated thinking for 21st-century sustainability challenges; Putting knowledge into action; Critical thinking and communication skills.	Leadership and senior management roles in sustainability in private and public sectors.
MEnvSc Environmental Science (Scarborough Campus)	☐ Background in the natural sciences; ☐ Interest in the professional practice of environmental science including	**Professional program** ☐ 12-month program; ☐ 16-week internship; ☐ Research paper option.	☐ Understanding and applying scientific methodologies; ☐ Science communication; ☐ Professional practice in		Professional environmental scientist in government, consulting, or private industry.

	Appeals to Students With	Program Structure	Key Themes	Commonalities	Career Trajectories
	environmental monitoring and assessment, climate change, and biodiversity and conservation.		environmental sector.		
MES Environment and Sustainability (St. George Campus)	☐ Any background; ☐ Interest in problem-centred research on global environmental challenges.	**Research-based program** ☐ 12-month program; ☐ Living Laboratory Experience; ☐ Ongoing thesis project throughout.	☐ Integration of perspectives from humanities, social sciences, and natural sciences; ☐ Transdisciplinary approach combining multiple sources of knowledge; ☐ University campus as a living laboratory for sustainability.		Research career in academia, government, or private sector.

	Appeals to Students With	**Program Structure**	**Key Themes**	**Commonalities**	**Career Trajectories**
Proposed MSc in Environmental Science (Scarborough Campus)	☐ Background in science or engineering; ☐ Interest in science-based research experience on environmental problems.	**Research-based program** ☐ 16-month program; ☐ Immediate immersion in research; ☐ Ongoing thesis project throughout.	☐ Understanding and applying the scientific method toward environmental problems; ☐ Collection and interpretation of original data; ☐ Communication of research results to diverse audiences; ☐ Research ethics.		Research career in academia, government, or private sector.

6 Enrolment

- Please provide details regarding the anticipated in-take by year, reflecting the expected increases to reach steady state. Include approximate domestic/international mix. This table should reflect normal estimated program length. (Please adjust the table as necessary.)
- Please provide an explanation of the numbers shown and their relation to the Faculty/division's enrolment plan. Please be specific where this may differ from approved enrolment plans.

The program's first cohort will have 8 students, rising by 3–4 additional students per year, until a steady-state annual enrolment of approximately 15 students is reached. Initially the focus will be on admitting domestic students to the program. The program will consult annually with the School of Graduate Studies and the Planning and Budget office on its ability to admit international students.

There are approximately 50 very research-active core graduate faculty and 15 adjunct faculty who will support this program and, thus, reaching a steady-state of 15 students per year is realistic. This number has been built into enrolment planning across the graduate offerings at UTSC, and should be sustainable based on the number of available master's spots.

Table 2: Graduate Enrolment Projections

Year of Study	2022-23	2023-24	2024-25 (steady-state)	2025-26	2026-27
Year 1	8	12	15	15	15
Year 2	0	8	12	15	15

*Note: the academic year consists of a Fall – Winter – Summer sequence; the first cohort of the M.Sc. in Environmental Science will start in May 2023.

7 Admission Requirements

- Provide a formal statement of admissions requirements as they will appear in the SGS Calendar entry.
- Explain how the program's admission requirements are appropriate for the learning outcomes established for completion of the program.
  - How will they help to ensure students are successful?
  - Provide sufficient explanation of any admissions requirements that are above or in addition to the normal minimum requirements for a graduate program at this level (including higher GPA, specific knowledge or skills — e.g., prior calculus; prior professional practice; additional language, interviews, portfolio, letters of intent, etc.) For example, are there specific undergraduate or master's programs from which students may be drawn?

Minimum Admission Requirements

- Applicants are admitted under the General Regulations of the School of Graduate Studies. Applicants must also satisfy the Graduate Department of Physical and Environmental Sciences' additional admission requirements stated below.
- Applicants whose primary language is not English, and who graduated from a university where the language of instruction and examination was not English, must demonstrate proficiency in English. See General Regulations section 4.3 for requirements.
- A science or engineering undergraduate degree, with a minimum mid-B grade average in the last two years of the undergraduate program.
- Applicants must submit a written, maximum 300-word statement describing their interests in Environmental Science. The statement should describe any research experience, the suitability of their academic background for a M.Sc. in Environmental Science, and their environmental science-related research objectives in the M.Sc. program. Applicants must make clear in their written statement the supervising professor with whom they plan to conduct their thesis research and their interest in conducting research in their chosen area.
- Applicants must have completed at least ONE of the following:
  - At least one supervised research experience during their undergraduate studies. This may include an honours thesis, a research-based work-term (which may be in a lab or involve field work or modelling), a summer research experience or another course formally linked to a research project. One of the applicant's reference letters must be from their research experience supervisor or co-supervisor.

- At least 10 one-term courses at the upper-level (Years 3 and 4 of full-time undergraduate studies) in a science discipline (e.g., environmental science, earth science, physical geography, biology, chemistry, mathematics/statistics, physics, computer science, forestry) or in a branch of engineering (e.g., civil, chemical, environmental).

A key component of the proposed M.Sc. in Environmental Science is the student's immediate immersion into the research process. For a student to be successful moving directly into research, they should already have a well-rounded scientific or quantitative undergraduate education and some idea of the research problem to be addressed.

The undergraduate degree and course requirements outlined in the Minimum Admission Requirements will ensure the student has a well-rounded undergraduate education in science or engineering. There is also a requirement for either a previous undergraduate research experience or completing a rigorous number of upper-level science courses. This is a necessary part of ensuring a student's success in the early research immersion that is foundational to the proposed M.Sc. program. Previous research experience and/or serious engagement in upper-level science and engineering courses at the undergraduate level will ensure that students are able to successfully and immediately engage with original research because these requirements give them either the experience and/or academic background to do so. These additional requirements will also help to ensure that students entering the program are serious, mature scientists who are prepared to be successful.

As part of the admissions process, the Graduate Department of Physical and Environmental Sciences will maintain a web-based listing of available research projects and supervising professors for each admissions cycle (October to March). Prospective students will be advised to contact potential supervising professors prior to applying to the program and will be expected, in their written statement, to communicate broad ideas for their thesis research. U of T uses an online application process that facilitates the involvement of potential supervisors in the admissions process. Potential supervisors will be expected to also make a case about the suitability of a particular student for this program.

8 Program Requirements, Learning Outcomes, Degree Level Expectations (DLEs) and Program Structure

- In a curriculum map, or in the table below, or in another format appropriate for the discipline, state the program learning outcomes and program requirements, and show how the program learning outcomes are appropriate for the degree level expectations.
- Discuss how the design, structure, requirements and delivery of the program are appropriate for the program learning outcomes and degree level expectations. Please include:
  - The sequencing of required courses or other learning activities, etc.
  - The mode of delivery of the program (face-to-face; blended or online; placement, etc.) and how it is appropriate to support students in achieving the learning outcomes of the program and the degree level expectations. Whether the program will be offered on a full-time basis only or will also be offered part-time and if so, why.
  - The program length for both full-time and part-time students. Address how the program requirements can reasonably be completed within the proposed time period.
  - Describe how the specific elements of the curriculum (e.g., Internships, etc.) will be administered.
  - A clear indication of how faculty "scholarship and research is brought to bear on the achievement of Degree Level Expectations" (UTQAP 1.1)
  - For research-focused graduate programs, provide a clear indication of the nature and suitability of the major research requirements for degree completion. For professional graduate programs, how the research expectations of the degree level expectations will be met.
  - Describe how the program structure and delivery methods reflect universal design principles and/or how the potential need to provide mental or physical health accommodations has been considered in the development of this program.
  - Describe how the program structure and delivery methods promote student well-being and resiliency in the learning and teaching environment.
  - Describe any elements that support a sense of community in the program
- Please include the standard text which has been inserted in the box.

Program Design

The proposed M.Sc. in Environmental Science is a full-time, 16-month program (1.5 FCE, plus thesis).

The May start is a distinctive part of the program design, and it recognizes the fact that many aspects of environmental science research are carried out and/or supported in the summer months. By beginning early, students can be immersed in their research for the entire duration of the program. Two potential concerns with an early immersion in research is a new M.Sc. student's *ability* to immediately conduct research and to collect the correct data in support of answering a specific research question. The offering of a research-related course and associated workshop in the first summer term — "Environmental Science Research Experience" (EES 1200H; 0.5 FCE) — and a carefully curated admissions process where students are "matched" with supervisors and projects, will serve to alleviate both concerns. The immediate immersion into research will give students the opportunity to train and collect data in the early months, focus on required and elective course work (an additional 1.0 FCE) for the Fall and Winter terms, with some possible follow-up work in the final Summer term concurrent with writing the thesis. This schedule is designed to fit the needs of environmental science research, to help students quickly launch their research, and to allow students to finish in time to start a Ph.D. program, while still completing substantive original research.

In Environmental Science, field work is a critical element of much of the original research. In the September entry model, it may be late in the season to begin most types of field research in Canada. Professors immersed in Fall teaching may have limited bandwidth to support early supervision, and students take courses from September through April, often starting the collection of original data in April or May. Field work generally continues through August or later. With the additional needs of having to conduct chemical and/or statistical analyses before writing up the research, finishing within one year can be challenging. Where another approach, such as mathematical modelling, is the dominant way of conducting research, an overall 16-month program would still be much more likely to result in publishable material. Confidence in this early research immersion approach stems from experience with NSERC Undergraduate Student Research Award (USRA) students. Funded by NSERC (or sometimes internally) bright students are chosen to carry out 16 weeks of summer research defined for them by the PI. USRA students have been particularly successful in the M.Env.Sc. and Ph.D. programs in Environmental Science, with many examples of students having published their research in peer-reviewed scientific literature. For many students in the M.Sc. program, the first term will therefore provide an important hands-on learning experience that will contribute to their better understanding of their research problem, and the inherent pitfalls, than any coursework will.

Program Learning Outcomes

The Program Learning Outcomes (PLOs) are described in detail here; to see the alignment of the Program Learning Outcomes to the Degree Level Expectations for a master's program, see Table 3, below.

By the end of the program, students will be able to:

PLO1: Understand the interdisciplinary nature of environmental science founded upon the integration of physical, biological, and information sciences, including: ecology, biology, physics, chemistry, plant science, hydrology, soil science/geology, physical geography and geospatial science; advance understanding of the systems approach to support critical thinking and synthesis of information across multiple disciplines.

PLO2: Critically evaluate the scientific validity of the content and sources of scientific information and recognize knowledge gaps by relying both on the breadth of environmental science knowledge and on the depth of knowledge related to the specific sub-discipline areas of students' research projects; be able to use this information to critically evaluate the robustness with which inferences can be drawn from past research.

PLO3: Understand the multitude of scientific methods required in the study of environmental systems.

PLO4: Design research projects within the context of established and/or emerging paradigms in environmental science. Specifically:

- Critically identify compelling scientific questions;
- Gather and/or produce data relevant to testing a hypothesis or in the pursuit of generating new knowledge in environmental science;
- Properly analyze and interpret data and contextualize new findings in relation to major concepts and methods within environmental science;
- Formulate a coherent discussion of research findings and provide context for how the research findings advance knowledge in environmental science;
- Critically evaluate the robustness of the key results and articulate strengths and weaknesses of a research project; and
- Propose future research directions that build upon the major findings of a completed project.

PLO5: Apply relevant statistical and mathematical modelling techniques and analytical methods used in environmental science to quantify the precision, accuracy, and robustness of research results.

PLO6: Produce research of a quality and extent to either merit peer-reviewed publication on its own or contribute significantly to a collaborative publication that is partially conceived, encouraged, and overseen by a supervisor.

PLO7: Understand their role and responsibilities in a team research setting, and conduct research and interact with team members in an ethical and professional manner.

PLO8: Understand and recognize the integrity of the scientific process.

PLO9: Write coherently, concisely, and with clarity.

PLO10: Give well-organized and focused oral presentations, including the ability to effectively summarize key information.

PLO11: Communicate effectively with a range of audiences, including environmental science experts.

PLO12: Demonstrate basic knowledge of the fundamental role of uncertainty in environmental science research and practice. Specifically:

- Understand the different types of uncertainty and their relative importance for scientists, stakeholders, policy makers, and the public;
- Recognize that scientific understanding is limited by our abilities to measure, observe, and perceive phenomena and that this ability changes as science progresses; and
- Recognize that the interpretation of a particular environmental issue is from an interdisciplinary point of view and that there are inherent limitations in examining issues at different scales and degrees of granularity.

To ensure students meet these program learning outcomes, the proposed M.Sc. in Environmental Science is structured around a 4-term model. Below is the term by term description of the pathway that details the program requirements and their alignment with the program learning outcomes. This information is also reflected in the curriculum map in Appendix G of this proposal.

Term 1 (May – August)

Students in the program are required to begin in May and to enrol in the term 1 course, EES 1200H (Environmental Science Research I). This course will begin with an in-person 4-day workshop outlining both short- and long-term program expectations, theory on research approaches, introduction of basic methodological tools, learning objectives with respect to project design, execution of research, data analysis and interpretation, critical synthesis, and information on important graduate student resources **(PLO3, PLO4, PL05)**. The course will be team-taught by supervising professors from each year's cohort of incoming students, with overall coordination by the Graduate Chair and/or Associate Graduate Chair. As detailed in the admission requirements, students enter the program knowing their particular research options and thus immediately begin research data collection under the mentorship of their supervising professor(s) **(PLO4)**. Research can take many forms (i.e., field and/or lab data collection, computer modelling, literature meta-analyses), but the principal requirement is that the student collect data. Training in the norms of data collection, the use of scientific instruments, application of the scientific method with integrity **(PLO8)** and integration of the student into the professional setting of a research group **(PLO7)** is led by the supervising professor(s). By the end of term 1, students must present a research poster **(PLO10, PLO11)** that critically reflects on their research objectives (and research hypotheses) **(PLO4)**, positions the research project within the broader context of the area of study, exhibits early data generation, undertakes an assessment of potential challenges and sources of uncertainty that could shape the outcome of the proposed research **(PLO12)**, and anticipates skill sets that are required and should be pursued over the course of the program in order to successfully complete the research.

Term 2 (September – December)

Starting in term 2, the student must begin "M.Sc. Research Thesis", which is the formal requirement to conduct research and complete a M.Sc. thesis by end of program, and enrol in the mandatory core course EES 1201H (Environmental Science: Approaches and Methods in Research). The core course will focus on the theory, critical analysis of past research, methodological frameworks that are essential for conducting environmental science research, communication, and professionalism **(PLO1, PLO2, PLO7, PLO8, PLO11)**. In particular, one of the major learning outcomes is to effectively communicate the multitude of scientific methods required and the uncertainties underlying the study of environmental systems, including the quantification of uncertainty **(PLO3, PLO5, PLO12)**. Faculty with different expertise in hydrology, ecology, environmental modelling, geospatial analysis, and environmental chemistry will highlight the interdisciplinary nature of environmental science and will foster the skills that are necessary to formulate any environmental problem as the result of a complex interplay among

physical, chemical, and biological mechanisms **(PLO1, PLO2, PLO12)**. By the end of EES 1202H students will be expected to have demonstrated the advancement of their research project both as a critical reflection of their first and second term research (P**LO2**) and with a solid plan for the completion of their research project **(PLO4)**. Another major training objective of the core course is the development of communication skills in the form of both oral presentations and scientific manuscripts for submission to peer-reviewed journals **(PLO9, PLO10)**. "M.Sc. Research Thesis" is completed through direct mentorship and training from the student's supervisor and the supervisory committee, and culminates with the write-up and oral defence of a M.Sc. thesis in term 4 **(PLO3, PLO4, PLO5, PLO6)**.

Term 2 and/or 3 (September – April)

The student is required to take a minimum of one additional course during term 2 or 3. The selection of the course(s) will be guided by the supervisory committee and will be directly related to the critical reflections during the first term (May – August) of the student's tenure in the program. GDPES offers an impressive number of graduate courses in environmental science that cover a wide array of topics in ecology, hydrology, environmental chemistry, environmental remediation, environmental modelling, geospatial analysis, fluid mechanics, and geology **(PLO1)**. Broadening student knowledge through elective courses will also help the student in critically evaluating scientific information **(PLO2)**. Continuing mentorship of students by supervising professors will further develop their ability to work as part of a scientific team and to develop their knowledge of the importance of scientific ethics **(PLO7, PLO8)**. During terms 2 and/or 3, the training of the students will be further augmented by teaching assistant assignments, which offer the opportunity to improve their communication skills, to think critically and independently, to seek out information from other disciplines, and to cultivate their mentoring abilities **(PLO2, PLO9, PLO11)**.

Term 4 (May – August)

In May of term 4, students will be required to present on their research to date, to peers and faculty, as part of the department's annual graduate research colloquium. The colloquium is an important event in the GDPES calendar. It provides a forum for the entire community to be informed on all the exciting work being conducted by the GDPES graduate students and encompasses a wide range of topics in aquatic ecology, agroforestry, hydrology, contaminant fate and transport, biogeochemistry, and environmental policy. The colloquium will provide another important opportunity for students to practice presentation skills, and cultivate their communication and public speaking skills **(PLO10, PLO11)**. Guided by their supervisors, students will be expected to synthesize their results and provide a comprehensive overview of their

research **(PLO2, PLO4)**. The colloquium is conveniently scheduled at the beginning of May (i.e., after completing one year of study in the program), thereby offering a unique opportunity for students to put all the research outputs together, interpret the results into one coherent story, organize thoughts, and identify strengths and weaknesses prior to writing their thesis **(PLO4, PLO5, PLO6)**. Students will complete the write-up of their thesis and finish a formal oral defence to a committee of three graduate faculty members by the end of term 4 **(PLO6, PLO8, PLO9, PLO11, PLO12)**.

Mode of Delivery

The program will be delivered face-to-face in the classroom, through direct supervisor-student mentorship, and on a full-time basis only. This is necessary since the rigour of the research process requires full-time attention to data collection, experimentation, field work, modelling or other approaches that may be undertaken. Part-time studies are likely to lead to gaps in data collection and interpretation that could be detrimental to a student's ability to defend the scientific validity of their findings.

Supervisor-student mentorship will be largely face-to-face in order to provide the hands-on training and critical constructive feedback that is required for student research success over the program duration. Classroom experiences in the program involve discussion, peer-to-peer interactive learning, and in several instances, specific training with instrumentation and methods. These pedagogical approaches lend themselves best to face-to-face classroom and practical experiences. All current courses in the graduate program are delivered in this way because of the superiority of this approach.

The program length for full-time students will be 16 months. The May start date and early immersion of students into research are key components of this program and will help to ensure that program requirements, which are largely research-based, can be reasonably completed within the proposed time period. Course requirements (1.5 FCE, plus thesis) are modest specifically to allow students to primarily immerse themselves into the research process.

The Graduate Chair and/or Associate Graduate Chair will administer the overall program, with specific oversight coordination of the term 1 course EES 1200H (Environmental Science Research I). Supervision of individual M.Sc. research projects will be the responsibility of supervising professors.

Given this is a research-based program, scholarship and research is brought to bear on the achievement of Degree Level Expectations through multiple means. This includes the

requirement to complete a M.Sc. thesis under the supervision of faculty. Supervising faculty will also be involved annually in the early research workshop for incoming students, during which they will share examples and experience from their own scholarship and research.

Students in the proposed M.Sc. in Environmental Science are required to complete original research through the collection, analysis, and synthesis of data, culminating in the production of a thesis. The thesis must include the application of relevant concepts, principles, and techniques used in environmental science to generate and analyze data, as well as a substantial discussion of the significance of the research findings.

U of T strives to be a fully accessible university. Important examples of this exist within the GDPES' infrastructure. This includes the fully accessible Environmental Science and Chemistry Building, where students will mainly be located. This five-year-old building incorporates accessible building access, elevators, wheelchair-accessible fumehood and laboratory benchtop spaces, and accessible access to the building's green roof, where students conduct a variety of outdoor experiments and measurements.

The proposed M.Sc. will reflect universal design principles both through an ability to ensure that there are no barriers for students of varied needs in courses and learning activities, and through the ability within environmental science to have a variety of research approaches, which can help in accommodating a range of needs. Moreover, the assessment of learning in required and elective graduate courses is specifically designed to ensure student well-being and resiliency in the learning and teaching environment. An impressive range of evaluation techniques are used by the course instructors that include, but are not limited to, presentation of seminars, research papers, or analytical reports, and, if appropriate, the submission of lab or field notebooks. In these papers, reports, and presentations, students are expected to exhibit depth, breadth, and application of knowledge, and formalism of applied environmental issues, critical thinking skills, and oral and written communication skills appropriate to the master's level. In addition, classical "midterm" and "final" exams are sometimes used, but these are commonly take-home exercises that require the synthesis of information. One faculty member also conducts one-on-one meetings to test student grasp of statistical or modelling tools.

There are a number of research approaches taken in environmental science, ensuring significant flexibility for students to complete their thesis research through multiple pathways, in the instance that one pathway turns out to be inaccessible. While accommodations already exist (see above) for physical barriers to field work and laboratory approaches, students can also rely on approaches to environmental science research that involve modelling and metadata synthesis, which tend to pose fewer physical barriers to participation. These approaches will still

lead to success with the learning outcomes of this program. Importantly, the proposed program relies on a close mentoring relationship between students and supervisors. Because of this, there is very good potential for individual solutions to barriers and/or accommodation of needs.

Finally, UTSC offers a suite of student services that are well-connected to the GDPES. This includes, for example, both Access*Ability* Services and Health and Wellness Services. Access*Ability* Services provides a space for students to access disability consultants and to arrive at accommodations that maintain the learning and training breadth and depth that is expected of students in a particular program. Health and Wellness Services provide mental and physical health services to students. The GDPES is fully aware of the struggle that many graduate students face with mental health. For two years now, the department has worked with Health and Wellness to have a mental health counsellor embedded within the unit on a part-time basis. This has proven itself a valuable resource for existing programs, and there is enough flexibility to additionally accommodate this program. As well, staff and faculty are trained, through programs offered by the University, to recognize mental health distress and know how to get help for students in need.

The Graduate Department of Physical and Environmental Sciences has an impeccable record in promoting student well-being and resiliency in the learning and teaching environment, as well as cultivating a sense of community in the M.Env.Sc. and PhD in Environmental Science programs. Students in the proposed M.Sc. will directly benefit from these activities. A few characteristic examples are:

(i) Informative orientation events: GDPES has developed a novel orientation model, where incoming students can meet faculty, staff and other students in an atmosphere where they feel valued and respected. Students are invited to a catered event at the Principal's residence, Miller Lash House, where they have the opportunity to attend talks by faculty, engage in fun activities purely for camaraderie, including an event modelled on "speed dating," where students circulate to different tables to meet with different faculty, other instructors and/or senior graduate students, ask questions and exchange information. Representatives from all the available student services at UTSC, including the Center for Teaching and Learning, are also invited and share information about the wide range of support that the UTSC campus provides. These orientation events have received many compliments and make for a good start each year.

(ii) Incorporating job searching workshops, and seminars by potential employers: Students in the proposed program will be encouraged to partake in a range of training workshops organized on a regular basis by the department, including preparation for job applications, cultivation of their interviewing skills, etc. Special events are also available, where potential employers,

including alumni of GDPES graduate programs, are invited to speak to the students regarding career prospects and job-hunting strategies.

(iii) Facilitating networking: In a world where “who you know” remains almost as important as “what you know,” GDPES tries to facilitate networking whenever possible. The department holds a social event for all graduating students the night before their graduation ceremony. Alumni, faculty, instructors, potential employers, and staff are all invited. GDPES also hosts "Networking Breakfast" events, where potential employers are invited to mingle with graduate students over a breakfast during different periods of the academic year. It is expected that the students of the proposed M.Sc. will be an integral part of these events.

Whereas the Province’s Quality Assurance Framework requires that students complete a minimum of two-thirds of courses at the graduate-level, the University of Toronto requires graduate students to complete all of their course requirements from amongst graduate-level courses. This proposed program complies with this requirement.

Table 3: Master's DLEs and the Program Learning Outcomes

Master's DLEs (based on the Ontario Council of Academic Vice-Presidents [OCAV])	**Master's Program Learning Outcomes**
Expectations**:** This M.Sc. in Environmental Science is awarded to students who have demonstrated:	
1. Depth and Breadth of Knowledge A systematic understanding of knowledge, and a critical awareness of current problems and/or new insights, much of which is at, or informed by, the forefront of the academic discipline, field of study or area of professional practice.	Depth and Breadth of Knowledge is defined in the M.Sc. in Environmental Science as a systematic understanding of the history of and approaches to knowledge generation in environmental science as an interdisciplinary field, as well as a critical awareness of current problems and/or new insights within a specific sub-discipline or subject area of environmental science. This is reflected in students who are able to: PLO1: Understand the interdisciplinary nature of environmental science founded upon the integration of physical, biological, and information sciences, including ecology, biology, physics, chemistry, plant science, hydrology, soil science/geology, physical geography, and geospatial science; and advance understanding of the systems approach to support advanced critical thinking and synthesis of information across multiple disciplines. PLO2: Critically evaluate the scientific validity of the content and sources of scientific information and recognize knowledge gaps by relying both on the breadth of environmental science knowledge and on the depth of knowledge related to the specific sub-discipline areas of students' research projects; and be able to use this information to critically evaluate the robustness with which inferences can be drawn from past research.
2. Research and Scholarship A conceptual understanding and methodological competence that: • Enables a working comprehension of how established techniques of	Research and Scholarship is defined in the M.Sc. in Environmental Science as the ability to understand disparate means of conducting environmental science research (modelling, field data collection, laboratory experimentation, remote sensing) and the instrumentation required to gather data in order to

research and inquiry are used to create and interpret knowledge in the discipline; • Enables a critical evaluation of current research and advanced research and scholarship in the discipline or area of professional competence; and • Enables a treatment of complex issues and judgments based on established principles and techniques; and, on the basis of that competence, has shown at least one of the following: • The development and support of a sustained argument in written form; or • Originality in the application of knowledge.	create and interpret knowledge in the discipline; the critical evaluation of peer-reviewed environmental science publications to recognize gaps in knowledge and needs for future research; and the gathering of defensible data and/or the development of theory synthesized from prior scientific knowledge via field measurements, digital data collection, metadata analysis, laboratory experimentation or modeling in environmental science. This is reflected in students who are able to: PLO3: Understand the multitude of scientific methods required in the study of environmental systems. PLO4: Design research projects within the context of established and/or emerging paradigms in environmental science. Specifically: • Critically identify compelling scientific questions; • Gather and/or produce data relevant to testing a hypothesis or in the pursuit of generating new knowledge in environmental science; • Properly analyze and interpret data and contextualize new findings in relation to major concepts and methods within environmental science; • Formulate a coherent discussion of research findings and provide context for how the research findings advance knowledge in environmental science; • Critically evaluate the robustness of the key results and articulate strengths and weaknesses of a research project; and, • Propose future research directions that build upon the major findings of a completed project. PLO5: Apply relevant statistical and mathematical modelling techniques and analytical methods used in environmental science to quantify the precision, accuracy and robustness of research results.

3. Level of Application of Knowledge Competence in the research process by applying an existing body of knowledge in the critical analysis of a new question or of a specific problem or issue in a new setting.	Level of Application of Knowledge is defined in the M.Sc. in Environmental Science as the ability to analyze and interpret data from various sources by applying standard techniques and an understanding of the existing knowledge in environmental science to the testing of scientific hypotheses via the interpretation of collected data or in the discovery of scientific phenomena. This is reflected in students who are able to: PLO4: Design research projects within the context of established and/or emerging paradigms in environmental science. Specifically: • Critically identify compelling scientific questions; • Gather and/or produce data relevant to testing a hypothesis or in the pursuit of generating new knowledge in environmental science; • Properly analyze and interpret data and contextualize new findings in relation to major concepts and methods within environmental science; • Formulate a coherent discussion of research findings and provide context for how the research findings advance knowledge in environmental science; • Critically evaluate the robustness of the key results and articulate strengths and weaknesses of a research project; and, • Propose future research directions that build upon the major findings of a completed project. PLO6: Produce research of a quality and extent to either merit peer-reviewed publication on its own or contribute significantly to a collaborative publication that is partially conceived, encouraged, and overseen by a supervisor.
4. Professional Capacity/ Autonomy	Professional Capacity/Autonomy is defined in the M.Sc. in Environmental Science as the ability to participate in environmental science research projects ethically and

• The qualities and transferable skills necessary for employment requiring: ▶ The exercise of initiative and of personal responsibility and accountability; and ▶ Decision-making in complex situations ▶ The intellectual independence required for continuing professional development; ▶ The ethical behavior consistent with academic integrity and the use of appropriate guidelines and procedures for responsible conduct of research; and ▶ The ability to appreciate the broader implications of applying knowledge to particular contexts.	with integrity; the ability to contribute responsibly as part of a research team; and the ability to recognize key determinants in complex scientific problems and prioritize actions accordingly. This is reflected in students who are able to: PLO7: Understand their role and responsibilities in a team research setting, and conduct research and interact with team members in an ethical and professional manner. PLO8: Understand and recognize the integrity of the scientific process.
5. Level of Communications Skills The ability to communicate ideas, issues, and conclusions clearly.	Level of Communications Skills is defined in the M.Sc. in Environmental Science as the ability to share research findings effectively with both expert and layperson audiences. This is reflected in students who are able to: PLO9: Write coherently, concisely, and with clarity. PLO10: Give well-organized and focused oral presentations, including the ability to effectively summarize key information. PLO11: Communicate effectively with a range of audiences, including environmental science experts.
6. Awareness of Limits of Knowledge Cognizance of the complexity of knowledge and of the potential contributions of other	Awareness of Limits of Knowledge is defined in the M.Sc. in Environmental Science as an understanding of the limits of scientific evidence as it relates to enviornmental issues, and the articulation of further

interpretations, methods, and disciplines.	research needs and/or knowledge gaps. This is reflected in students who are able to: PLO12: Demonstrate basic knowledge of the fundamental role of uncertainty in environmental science research and practice. Specifically: • Understand the different types of uncertainty and their relative importance for scientists, stakeholders, policy makers, and the public; • Recognize that scientific understanding is limited by our abilities to measure, observe, and perceive phenomena and that this ability changes as science progresses; and, • Recognize that the interpretation of a particular environmental issue is from an interdisciplinary point of view and that there are inherent limitations in examining issues at different scales and degrees of granularity.

9 Assessment of Learning

- Appropriateness of the proposed methods for the assessment of student achievement of the intended program learning outcomes and degree level expectations.
- Describe plans for documenting and demonstrating the level of performance of students consistent with the DLEs. (Assessment of Teaching and Learning examples in Guide to Quality Assurance Processes.)

Students demonstrate the degree level expectations through the writing and successful defense of their research thesis, the successful completion of course work, their teaching experiences, collaborations, and their contributions to conferences or other professional meetings, including Graduate Professional Skills courses. Specifically, each program learning outcome is assessed as follows:

PLO1: Assessed through both the completion of a thesis literature review and in-class assignments related to both benchmark published case studies and the review of popular articles in the course EES 1201H (Environmental Science: Approaches and Methods in Research). Students will be expected to apply knowledge gained from coursework and in the context of scholarship traditions in Environmental Science.

PLO2: Assessed through the completion of a thesis literature review — Research requires a sound understanding of the foundation of our current understanding such that new ideas may be generated. By writing a literature review, students will engage deeply with a specific sub-disciplinary subject area of environmental science and learn to both critically evaluate previous research and synthesize research in order to evaluate past research, critically identify compelling scientific questions, and design research projects within the context of established and/or emerging paradigms in environmental science. The supervising professor will oversee the completion of the thesis literature review and provide critical feedback as needed. The underlying outcome here is to increase content knowledge, to improve critical evaluation and synthesis skills and to improve written communication abilities.

PLO3: Assessed as part of two courses: EES 1200H (Environmental Science Research Experience) and EES 1201H (Environmental Science: Approaches and Methods in Research) and through the research process leading to the successful defense of a thesis. The critical evaluation of published research will be reviewed as part of both mandatory courses. A key criterion for successful defense of the master's thesis will be inherent in the student's ability to understand (and possibly adopt) the diverse range of scientific methods required and the uncertainties

underlying the study of environmental systems. Special emphasis will be given to the ability of students to distinguish between knowledge gained and gaps that collectively shape the robustness of the inference drawn in environmental science.

PLO4: Assessed through both the early research immersion experience in EES 1200H (Environmental Science Research Experience) and through the completion and successful defense of a thesis. Students in the early research immersion experience will present a poster outlining the overarching goals of their project, elaborate on the novelty of their work, and articulate early research findings. The veracity of data collection or production is a key component of the successful defense of the thesis. Another important criterion for the successful defence of the thesis is the analysis and interpretation of data according to methods that are accepted within the discipline. As part of a thesis discussion, new findings must be contextualized in relation to major concepts and/or methods within environmental science. The discussion must include a connection between research findings and other advanced knowledge in environmental science. It is also expected that there will be a critical evaluation of the robustness of key results and a critical presentation of the strengths and weaknesses of a research project. The thesis should also include future research directions that build upon the major findings of the completed project.

PLO5: Introduced in EES 1201H (Environmental Science: Approaches and Methods in Research) and ultimately assessed through both supervisor mentorship and the successful defense of the thesis. Additionally, students can opt to take a quantitative methods course if statistical analyses are particularly important to completing the thesis. Depending on the topic addressed, the dissertation will be expected to incorporate concepts and strategies from the value-of-information theory and power analysis to assess the robustness of the presented results. The contextualization of the completed project within a study area of interest in environmental science is expected to be supported by solid evidence and rigorous statistical analysis.

PLO6: Assessed through the successful defense of a research thesis overseen by a committee of three professors, including the supervising professor or co-supervising professors. Students will be mentored by supervisors to produce a research outcome that can either merit peer-reviewed publication on its own or contribute significantly to a collaborative publication.

PLO7: This outcome is primarily concerned with the student's performance in a real research group setting, and will be assessed through the supervisor-student relationship during the student's work in gathering or producing data for production of the thesis.

PLO8: Assessed through a case study assignment in EES 1201H (Environmental Science: Approaches and Methods in Research). Case studies will focus on examples of both exemplary and poor handling of the integrity of data and the scientific process. Ethical considerations in environmental science are included in the curriculum of this course. Additionally, students will peer-review group members for at least one group assignment.

PLO9: Assessed through coursework assignments and through the successful defense of the thesis. The clarity and appropriate conciseness of the writing is inherent within the criteria of the thesis having merit to be or contribute to a peer-reviewed publication.

PLO10: Oral communication abilities are assessed through student participation in the annual research colloquium, through course assignments, and as part of the successful oral defense of the thesis.

PLO11: Assessed through participation in the annual research colloquium, through the public presentation of the "Environmental Science Research" poster assignment, and as part of the successful defense of the thesis. Across these oral presentation platforms, students will need to effectively communicate with audiences ranging from the public, students in other disciplines, peers, and faculty who are experts in certain subject matters.

PLO12: Assessed through assignments in EES 1201H (Environmental Science: Approaches and Methods in Research) and other relevant courses that are offered by the GDPES. The early research immersion of students in the program is key for honing their ability to understand the limits of knowledge generation and how this affects the interpretation of findings. It can also be assessed through supervisor mentorship and ultimately through the successful defence of the thesis. Students are expected to gain basic knowledge of the fundamental role of uncertainty and its ability to produce critical planning information in environmental management. Through their assignments, students are expected to show their understanding of the different types of uncertainty and their relative importance for scientists, stakeholders, and environmental policy makers.

The demonstration of student performance consistent with the DLEs will be promoted through specific course assignments and requirements that are graded and then, in relation to most DLEs, culminate in the successful completion and oral defense of a master's thesis. By successfully completing the required coursework and their thesis, students will have achieved the proposed M.Sc. program's learning outcomes. GDPES has extensive experience in monitoring program performance, and there is a rigorous plan to assess (document and demonstrate) whether all the effort put into designing and delivering the program is consistent

with the expected levels of success. The Graduate Chair, the Associate Graduate Chair, the full-time administrator, and three faculty members (as part of their regular workload) will form a Supervisory Program Committee. Indicators that will be used to evaluate the overall program performance include student grades, awards data, and exit surveys. Quality in the delivery of the graduate courses, assessment practices, and grade distribution will be closely monitored by the Committee on an ongoing basis. Career success, degree of satisfaction, and other feedback from students, faculty, teaching assistants, and GDPES community members will be obtained and assessed.

Every effort will be made to maintain contact with graduates of the program through exit and alumni surveys. Students and alumni will be asked to reflect on the program, including its content, modes of delivery, and program learning outcomes. Other methods of assessment may include tracking publications and placements in doctoral programs. These global methods of assessment will provide a broader view of the program and student performance.

Efforts to improve the program, whether in content or delivery, in response to data/feedback will be ongoing in order to better address contemporary issues that arise. These assessment methods will collectively provide the evidence of success of the program. The Supervisory Program Committee will be empowered to introduce curricular changes, whereby the continuous structural/functional improvements of the program will be ensured, and the program will be prepared to undergo formal cyclical reviews. GDPES has extensive experience with exit and alumni (five-year post-completion) surveys, which have provided a broader view of program and student performance and have inspired numerous curricular advancements in the M.Env.Sc. and Ph.D. in Environmental Science.

10 Program Description & Calendar Copy

- Provide a description of the program (audiences: prospective and current students, staff, and employers) that can be used for external and internal posting that includes the following information:
  - Program's purpose (who is it for, what are the outcomes)
  - Nature of learning environment (including mode of delivery)
  - Approaches to teaching/learning/assessment
- Provide, as an appendix, a clear and full calendar copy including:

  - The program description; the program requirements including all required courses and recommended electives and their prerequisites, including for any fields/concentrations.
- Provide as an appendix:
  - A full list of the all courses included in the program including course numbers, titles, and descriptions.
    - Please indicate clearly whether they are new/existing. (Please note that all new courses should be proposed and approved independently in line with established academic change procedures. Where possible, append full course proposals as an appendix.)

Program Description

The purpose of the M.Sc. in Environmental Science is to train Bachelor of Science or Engineering graduates in the design, execution, and dissemination of research that is focused on the interfaces between traditional disciplines in dealing with fundamentally scientific, environment-focused issues. This is a full-time, 16-month program with a unique May start date that will help students to rigorously gather data towards the completion of a M.Sc. thesis. The M.Sc. in Environmental Science will allow students to address major emerging research themes in the environment and pursue projects that make use of complementary research concepts, approaches, and tools. Faculty members are cross-appointed from several graduate units including: Cell and Systems Biology, Chemical Engineering and Applied Chemistry, Chemistry, Earth Sciences, Ecology and Evolutionary Biology, Geography and Planning, Forestry, and Physics, which ensures the supervision of research projects across a broad range of expertise and research facilities. This program will engage these strengths in order to foster research that is critical for finding solutions to, or elucidating the root causes of, today's critical environmental challenges.

Please see Appendix A for a full list of the course numbers and titles, indicating clearly whether they are new or existing.

Please see Appendix B for proposed *SGS Calendar* copy.

11 Consultation

- Describe the expected impact of what is being proposed on the nature and quality of other programs delivered by the unit/division.

- Describe the expected impact of what is being proposed on programs being offered by other units/divisions.
- Describe any consultation with the Deans of Faculties/divisions that will be implicated or affected by the creation of the proposed program as per UTQAP 2.4.2 "The Dean ensures that appropriate consultation is conducted with faculty and students, other university divisions, and external institutions."

Consultation at UTSC

Within the DPES and GDPES, a "New Graduate Programs Committee" was established in early 2019 to facilitate department-level consultation and provide feedback on this proposal. Additionally, updates have been provided to faculty and staff at regular faculty/staff meetings. Feedback from these sources has been incorporated into this proposal.

Consultation with the Office of the Vice-Principal Academic and Dean at UTSC began in Fall 2018 and has been ongoing; feedback from the Vice-Dean Graduate and Postdoctoral Studies, and the Academic Programs Officer, has been incorporated into the proposal.

The proposal was shared with the Department of Biological Sciences in June 2021, and no questions or concerns were raised.

Consultation Beyond UTSC

The primary or affiliate graduate departments of all faculty participating in the proposed M.Sc. program may be affected, as some students might divert away from single disciplines to inter-disciplinary ones. Minimal to no impact is anticipated for existing or proposed, environment-related master's level programs at the wider University because of the distinctiveness of these programs from each other and from the proposed program. All the potentially interested parties have been contacted by email and a number of these consultations have been followed up in person.

Professor Carl Mitchell, as Associate Graduate Chair, first contacted leadership in other departments with particular environmental graduate program foci in November 2017 to introduce the idea that GDPES was beginning to put together a formal proposal. This included the School of the Environment (Prof. Kimberly Strong), UTM (Prof. Shashi Kant) and the Faculty of Forestry (Profs. Sally Krigstin and John Caspersen). Responses were unanimously positive and supportive.

In September 2019, Prof. Mitchell (Department of Physical and Environmental and Sciences, UTSC), Prof. Steve Easterbrook (School of Environment, Faculty of Arts and Science), and Prof. Shashi Kant (M.Sc.S.M. program, University of Toronto Mississauga) met in person to discuss the space within which all four current or proposed master's programs fit within U of T's environment-related scholarly mission. The results of this meeting and subsequent discussion resulted in the map provided in Table 1, above, and also helped to form part of the School of the Environment's master's program proposal.

Later in the fall of 2019, Prof. Mitchell followed up with these same programs again to specifically ensure that the descriptions of their programs in this proposal are correct. Profs. Krigstin and Caspersen approved the descriptions. Prof. Kant responded in early October 2019 with a slightly modified M.Sc.S.M. program description and it has been incorporated in this document. Profs. Easterbrook, Strong, and John Robinson all provided some comments from the School of the Environment, which also have been incorporated into this document. The overarching response is that there is room for these programs to co-exist at the University and it will not be difficult for students to distinguish why they might select one program over another.

In June, 2021, UTSC shared the proposal with the Office of the Dean of the following divisions, with a request to share it widely with any potentially interested academic units:

- The University of Toronto Mississauga: no questions or concerns were relayed.
- The John H. Daniels Faculty of Architecture, Landscape and Design: no questions or concerns were relayed.
- The Faculty of Arts and Science:
    - The Department of Physics noted concerns about financial support for students given the program is 16 months, but funding is guaranteed for 12 months. This is a fair comment, but we would note that this program is in line with FAS offerings which offer at most 12 months of funding at the master's level. So while we agree funding for the full length of the program would be ideal, guaranteed funding for 12 months is within the norms for U of T.
    - The Department of Geography and Planning provided detailed feedback on the proposal. On October 1, 2021 a meeting was held between Dean Gough and Vice-Dean Silcox from UTSC, with Acting Vice-Dean Gillian Hamilton from the Faculty of Arts and Science, and Graduate Chair of the Tri-campus Graduate Program in Geography and Planning, Ronald Buliung. The conversation was extremely constructive, and focused on opportunities for Geography and Planning students and faculty with respect to the planned M.Sc. program. In particular, UTSC affirmed that Geography and Planning students would continue to be welcomed into Environmental Science courses, and that tri-campus graduate faculty in

Geography and Planning would enjoy opportunities to engage in primary supervision of students in the M.Sc. in Environmental Science. The outcome of the conversation was a sense of optimism for a continuing constructive relationship between Geography and Planning and GDPES. The content of this description of the meeting was shared with Acting Vice Dean Hamilton and G&P Graduate Chair Buliung prior to being included in this proposal; they agree that it accurately represents the conversation that has taken place.

- The Faculty of Applied Science and Engineering: no questions or concerns were relayed.
- On September 23, 2021, the proposal was reviewed at Tri-Campus Deans. They were pleased with the proposal, and noted in particular the robust consultation with other Environmental Science programs. There was one question from the Committee about the entrance requirement for an undergraduate research experience, and whether it might bias the applicant pool. We acknowledge that it may be a limitation for some students, but there are a lot of ways that it can be fulfilled, and most students who want to go to graduate school will have had some kind of experience that would qualify. It is also important to note that we are very cognizant of the need to ensure that students are set up for success, in light of the fact that they will start the program with a research-focussed first semester.

12 Resources

12.1 Faculty

- Complete Table 4 below
- Brief commentary to provide:
  - Evidence of the participation of a sufficient number and quality of faculty who will actively participate in the delivery of (teach and/or supervise) the program
  - Evidence of and planning for adequate numbers and quality of faculty and staff to achieve the goals of the program
  - That faculty have the recent research or professional/clinical expertise needed to sustain the program, promote innovation and foster an appropriate intellectual climate
  - Evidence of how supervisory loads will be distributed, and the qualifications and appointment status of faculty who will provide instruction and supervision
  - Planned/anticipated class sizes (connect this to delivery method, Section 8 and assessment methods, Section 9)
  - If relevant, plans and commitment to provide additional faculty resources to support the program.

  - The role of any adjunct or contractual (e.g., stipendiary) faculty.
- Provide the CVs of all faculty who appear in Table 3, as evidence substantiating the above. The appendix should form a separate document with a table of contents and all CVs in alphabetical order. CVs should be submitted in a consistent format.

No new faculty are required to support the proposed M.Sc. in Environmental Science. Over 50 faculty across U of T's three campuses will actively participate in the delivery of the program, be it through teaching, direct supervision of thesis projects, or as members of the student's supervisory and defence committee. All faculty that are currently active in, or eligible for, supervising students in the Ph.D. in Environmental Science will be immediately available to participate as primary supervisors and committee members for students in the proposed M.Sc. program.

The core faculty, with appointments primarily in the Department of Physical and Environmental Sciences, produce well over 150 peer-reviewed publications annually, receive research funding that in the past five years has consistently exceeded $2M annually, and maintain a research infrastructure that is world-class. Faculty research is funded from tri-council grants, from U of T internal granting schemes, and through research contracts. Faculty members hold tri-council grants from the *Natural Sciences and Engineering Research Council of Canada* (NSERC), *Canadian Institutes of Health Research* (CIHR) or *Social Sciences and Humanities Research Council* (SSHRC) and have research contracts to support their research enterprise. Many of the journal publications from GDPES faculty and their graduate students appear in the best journals in the physical and environmental sciences, including prestigious journals such as *Science, Nature Chemistry, Nature Geoscience, Nature Communications,* and the *Proceedings of the National Academy of Sciences.*

Admission of students will be based on their fit with the research expertise of faculty who are interested in supervising M.Sc. students in any given year. Supervisory loads will be distributed through annual polling of graduate faculty in mid-Autumn of each year, in which faculty will be asked for a short project description and desire to take on a M.Sc. student in the next admissions cycle. As previously explained, student admissions will be connected to supervisor projects early in the admissions process. All tenure-stream faculty with full graduate memberships will be eligible to supervise students in the proposed M.Sc. and all associate graduate faculty members will be eligible to co-supervise students.

Teaching-stream faculty whose scholarship is in the area of environmental science are expected to play a major role with the delivery of the program. One teaching-stream faculty member, who is directly appointed to GDPES, will be responsible for the delivery of several climate science courses and is available as a thesis committee member. Three additional teaching-

stream faculty in Environmental Science are associate members of the GDPES and could serve as thesis committee members or teach future course offerings.

In addition to its large cohort of appointed faculty, the Graduate Department of Physical and Environmental Sciences has an active group of adjunct faculty that complement the existing expertise and strengthen programs in important areas such as atmospheric chemistry, invasive species/aquatic ecology, and climate change. Most adjunct faculty are outstanding government scientists who collaborate extensively with GDPES faculty and graduate students. As such, they serve as an important link between the Department's research output and its relevance to provincial, national, and international environmental policy. Adjunct faculty regularly deliver graduate courses, and participate in guest lecturing and the co-supervision of graduate students. The Graduate Department of Physical and Environmental Sciences generally reviews adjunct faculty appointments on a three- to five-year schedule and adds faculty based on current needs to round out research expertise in graduate student supervision and/or thesis defense committees.

Class sizes in the two mandatory core courses will be capped at annual student program enrolment levels (i.e., no more than 15 students). Students will select program science electives from those already offered within GDPES or from other cognate departments on the other two campuses. There are already a large number of graduate course offerings and therefore room to accommodate a few more students in each of these courses.

The Graduate Department of Physical and Environmental Sciences already administers two highly successful graduate programs in Environmental Science. 919 students have graduated from the M.Env.Sc. since the inception of the program in 2006 and 36 students have graduated from the Ph.D. in Environmental Science since its inception in 2010. Faculty support for the proposed program is very strong, and the program plan was strongly endorsed by the review team for the most recent UTQAP external review held in 2015-16.

Please see the CV Compendium for the CVs of all faculty who appear in Table 4.

Table 4: Faculty Complement (please list alphabetically)

Name	Unit of Primary Budgetary Appointment and Percentage	Unit of Other Budgetary Appointment and Percentage (if applicable)	Graduate Faculty Membership Status (e.g., Associate/ Full privileges)	Commitment to Other Academic Units including GDPES. Abbreviations (P) and (S) Denote Primary and Secondary Appointments.	Nature of Contribution to this Program (Course Instructor [CI], Thesis Supervision [TS], Thesis Co-supervision [TCS])
Tenure Stream: Full					
Abbatt, John	Chemistry, 100% (FAS)		Full	Chemistry (P); GDPES, UTSC (S)	TS
Allen, Grant	Chemical Engineering and Applied Chemistry, 100% (FASE)		Full	Chemical Engineering and Applied Chemistry (P); GDPES, UTSC (S)	TS
Archontitsis, George	DPES, 100% (UTSC)		Full	Geography and Planning (P); Ecology and Evolutionary Biology (S); GDPES, UTSC (S)	CI (EES1118, EES1119), TS
Cadotte, Marc	Biological Sciences, 100% (UTSC)		Full	Ecology and Evolutionary Biology (P); GDPES, UTSC (S)	CI (EES3114), TS

Name	**Unit of Primary Budgetary Appointment and Percentage**	**Unit of Other Budgetary Appointment and Percentage (if applicable)**	**Graduate Faculty Membership Status (e.g., Associate/ Full privileges)**	**Commitment to Other Academic Units including GDPES. Abbreviations (P) and (S) Denote Primary and Secondary Appointments.**	**Nature of Contribution to this Program (Course Instructor [CI], Thesis Supervision [TS], Thesis Co-supervision [TCS])**
Chen, Jing	Geography and Planning, 100% (FAS)		Full	Geography and Planning (P); GDPES, UTSC (S)	TS
Desloges, Joseph	Geography and Planning, 51% (FAS)	Earth Sciences, 49% (FAS)	Full	Geography and Planning (P); GDPES, UTSC (S)	TS
Diamond, Miriam	Earth Sciences, 100% (FAS)		Full	Geography and Planning (P); Public Health Sciences (S); School of the Environment (S); GDPES, UTSC (S)	TS
Dittrich, Maria	DPES, 100% (UTSC)		Full	Earth Sciences (P); School of the Environment (S); GDPES, UTSC (S)	CI (EES1127), TS
Donaldson, Jamie	DPES, 100% (UTSC)		Full	Chemistry (P); Physics (S); GDPES, UTSC (S)	TS

Name	Unit of Primary Budgetary Appointment and Percentage	Unit of Other Budgetary Appointment and Percentage (if applicable)	Graduate Faculty Membership Status (e.g., Associate/ Full privileges)	Commitment to Other Academic Units including GDPES. Abbreviations (P) and (S) Denote Primary and Secondary Appointments.	Nature of Contribution to this Program (Course Instructor [CI], Thesis Supervision [TS], Thesis Co-supervision [TCS])
Evans, Greg	Chemical Engineering and Applied Chemistry, 100% (FASE)		Full	School of the Environment (P); School of Public Health (S); GDPES, UTSC (S)	TS
Eyles, Nicholas	DPES, 100% (UTSC)		Full	Earth Sciences (P); GDPES, UTSC (S)	CI (EES1106), TS
Fulthorpe, Roberta	DPES, 100% (UTSC)		Full	GDPES(P); Ecology and Evolutionary Biology (S); Cell and Systems Biology (S); Chemical Engineering and Applied Chemistry (S); School of the Environment (S)	CI (EES1104, EES1108), TS
Gough, William	DPES, 100% (UTSC)		Full	Geography and Planning (P); School of the Environment	CI (EES1112, EES1117, EES1133), TS

Name	Unit of Primary Budgetary Appointment and Percentage	Unit of Other Budgetary Appointment and Percentage (if applicable)	Graduate Faculty Membership Status (e.g., Associate/ Full privileges)	Commitment to Other Academic Units including GDPES. Abbreviations (P) and (S) Denote Primary and Secondary Appointments.	Nature of Contribution to this Program (Course Instructor [CI], Thesis Supervision [TS], Thesis Co-supervision [TCS])
				(S); GDPES, UTSC (S)	
He, Yuhong	Geography, Geomatics and Environment (UTM), 100%		Full	Geography and Planning (P); School of the Environment (S); GDPES, UTSC (S)	TS
Howard, Ken	DPES, 100% (UTSC)		Full	Earth Sciences (P); School of the Environment (S); GDPES, UTSC (S)	TS
Isaac, Marney	DPES, 51% (UTSC)	Global Development Studies, 49%	Full	Geography and Planning (P); School of the Environment (S); GDPES, UTSC (S)	CI (EES1128), TS
Izmaylov, Artur	DPES, 100% (UTSC)		Full	Chemistry (P); GDPES, UTSC (S)	TS
Kraatz, Heinz-Bernhard	DPES, 100% (UTSC)		Full	Chemistry (P); Chemical	TS

Name	Unit of Primary Budgetary Appointment and Percentage	Unit of Other Budgetary Appointment and Percentage (if applicable)	Graduate Faculty Membership Status (e.g., Associate/ Full privileges)	Commitment to Other Academic Units including GDPES. Abbreviations (P) and (S) Denote Primary and Secondary Appointments.	Nature of Contribution to this Program (Course Instructor [CI], Thesis Supervision [TS], Thesis Co-supervision [TCS])
				Engineering & Applied Chemistry (S); GDPES, UTSC (S)	
Lowman, Julian	DPES, 100% (UTSC)		Full	Astronomy & Astrophysics (P); Physics (S)	TS
Lovejoy, Nathan	Biological Sciences, 100% (UTSC)		Full	Ecology and Evolutionary Biology (P); Cell and Systems Biology (S); GDPES, UTSC (S)	TS
Mandrak, Nicholas	Biological Sciences, 100% (UTSC)		Full	Ecology and Evolutionary Biology (P); GDPES, UTSC (S)	CI (EES1100, EES3000, EES3003), TS
Mitchell, Carl	DPES, 100% (UTSC)		Full	Geography and Planning (P); School of the	CI (EES1126, EES1200, EES1201), TS

Name	Unit of Primary Budgetary Appointment and Percentage	Unit of Other Budgetary Appointment and Percentage (if applicable)	Graduate Faculty Membership Status (e.g., Associate/ Full privileges)	Commitment to Other Academic Units including GDPES. Abbreviations (P) and (S) Denote Primary and Secondary Appointments.	Nature of Contribution to this Program (Course Instructor [CI], Thesis Supervision [TS], Thesis Co-supervision [TCS])
				Environment (S); GDPES, UTSC (S)	
Murphy, Jennifer	Chemistry, 100% (FAS)		Full	Chemistry (P); School of the Environment (S); GDPES, UTSC (S)	TS
Sherwood-Lollar, Barbara	Earth Sciences, 100% (FAS)		Full	Earth Sciences (P); Chemistry (S); Chemical Engineering and Applied Chemistry (S); GDPES, UTSC (S)	TS
Simpson, Andre	DPES, 100% (UTSC)		Full	Chemistry (P); School of the Environment (S); GDPES, UTSC (S)	CI (EES1102), TS
Simpson, Myrna	DPES, 100% (UTSC)		Full	Chemistry (P); Geography and Planning (S); Earth	CI (EES1105), TS

Name	Unit of Primary Budgetary Appointment and Percentage	Unit of Other Budgetary Appointment and Percentage (if applicable)	Graduate Faculty Membership Status (e.g., Associate/ Full privileges)	Commitment to Other Academic Units including GDPES. Abbreviations (P) and (S) Denote Primary and Secondary Appointments.	Nature of Contribution to this Program (Course Instructor [CI], Thesis Supervision [TS], Thesis Co-supervision [TCS])
				Sciences (S); School of the Environment (S); GDPES, UTSC (S)	
Smith, Sandy	John H. Daniels Faculty of Architecture, Landscape, and Design, 100% (FALD)		Full, Graduate Department of Forestry	Ecology and Evolutionary Biology (P); School of the Environment (S); GDPES, UTSC (S)	TS
Strong, Kim	Physics, 100% (FAS)		Full	Physics (P); School of the Environment (S); GDPES, UTSC (S)	TS
Tsuji, Leonard	Health and Society, 100% (UTSC)		Full	GDPES, UTSC (P)	CI (ESS1135), TS
Vanlerberghe, Greg	Biological Sciences, 100% (UTSC)		Full	Cell and Systems Biology (P); GDPES, UTSC (S)	TS

Name	Unit of Primary Budgetary Appointment and Percentage	Unit of Other Budgetary Appointment and Percentage (if applicable)	Graduate Faculty Membership Status (e.g., Associate/ Full privileges)	Commitment to Other Academic Units including GDPES. Abbreviations (P) and (S) Denote Primary and Secondary Appointments.	Nature of Contribution to this Program (Course Instructor [CI], Thesis Supervision [TS], Thesis Co-supervision [TCS])
Wania, Frank	DPES, 100% (UTSC)		Full	Chemistry (P); Chemical Engineering & Applied Chemistry (S); School of the Environment (S); GDPES, UTSC (S)	CI (EES1121), TS
Wells, Mathew	DPES, 100% (UTSC)		Full	GDPES, UTSC (P); Geography and Planning (S); Physics (S); Earth Sciences (S);	CI (EES1120), TS
Tenure Stream: Associate					
Bergquist, Bridget	Earth Sciences, 100% (FAS)		Full	Earth Sciences (P); School of the Environment (S); GDPES, UTSC (S)	TS
Finkelstein, Sarah	Earth Sciences, 100% (FAS)		Full	Earth Sciences (P); Geography and Planning (S); School	TS

Name	Unit of Primary Budgetary Appointment and Percentage	Unit of Other Budgetary Appointment and Percentage (if applicable)	Graduate Faculty Membership Status (e.g., Associate/ Full privileges)	Commitment to Other Academic Units including GDPES. Abbreviations (P) and (S) Denote Primary and Secondary Appointments.	Nature of Contribution to this Program (Course Instructor [CI], Thesis Supervision [TS], Thesis Co-supervision [TCS])
				of the Environment (S); GDPES, UTSC (S)	
Kerman, Kagan	DPES, 100% (UTSC)		Full	Chemistry (P); GDPES, UTSC (S)	TS
Klenk, Nicole	DPES, 51% (UTSC)	Political Science, 49% (UTSC)	Full	Geography and Planning (P); School of the Environment (S); GDPES, UTSC (S)	CI (EES1134), TS
Wiseman, Clare	School of the Environment, 100% (FAS)		Full	Public Health Sciences (P); GDPES, UTSC (S)	TS
Zhang, Xiao-an	DPES, 100% (UTSC)		Full	Chemistry (P); GPES, UTSC (S)	TS
Tenure Stream: Assistant					
Caron-Beaudoin, Elyse	Health and Society, 100% (UTSC)		Full	GDPES, UTSC (P)	

Name	Unit of Primary Budgetary Appointment and Percentage	Unit of Other Budgetary Appointment and Percentage (if applicable)	Graduate Faculty Membership Status (e.g., Associate/ Full privileges)	Commitment to Other Academic Units including GDPES. Abbreviations (P) and (S) Denote Primary and Secondary Appointments.	Nature of Contribution to this Program (Course Instructor [CI], Thesis Supervision [TS], Thesis Co-supervision [TCS])
Latulippe, Nicole	Human Geography, 51% (UTSC)	DPES, 49% (UTSC)	Full	Geography and Planning (P); GDPES, UTSC (S)	TS
Lehnherr, Igor	Geography, Geomatics and Environment (UTM), 100%		Full	Geography and Planning (P); School of the Environment (S); Institute for Management & Innovation, UTM (S); GDPES, UTSC (S)	TS
Martin, Adam	DPES, 100% (UTSC)		Full	GDPES, UTSC (P); Geography (S)	CI (EES1108), TS
McIvor, Scott	Biological Sciences, 100% (UTSC)		Full	Ecology and Evolutionary Biology (P); GDPES, UTSC (S)	CI (EES3113), TS
Molnar, Peter	Biological Sciences, 100% (UTSC)		Full	Ecology and Evolutionary	CI (EES3003), TS

Name	Unit of Primary Budgetary Appointment and Percentage	Unit of Other Budgetary Appointment and Percentage (if applicable)	Graduate Faculty Membership Status (e.g., Associate/ Full privileges)	Commitment to Other Academic Units including GDPES. Abbreviations (P) and (S) Denote Primary and Secondary Appointments.	Nature of Contribution to this Program (Course Instructor [CI], Thesis Supervision [TS], Thesis Co-supervision [TCS])
				Biology (P); GDPES, UTSC (S)	
Rochman, Chelsea	Ecology and Evolutionary Biology, 100% (FAS)		Full	Ecology and Evolutionary Biology (P); GDPES, UTSC (S)	TS
Sullan, Ruby	DPES, 100% (UTSC)		Full	Chemistry (P), GDPES, UTSC (S)	TS
Voznyy, Oleksandr	DPES, 100% (UTSC)		Full	Chemistry (P); GDPES, UTSC (S)	TS
Wunch, Debra	Physics, 51% (FAS)	School of the Environment, 49% (FAS)	Full	Physics (P); GDPES, UTSC (S)	TS
Teaching Stream: Associate					
Meriano, Mandana	DPES, 100% (UTSC)		Associate	GDPES, UTSC (P)	TS
Teaching Stream: Assistant					
Daxberger, Heidi	DPES, 100% (UTSC)		Associate	GDPES, UTSC (P)	TS
Smith, Karen	DPES, 100% (UTSC)		Associate	GDPES, UTSC (P); School of Environment (S)	CI (EES1117, EES1132, EES1133), TS

Name	Unit of Primary Budgetary Appointment and Percentage	Unit of Other Budgetary Appointment and Percentage (if applicable)	Graduate Faculty Membership Status (e.g., Associate/ Full privileges)	Commitment to Other Academic Units including GDPES. Abbreviations (P) and (S) Denote Primary and Secondary Appointments.	Nature of Contribution to this Program (Course Instructor [CI], Thesis Supervision [TS], Thesis Co-supervision [TCS])
MacLellan, James	DPES, 100% (UTSC)		Associate	GDPES, UTSC (P)	TS
Adjunct Faculty					
Arnot, Jon			Associate		TCS
Bailey, Sarah			Associate		TCS
Bavsar, Satyedra			Associate		TCS
DeSilva, Amila			Associate		TCS
Doughty, Michael			Associate		CI (EES1109), TCS
Drake, Andrew			Associate		TCS
Dunlop, Erin			Associate		TCS
Helm, Paul			Associate		TCS
Hung, Hayley			Associate		TCS
Koops, Marten			Associate		TCS
Mackereth, Rob			Associate		TCS
Muir, Derek			Associate		TCS
Richards, Agnes			Associate		TCS
Yerubandi, Ram			Associate		TCS
Zhu, Jiping			Associate		TCS

Learning Resources

- Evidence that there are adequate resources to sustain the quality of scholarship and research activities of undergraduate and graduate students, including library support.
- Describe any resources that enhance the learning and teaching environment, including resources to promote student well-being and resiliency in the learning and teaching environment. *Note: Standard appendices on the library and student support are always included in the proposal. You may also wish to highlight specific aspects of the following resources and supports as appropriate for the proposed program:*
  - Library
  - Co-operative Education
  - Academic Advising (including international student advising)
  - Teaching and Learning Office
  - Technology Support for Teaching and Learning
  - Distance/Online Learning
  - Peer Learning Support
  - Disabilities/Accessibility Services
  - Student Academic Support Services
  - Academic Computing Services
  - Other unit- or program-specific supports/services

Please see the following appendices:

- Appendix C: Library statement confirming the adequacy of library holdings and support for student learning
- Appendix D: Standard statement concerning student support services

12.2 Financial Support for Graduate Students

- Where appropriate to the program, evidence that financial assistance for students will be sufficient to ensure adequate quality and numbers of students.

Students in the proposed M.Sc. in Environmental Science will receive a base funding package for 12 of the 16 months of the program. During the period that they are funded, supervisors will contribute to a base funding package that is projected to provide students with the cost of annual tuition, plus $19,000 as a living expenses stipend.

For the four months that they are unfunded, students will be able to apply for TAships, as well as needs-based support administered departmentally. Because UTSC runs a robust slate of summer

offerings, it is anticipated that there will be opportunities available for students who would like to TA. Funding opportunities may also be available from RAships offered by GDPES faculty. It is anticipated that these various sources of funding will allow students to complete their degree program without the need to seek external work.

12.3 Space/Infrastructure

- Evidence that there are adequate resources to sustain the quality of scholarship and research activities of undergraduate and graduate students, including information technology support and laboratory access; address any unique requirements including renovations to existing space, new space, equipment, etc.
- Note: The requirements for physical facilities should be identified by providing information on the change in the number of people to be accommodated by type (i.e., faculty, students, administrative staff, etc.) as well as information on changes in equipment and activities requiring accommodation. The division/Faculty should state whether it plans to bring forward proposals for additional space; the renovation of existing space; or whether the current space allocation to the academic program will accommodate the new initiative.

There are no additional space needs; students will be accommodated in faculty labs and graduate student spaces on all three campuses. The Environmental Science and Chemistry Building (ESCB) at UTSC, provides high-quality dedicated office, lab, and administrative space for graduate students in Environmental Science.

The ESCB is a five-story LEED-Gold certified building that houses undergraduate teaching, administration offices, and seminar rooms on its bottom two floors, two stories of state-of-the-art wet laboratory research spaces, and one story of dry laboratory research space, Additional storage and movement-sensitive research laboratory space is provided in the basement. Importantly, the ESCB houses the Teaching and Research in Analytical Chemistry and Environmental Sciences (TRACES) facility, which houses over 40 state-of-the-art instruments for central use for both teaching and research needs. A full-time lab manager and technician oversee day-to-day operations and operational capabilities of the instruments, as well as training and oversight of students and student researchers. The ESCB also houses its own Chemical Stores facility with full-time staff. Chemical Stores support research and teaching activities by providing faculty and students with chemicals, equipment, supplies, and waste handling services. Furthermore, this facility is responsible for shipping and receiving activities in ESCB, assisting with departmental compliance with Environmental Health and Safety regulations, submitting purchase orders, and maintaining an electronic repository of packing slips, invoices and lab chemicals.

The current Coordinator role for the Ph.D. in Environmental Science is being transitioned from 49% to 100%, and this role will be responsible for supporting the proposed M.Sc. program. There is no anticipated need for additional administrative staff, beyond this.

12.4 Other Resource Implications

- For example,
  - Is a new graduate unit contemplated that would require a separate graduate chair appointed under the PAAA?
  - Are there interdivisional teaching implications?
  - Will the new program affect any existing agreements with other institutions, or require the creation of a new agreement to facilitate the new program (e.g., Memorandum of Understanding, Memorandum of Agreement, etc.). (Existing joint programs are offered with Centennial, Sheridan and Michener.)
  - If this is a new joint program, please indicate how future reviews of the program will be conducted in accordance with UTQAP 2.1: "Where a program is held jointly with an Ontario institution that does not have an IQAP that has been ratified by the Quality Council, the UTQAP will serve as the guiding document and University of Toronto will be the lead institution. Where a program is held jointly with an Ontario institution that does have an IQAP that has been ratified by the Quality Council, a lead institution will be selected. Program proposals specify how future reviews will be conducted."
- Please consult with the Provost's office (vp.academicprograms@utoronto.ca) early regarding any resource implications described in this section.

The proposed M.Sc. will be offered in the existing Graduate Department of Physical and Environmental Sciences (GDPES); the current Chair of the Graduate unit is Dr. George Archontitsis.

There are no interdivisional teaching implications associated with the proposal. Should any arise, the appropriate processes will be followed.

The proposed program will not affect any existing agreements with other institutions, and does not require the creation of any new agreements.

This is not a proposal for a new Joint program.

13 Quality & Other Indicators

- Please describe the appropriateness of the faculty's collective expertise and how it contributes substantively to the proposed program. Define and use indicators to provide evidence of the quality of the faculty (e.g., qualifications, research, innovation and scholarly record)
- Please explain how the program structure and faculty research will ensure the intellectual quality of the student experience.
- Please describe any elements that enhance the program's diversity.

UTSC is an ideal location for the proposed M.Sc. in Environmental Science. GDPES reflects UTSC's commitment to leadership in graduate education and graduate student supervision in environmental science. Moreover, the proposed M.Sc. will address a long-recognized gap in the graduate offerings. The faculty involved in the Ph.D. in Environmental Science identified the need for such a program well over five years ago, to address the need for a means of recruiting shorter-term highly qualified personnel (HQP) into interdisciplinary, environmentally relevant research areas. In 2015-2016, GDPES programs underwent a highly successful external review, in which the pursuit of a research-based master's was strongly supported by external reviewers. The existing Ph.D. in Environmental Science has been running very successfully since 2010. This success clearly demonstrates that the academic, technical, and administrative expertise needed to mount and sustain the administration of the proposed M.Sc. in Environmental Science exists within GDPES and at UTSC.

The academic design of the program draws upon the impressive expertise of GDPES core faculty, who are highly productive; several are considered to be international leaders in the fields of biogeochemistry, hydrology, hydrogeology, agroforestry, limnology, environmental or biological chemistry, environmental policy and governance, uncertainty analysis, and modelling at both local and global scales. Consistent with their research activities, the proposed M.Sc. will offer opportunities for laboratory and field-based projects in addition to theoretical and high performance computing studies. Within the core group of GDPES faculty, there are five major research themes (Biological Chemistry, Environmental Chemistry, Biogeochemistry, Environmental Geoscience, and Environmental Studies), although all are quite broadly defined, with individual faculty often having additional research directions and interests. As such, the GDPES faculty will offer students in the proposed program an extraordinary array of different potential research opportunities, all grounded in rigorous scientific data collection and analysis.

Biological Chemistry includes **Prof. A. Izmaylov** (Sloan Fellow), a theoretical physical chemist, using state-of-the-art computational tools to understand the fundamentals of chemical reactions; **Prof. K. Kerman** (Canada Research Chair), a bioanalytical chemist, developing cutting-edge sensors for the accurate identification of disease markers; **Prof. H. Kraatz** (Fellow of the Royal Society of Canada), a bio-inorganic/bio-analytical chemist with research interests that revolve around the use of bioconjugates for the design and synthesis of sensors of biological events and pathogens; **Prof. R. Sullan**, a biophysical chemist interested in studying the binding forces of bacterial adhesins responsible for the initial attachment of bacteria to surfaces; **Prof. O. Voznyy** (ISI Highly Cited Author) with a research program that works on developing novel materials for Li-ion batteries, hydrogen storage, CO_2 capture, and photovoltaics; and **Prof. X. Zhang** a bio-organic chemist, working to develop novel and selective imaging probes for in-vivo detection of disease and biochemical activities.

Environmental Chemistry consists of **Prof. J. Donaldson**, a physical chemist studying atmospheric chemical processes, especially those taking place at the surfaces of water, ice, dust, and city windows; **Prof. A. Simpson,** an analytical chemist with a strong interest in the development of novel nuclear magnetic resonance (NMR) methods to study environmental processes and complex multiphase samples and mixtures; **Prof. M. Simpson** (Canada Research Chair) studies the binding mechanisms of organic contaminants to soils/sediments and develops NMR-based metabolomics method to detect sub-lethal toxic stress levels in indicator organisms; **Prof. F. Wania** (Fellow of the Royal Society of Canada), an internationally known environmental chemist studying the distribution and transport of persistent pollutants in multiple media.

Biogeochemistry includes **Prof. R. Fulthorpe**, an environmental microbiologist specializing in the degradation of organic contaminants by bacteria, with a recent focus on the role of degradative bacteria that associate with plants as endophytes; **Prof. M. Isaac** (Canada Research Chair) with research expertise in agroecology, plant-soil interactions, nutrient cycling, and the social framework promoting prosperity in rural communities; **Prof. A. Martin** is interested in how differences in the morphological, chemical, and physical characteristics of plants — or their functional traits — influence the structure and function of agroecosystems; **Prof. C. Mitchell's** research program aims to elucidate the paths through which hydrology influences biogeochemical processes and contaminant fate and transport in both the Canadian Shield and urban landscapes, with a focus on isotope hydrology and water quality.

Environmental Geoscience includes **Prof. G. Arhonditsis**, an environmental modeler that addresses eutrophication problems, quantifies land-lake interactions, identifies climate change effects on ecosystem phenology, and studies food web dynamics; **Prof. M. Dittrich** is a geobiologist, who investigates the effects of microbes on key biogeochemical processes, such as

the formation of carbonates in water columns and biofilms, the oxidation of iron and manganese, and the formation of phosphorous binding minerals; **Prof. N. Eyles'** expertise lies in glacial geology and sedimentology, and his primary research interests encompass Pleistocene glaciations of Canada and the record of ancient pre-Pleistocene glacial climates in Earth history; **Prof. W. Gough** investigates various phenomena related to climate change, including climate change in the eastern Arctic, numerical ocean and climate modelling, air quality in southwestern Ontario, urban climate, hurricanes, climate change impact assessment, and climate change policy; **Prof. K. Howard's** research is concerned with all aspects of groundwater resource evaluation, management, and protection; **Prof. M. Wells** aims to quantify water body flows and mixing — particularly in large lakes and the coastal ocean where stratification and the Earth's rotation play a dominant role in the dynamics.

Environmental Studies: This new theme is currently supported by Prof. N. Klenk with a research focus on the role of (environmental) science in society, the science-policy interface, the politics of knowledge co-production, mobilization, and application, and new modes of environmental governance; and **Prof. L. Tozer** with a research program that examines whether urban nature-based solutions such as green roofs can contribute to climate change mitigation (e.g., building insulation for energy efficiency) and adaptation (e.g., water management), while also enhancing biodiversity and contributing to economic and social well-being.

Within the GDPES, there are several teaching stream faculty. **Profs, M. Meriano (Environmental Geoscience), H. Daxberger (Environmental Geoscience), K. Smith (Director of the Climate Change Impact Assessment field in the MEnvSc program), J. MacLellan (Policy Analysis & Risk Assessment)** all teach in the DPES undergraduate environmental science programs, but also contribute significantly to GDPES through the teaching of graduate courses or active research supervision of M.Env.Sci students, and would be able to serve as committee members for students in the proposed program.

The GDPES also has an impressive contingent of cross-appointed research faculty (see https://www.utsc.utoronto.ca/physsci/graduate-faculty). Some are drawn from the UTSC Department of Biological Sciences, others teach and run research labs at St. George or UTM and are drawn from various departments because they are currently either supervising (or wish to supervise) graduate students or serve on graduate committees. Those in the first category include **Profs. N. Mandrak, L. Tsuji, N. Lovejoy, M. Cadotte, M. Diamond, J. Abbatt, J. Murphy, P. Molnar, A. Grant, C. Jing, J. Desloges, G. Evans, Sherwood-Lollar, S. Smith, and G. Vanlerberghe**. Among those newly cross-appointed who wish to take on new graduate students are **Profs. I. Lehnherr, S. Finkelstein, K. Strong, B. Bergquist, Y. He, C. Wiseman, S. McIvor, C.**

Rochman, and D. Wunch. All of these faculty conduct research related to the main research foci of the proposed program.

Finally, Adjunct Professors in the GDPES also conduct research, largely within government institutions. They bring funding, as well as significant expertise, to GDPES graduate students, and also offer many GDPES students employment opportunities upon their graduation.

The GDPES has a strong reputation as a high-standard teaching enterprise and several faculty members have received prestigious teaching awards. Additionally, tenure-stream faculty members have received numerous institutional, provincial, national, and international awards and recognitions. This impressive research and teaching expertise, the tight connections with the provincial and federal government, the diversity of opportunities to delve into the multifaceted nature of environmental problems, and the design of a curriculum that is conducive to critical thinking and explicit recognition of the multitude of sources of uncertainty typically characterizing environment systems provide a uniquely robust foundation for the proposed M.Sc. in Environmental Science.

Appendix A: Courses

Required Courses

EES 1200H Environmental Science Research Experience (new course)
Description: This course is designed to facilitate student integration into the research process at the very start of M.Sc. studies. The course begins with an intensive workshop co-taught by current M.Sc. supervising faculty, focusing on experimental design, approaches to environmental science research and connection to important research resources. The summer term course continues with the integration of the student into their thesis supervisor's research group for the collection of data toward addressing a research question. Student success in summer research is supported through a direct supervisor-student research mentorship.

EES 1201H Environmental Science: Approaches and Methods in Research (new course)
Description: This course introduces major theories, concepts, methods, and intellectual and creative traditions within environmental science research. There is a particular focus in this course on the critical evaluation of existing knowledge, oral and written communication skills, teamwork, and the ethical and professional responsibilities of environmental scientists.

Elective Courses

EES 1102H Analytical Chemistry for Geoscientists
Description: This course will familiarize students with a working knowledge of analytical chemistry and modern instrumentation and the common laboratory methods used in the analysis of contaminants and ions in environmental media. Students will be introduced to a number of instruments and techniques and the methods used to analyze soils, air, and water.

EES 1104H Microorganisms and the Environment
Description: This applied microbiology course introduces students to microbial activities with environmental implications in diverse areas such as public health, bioremediation, agriculture, and green technologies. A key focus of the course is to introduce classical and advanced molecular methods used to detect and quantify microbes, and microbial activities, in environmental samples. Students are given the opportunity to perform microbial enumeration and characterization techniques in the lab to supplement the lectures.

EES 1105H Soil Contamination Chemistry

Description: This course will present fundamental chemical concepts and reactions that occur in soils with emphasis on contaminant behavior. The basics of soil chemistry will be introduced and the processes that relate to: quantities, attenuation, sequestration and movement of ions, heavy metals, and organic molecules in terrestrial environments will be addressed in detail. Students will become familiar with geochemical computer models and these models will be used to predict the behavior of ions in soil. Soil chemical characteristics, which can be used to predict the fate of contaminants in terrestrial environments, will also be presented.

EES 1106H Geological Evolution and Environmental History of North America

Description: This course reviews the geological and environmental evolution of the North American continent over the past 4 billion years by exploring the range of plate tectonic processes involved in continental growth and how those processes are expressed today as geologic hazards. The course will also review the origins of Canada's natural resources and review changes in terrestrial and marine environments including climate, and the associated ecosystem changes up to the present day. Students will become familiar with recent anthropogenic influences on the environment in regard to waste management, resource extraction and the impacts of urbanization on watersheds on a weekend field trip. This course will provide students with knowledge of naturally occurring long- and short-term environmental changes as context to modern day environmental concerns.

EES 1108H Environmental Science Field Camp

Description: This course allows students to explore areas of the world that have unique geological and biological features, and showcase examples of environmentally relevant technologies and issues. Students are typically asked to prepare background material prior to the 1–2 week field trip. On the trip students participate in field exercises and present material to the class on the key features. Evaluation is based on field notes, completion of exercises, quizzes, and post-trip reports. Field trip destinations differ from year to year, and have included Costa Rica, Arizona, the Rocky Mountains, and the island of Dominica.

EES 1109H Advanced Techniques in Geographic Information Systems

Description: This course covers an advanced set of techniques and applications of GIS, including a substantial practical component. Technical issues (including data format and conversion, geo-referencing, spatial indexing, and terrain analysis), application/spatial modeling (including watershed analysis, land-use classification, soil erosion modeling, etc.) as well as visualization and incorporation of spatial data and analysis into decision support systems will be examined. Underlying programming techniques will be reviewed and extended on a student-project basis.

EES 1111H Freshwater Ecology and Biomonitoring

Description: Freshwater environments support diverse communities of plants and animals that are controlled by both biotic and abiotic factors. Organisms respond to changes in the habitat through detectable shifts in population abundances and the loss/gain of species. Monitoring such biological changes in freshwater communities is an established protocol for assessing the condition of rivers, lakes, and ponds subject to human influence. This course will have a large practical component in which students will have the opportunity to learn the skills necessary to evaluate the condition of aquatic environments variously affected by urbanization.

EES 1112H Boundary Layer Climates and Contaminant Fate

Description: This course examines the dynamics and radiation physics of the atmospheric planetary boundary layers. Topics include the formation of a planetary boundary layer, vertical stability, temperature inversions, diurnal and seasonal variations, and impacts of local and regional scale circulation. With this foundation the dispersion of airborne pollutants will be studied. The course will conclude with modeling of airborne pollutants and case studies.

EES 1113H Groundwater Hydrochemistry and Contaminant Transport

Description: This course focuses on groundwater contamination and the various methods used to investigate, assess, and evaluate the movement and behavior of contaminants in the subsurface. Emphasis will be on urban groundwater issues with case study examples taken from North America, Europe, central Asia, and Africa.

EES 1114H Directed Readings in Environmental Science I

Description: EES1114H provides an opportunity for a student to work closely with a member of the faculty in order to conduct a literature review, a research proposal and/or some preliminary investigations on a particular topic. The faculty supervisor will determine in which way the EES1114H course will be used and what the expected product will be, based on the three models above — or mixtures of them.

EES 1117H Climate Change Impact Assessment

Description: The study and consideration of climate change is of increasing significance to society. This course will review the evidence for climate change over the past 150 years using both direct measurements and proxy data. Projection of future climate change will also be considered by modeling. Students will complete a major case study and research paper.

EES 1118H Fundamentals of Ecological Modelling

Description: This course provides an introduction to the rapidly growing field of ecological and environmental modelling. Students will become familiar with most of the basic equations used

to represent ecological processes. The course will also provide a comprehensive overview of the population and dynamic biogeochemical models; prey-predator, resource competition, and eutrophication models will be used as illustrations. Emphasis will be placed on the rational model development, objective model evaluation and validation, extraction of the optimal complexity from complicated/intertwined ecological processes, explicit acknowledgment of the uncertainty in ecological forecasting, and its implications for environmental management.

EES 1119H Quantitative Environmental Analysis

Description: This course provides an introduction to the field of ecological statistics. Students will become familiar with several methods of statistical analysis of categorical and multivariate environmental data. The course will provide a comprehensive presentation of analysis of variance, regression analysis, structural equation modeling, ordination (principal component & factor analysis) and classification (cluster & discriminant analysis) methods, and basic concepts of Bayesian analysis. Emphasis will be placed on how these methods can be used to identify significant cause-effect relationships, detect spatiotemporal trends, and assist environment management by elucidating ecological patterns (e.g., classification of aquatic ecosystems based on their trophic status, assessment of climate variability signature on ecological time series, landscape analysis). The course will consist of two-hour lectures/tutorials where the students will be introduced to the basic concepts of the statistical methods and two-hour lab exercises where the students will have the opportunity to get hands-on experience in statistical analysis of environmental data.

EES 1120H Fluid Dynamics of Contaminant Transport

Description: This course will introduce the mechanisms of contaminant transport in lakes and the coastal ocean. The emphasis will be on a practical understanding of different dispersion regimes from point and distributed pollution sources. Students will learn to use the basic equations that model these processes and understand how these equations are used in water quality models. Students will also be introduced to field measurement techniques and learn to compare field data with model data. Among the subjects to be discussed are the dispersion of pollutants in lakes, rivers, and the coastal zone, mixing in stratified estuaries, and the dynamics of the seasonal thermocline.

EES 1121H Modeling the Fate of Organic Chemicals in the Environment

Description: This course will give an introduction to quantitative approaches to describing the behaviour of organic chemicals in the environment. Building upon a quantitative treatment of equilibrium partitioning and kinetically controlled transfer processes of organic compounds between gaseous, liquid, and solid phases of environmental significance, students will be

shown how to build, use, and evaluate simulation models of organic chemical fate in the environment. The course will provide hands-on experience with a variety of such models.

EES 1126H Hydrology and Watershed Management

Description: This course focuses on advanced processes in watershed hydrology for furthering our understanding of complex environmental problems, ranging from the characterization of freshwater resources to contaminant transport in aquatic systems. Course topics will include a quantitative understanding of how water moves on, and below, the earth's surface, how tracer studies can be coupled with physical measurements to understand complex problems in hydrology and water quality, land-use change impacts, and approaches to watershed management. Students will participate in discussions on current and benchmark scientific literature.

EES 1127H Applied Biogeochemistry and Geomicrobiology

Description: The course will provide an introduction to geomicrobiology and describe how microbial communities have influenced biogeochemical and mineralogical processes through geologic time. Topics will include microbial properties and diversity; microbial metabolism, cell surface reactivity, and metal sorption; biomineralization; microbial weathering; microbial zonation and early microbial life. This course will also include a practical laboratory part; students will perform experiments on microbial zonation and biomineralization.

EES 1128H Biophysical Interactions in Managed Environments

Description: This course will focus on biophysical interactions at the advanced level, incorporating specialized concepts on plant-soil relationships, biogeochemical cycles, and ecosystem functioning in managed forests and agriculture. Students will be provided the opportunity to engage with course topics in seminar, field, and laboratory formats. Sampling and analytical techniques covered are in-situ soil and leaf-level gas exchange analysis, soil sampling, preparation, and elemental analysis and quantification of plant metrics. By the end of this course, students will have an understanding of the complexities and dynamics in managed environments, specifically ecosystem structure and function, soil fluxes including decomposition and mineralization processes, plant growth and nutrition, and production-diversity relationships.

EES 1130H Ontario BioGeospheres Field Course

Description: This course will involve a circular tour of central Ontario that exposes students to key features of the Ontario environment that allow for observation, measurement, and sampling opportunities. Locations may vary from year to year but the most likely destinations will be: Manitoulan Island (to illustrate Devonian and Silurian rock formations), Killarney

Provincial Park (to demonstrate lake acidification and collect phytoplankton samples), Parry Sound (to demonstrate geophysical mapping of Lake Huron and sampling), Havelock (central metasedimentary belt geology, forest diversity surveys, lake mapping, water quality testing inside and outside of anthropogenic inputs), and Burketon or Pontypool (Geology and hydrology of Oak Ridges Moraine).

EES 1131H Applied Climatology

Description: This course will introduce and discuss the basic topics and tools of applied climatology, and how its concepts can be used in everyday planning and operations (e.g., in transportation, agriculture, resource management, health, and energy). The course involves the study of the application of climatic processes and the reciprocal interaction between climate and human activities. Students will also learn the methods of analyzing and interpreting meteorological and climatological data in a variety of applied contexts. Topics include: Solar Energy; Synoptic Climatology and Meteorology; Climate and Agriculture; Climate and Energy; Climate and Human Comfort; Urban Effects on Climate and Air Pollution.

EES 1132H Climate Data Analysis

Description: This course will offer an advanced introduction to climate data analysis. It is intended for graduate students studying climate science and is mainly laboratory (computer) based. For the first part of the course, the goal is to provide an understanding of the theory underlying the statistical analysis of climate data, in the space, time, and spectral domains. In the second part of the course, the basic concepts of time series analysis will be introduced in terms of identifying stationarity or trends in the data. Some of the important statistical estimation techniques such as regression, correlation, and spectral analysis will be used for the time series analysis by giving a detailed account of the interpretation of the data and the associated climatological questions. Although some previous knowledge of probability and statistics will be helpful, a review will be provided at the beginning of the course. Concepts and notation will be reintroduced, as needed. If time permits, the statistical modelling approach will also be covered.

EES 1133H Climate Change Science and Modelling

Description: The course is designed to introduce the fundamental concepts underlying our current understanding of the climate system. The science of climate includes basic radiation physics and dynamics, which are the basis of modern climate modelling. The changes in the radiation energy budget will be examined in terms of natural variability and anthropogenic activities, in particular, greenhouse gases and their sources and sinks. Underlying physical processes that shape our climate will be explored, e.g., solar variability, orbital mechanics, atmospheric and oceanic circulation, and volcanic and atmospheric aerosols. In addition, the

types of climate modelling experiments performed with modern climate models and scenarios will be reviewed by focusing on the evidence for past and present climate change. The latest projections of future climate on a variety of temporal and spatial scales will also be presented and evaluated. This course is aimed at connecting the essentials of climate science and modelling, and training students to interpret the results of modelling experiments.

EES 1134H Climate Change Policy

Description: Climate change represents one of the most complex and profound environmental issues facing modern society. Devising an effective response therefore, requires a nuanced understanding of how the domains of science, management, and policy can be integrated. This course pursues an understanding of the human dimensions of climate change, and the associated international/national policy response. The aim of the course is to provide a framework to evaluate why climate change represents a major and also difficult social, economic, and environmental problem with differing perspectives on policy solutions, both domestically and internationally. To track the complexity of the issue, an historical approach will be enlisted to contextualize the evolution of our collective scientific understanding of 'climatic change,' and associated management/policy responses. Practical lessons learned will be identified and used to examine the science/policy interface with respect to communication and collaboration, between and among, scientists, government bureaucrats, and stakeholders.

EES 1135H Environmental Change and Human Health

Description: The didactic portion of this course will take a holistic approach to the issue of environmental change and human health. Environmental change and human health issues are often complex and require a holistic approach where the lines between different disciplines (e.g., natural, physical, health, and social sciences) are often obscured. Environmental change, as defined in this course, includes biophysical and built (social, cultural, political) settings. Human health is broadly defined to include the concept of well-being. Case studies will be used to introduce students to topics, such as: toxicants (e.g., "heavy" metals; persistent organic pollutants); toxins (e.g., botulinum); diabetes; infectious diseases (e.g., West Nile Virus); and oral health. Concepts introduced in these case studies — such as, the etiology of disease — will provide the foundation for the hands-on portion of the course. In this part of the course, students will learn how to write a CV (curriculum vitae) and complete a Canadian Institutes of Health Research open operating grant proposal (or similar grant proposal with permission of the instructor). Students will learn about the different elements of a grant proposal required for success, while honing their researching, writing, and presentation skills. Students will also increase their content knowledge about the environmental health issue they have chosen for the grant proposal.

EES 1136H Climate Change Adaptation

Description: This graduate course will focus on adaptation science and practice at local, provincial, national, and international scales. Students will learn about how climate change adaptation is perceived, studied, and performed by civil society groups and governments through various theoretical perspectives: resilience theory, neo-liberal theory, and critical theory. Students will also learn about different governance approaches that support adaptation: multilevel, poly-centric, experimental, and anticipatory governance arrangements. Using case studies ranging from local adaptation planning in Canada to the IPCC's contributions to knowledge synthesis, students will gain a better understanding of the social, economic, political, and ethical dilemmas at the core of adaptation science and practice. Combined lecture-seminar format.

EES 1137H Quantitative Applications for Data Analysis

Description: In this course, data analysis techniques utilizing Python and R statistical languages will be discussed and introduced, as will the basics of programming and scientific computing. The goal of this course is to prepare graduate students to perform scientific data analysis. Students will learn how to use statistical inference tools to gain insight into large and small data sets, as well as be exposed to cutting-edge techniques and best practices to store, manage, and analyze (large) data. Topics include: Python and R programming, version control, automation, modular programming, and scientific visualization.

EES 3000H Applied Conservation Biology

Description: Canada has a complex conservation landscape. Through lectures and interactive discussions with leading Canadian conservation practitioners, this course will emphasize how conservation theory is put into practice in Canada, from its international obligation (Convention on Biological Diversity) to its federal legislation (Species at Risk Act) and policies (Canadian Biodiversity Strategy) to provincial legislation and policies, and the role of environmental nongovernment organizations (ENGOs). The course will link conservation science theory to policy in Canada through lectures and interactive panel discussions with leading Canadian conservation practitioners. The course will provide the students with an in-depth understanding of the role of science in Canadian conservation policy and the roles of conservation practitioners in government agencies and ENGOs and will better prepare students to engage in the Canadian conservation landscape.

EES 3001H Professional Scientific Literacy

Description: Conservation professionals often act as the interface between basic science and policy or management decisions. Thus students require a fundamental basic scientific literacy. The main topics covered in this course include: 1) writing for scientific, policy, and general

audiences; 2) reading and interpreting basic statistics; 3) writing sound funding proposals for different types of funders, including government agencies, NGOs, and industry; and 4) designing data collection for different purposes, including hypothesis testing, baseline monitoring, and impact assessments.

EES 3002H Conservation Policy

Description: Through lectures, this course will examine the legislation, regulations, and policies that form the foundation for the conservation of biodiversity in Canada including our international obligations and federal and provincial legislation and policies. To become professional conservation practitioners, students must understand the legislation, regulations, and policies that form the foundation for the conservation of biodiversity in Canada. The course will provide an in-depth examination of conservation policy in Canada from its international obligation (Convention on Biological Diversity) to its federal legislation (Species at Risk Act) and policies (Canadian Biodiversity Strategy) to provincial legislation and policies.

EES 3003H Topics in Applied Biodiversity

Description: Taxonomic skills are in increasing demand among the Canadian conservation community. This course will provide students with in-depth taxonomic training. The course will include lecture, lab, and field components taught by taxonomic experts and will be held over 37.5 hours during the second last week of April. Students will be required to choose training for one taxonomic group.

EES 3113H Topics in Population and Community Ecology

Description: The field of ecology is rapidly changing and this course will cover recent advances, concepts, and/or controversies in ecology. This course will focus on specific scientific issues using current literature, and the learning experience will be augmented by student presentations and discussions. The course will help ensure that students become familiar with current basic ecological concepts. Students who did not take advanced ecology courses during their undergraduate studies will find this course especially attractive. This ‘Topics’ course is meant to be a flexible offering that focuses on recent advances, concepts, and/or controversies in ecology.

EES 3114H Topics in Urban and Rural Ecology

Description: Nowhere is the human impact on natural systems more apparent than in urban and rural (human-impacted landscapes outside of cities) settings. Students embarking on a career in conservation need to understand how biodiversity is impacted in human-dominated systems, and how various management options can help enhance biodiversity and ecosystem function. Students will use current literature to apply current theories to the ecology of urban

and rural ecosystems. The course will introduce to important ecological and conservation issues in human-dominated landscapes. This 'Topics' course is meant to be a flexible offering that focuses on the processes and management options in urban and rural systems.

Appendix B: Graduate Calendar Copy

Master of Science in Environmental Science

Program Description

The purpose of the M.Sc. in Environmental Science is to train Bachelor of Science or Engineering graduates in the design, execution, and dissemination of research that is focused on the interfaces between traditional disciplines in dealing with fundamentally scientific, environment-focused issues. This is a full-time, 16-month program with a unique May start date that will help students to rigorously gather data towards the completion of an M.Sc. thesis.

The M.Sc. in Environmental Science will allow students to address major emerging research themes in the environment and pursue projects that make use of complementary research concepts, approaches, and tools. Faculty members are cross-appointed from several graduate units including: Cell and Systems Biology, Chemical Engineering and Applied Chemistry, Chemistry, Earth Sciences, Ecology and Evolutionary Biology, Geography and Planning, Forestry, and Physics, which ensures the supervision of research projects across a broad range of expertise and research facilities. This program will engage these strengths in order to foster research that is critical for finding solutions to, or elucidating the root causes of, today's critical environmental challenges.

Minimum Admission Requirements

- Applicants are admitted under the General Regulations of the School of Graduate Studies. Applicants must also satisfy the Graduate Department of Physical and Environmental Sciences' additional admission requirements stated below.
- Applicants whose primary language is not English, and who graduated from a university where the language of instruction and examination was not English, must demonstrate proficiency in English. See General Regulations section 4.3 for requirements.
- A science or engineering undergraduate degree with a minimum mid-B grade average in the last two years of the undergraduate program
- Applicants must submit a written, maximum 300-word statement describing their interests in Environmental Science. The statement should describe any research experience, the suitability of their academic background for an M.Sc. in Environmental Science, and their environmental science-related research objectives in the M.Sc. program. Applicants must make clear in their written statement the supervising professor with which they plan to conduct their thesis research and their interest in conducting research in their chosen area.
- Applicants must have completed **one** of the following:

- At least one supervised research experience during their undergraduate studies. This may include an honours thesis, a research-based work term (involving lab or field work, modelling), a summer research experience, or another course formally linked to a research project. One of the applicant's reference letters must be from their research experience supervisor or co-supervisor.
- At least ten one-term courses at the upper levels (Years 3 and 4 of full-time undergraduate studies) in a science discipline (e.g., environmental science, earth science, physical geography, biology, chemistry, mathematics/statistics, physics, computer science, forestry) or in a branch of engineering (e.g., civil, chemical, environmental).

Program Requirements

- **Coursework.** Students must successfully complete a minimum of **1.5 full course equivalents (FCEs)** as follows:
  - Two mandatory 0.5 FCE courses (EES 1200H *Environmental Science Research Experience* and EES 1201H *Environmental Science: Approaches and Methods in Research*) plus a minimum of 0.5 FCE in elective courses to provide background for the student's research. Courses selected must be approved by the student's supervisor and the Graduate Chair. In some cases, additional courses may be required if a student's preparedness is assessed as being insufficient.
  - Students may apply to take a number of graduate-level courses taught by the core faculty, both within the Graduate Department of Physical and Environmental Sciences and outside the Graduate Department of Physical and Environmental Sciences as part of their 0.5 FCE in elective courses for the degree. However, all courses for the M.Sc. degree must be approved by the student's supervisor and the Graduate Chair.
- **Thesis.** The execution of an original piece of research in environmental science carried out under faculty supervision and presented in thesis form. The program requires the oral examination of the completed thesis to a committee of three faculty members, including the faculty supervisor(s).

Program Length

16 months full-time (typical registration sequence: S/F/W/S)

Time Limit

3 years full-time

Appendix C: Library Statement

University of Toronto Libraries Report for Master of Science (M.Sc.) in Environmental Science, Graduate Department of Physical and Environmental Sciences (PESSC) at the University of Toronto Scarborough (UTSC)

May 18, 2021

Context: The University of Toronto Library (UTL) system is the largest academic library in Canada and is currently ranked fourth among academic research libraries in North America.[2] The UTL has an annual acquisition budget of $41 million. Its research and special collections comprise over 12.4 million print volumes, 5.6 million microforms, over 10,000 print journal subscriptions, and rich collections of manuscripts, films, and cartographic materials. The system provides access to more than 2.6 million electronic books, 150,000 electronic journals, and rich primary source materials.[3] Numerous, wide-ranging collections, facilities, and staff expertise reflect the breadth of research and instructional programs at the University, and attract unique donations of books and manuscripts from around the world, which in turn draw scholars for research and graduate work.

Major North American Research Libraries					
	2014-2015	**2015-2016**	**2016-2017**	**2017-2018**	**2018-2019**
ARL RANK	UNIVERSITY	UNIVERSITY	UNIVERSITY	UNIVERSITY	UNIVERSITY
1	Harvard	Harvard	Harvard	Harvard	Harvard
2	Yale	Yale	Yale	Yale	Yale
3	Columbia	Michigan	Michigan	**Toronto (3rd)**	Columbia
4	**Toronto (4th)**	Columbia	Columbia	Columbia	**Toronto (4th)**
5	Michigan	New York	New York	Michigan	Michigan
6		**Toronto (6th)**	**Toronto (6th)**		

[2] As per Association of Research Libraries Statistics.

[3] Figures as of January 2020

Top 5 Canadian Universities in the ARL Ranking of Major North American Research Libraries				
2014-2015	**2015-2016**	**2016-2017**	**2017-2018**	**2018-2019**
RANK/ UNIVERSITY	**RANK/ UNIVERSITY**	**RANK/ UNIVERSITY**	**RANK/ UNIVERSITY**	**RANK/ UNIVERSITY**
4/Toronto	**6/Toronto**	**6/Toronto**	**3/Toronto**	**4/Toronto**
27/Alberta	31/Alberta	29/Alberta	29/Alberta	30/Alberta
31/British Columbia	35/British Columbia	37/British Columbia	33/British Columbia	40/British Columbia
43/McGill	42/McGill	40/McGill	38/McGill	47/McGill
49/Calgary	63/Calgary	75/Calgary	69/Manitoba	62/Ottawa

Space and Access Services: The UTL's 42 libraries are divided into four administrative groups: Central, Departmental/local, Campus (UTM & UTSC) and Federated and Affiliated College Libraries. The UTL provides a variety of individual and group study spaces for students. Study space and computer facilities are available twenty-four hours, five days per week at one location, Robarts Library, with additional extended hours during study and exam periods at both UTSC and UTM. Web-based services and electronic materials are accessible at all times from campus or remote locations.

Teaching, Learning & Research Support: Libraries play an important role in the linking of teaching and research in the University. To this end, information literacy instruction is offered to assist in meeting the Master of Science (M.Sc.) in Environmental Science degree level expectations in the ability to gather, evaluate, and interpret information. Librarians collaborate with instructors on assignment design, provide student research consultations, and offer just-in-time student research help in person, by phone, or through online chat. Librarians are also available to support curriculum mapping initiatives. Special initiatives, such as the Libraries Undergraduate Research Prize, and an annual forum for student journal editors, extend information literacy beyond the classroom. These services align with the Association of College and Research Libraries (ACRL) *Framework for Information Literacy for Higher Education*.[4]

Program Specific Instructional Support: Instruction occurs at a variety of levels for M.Sc. in Environmental Science students and is provided by the faculty liaison librarian for Environmental Sciences. The UTSC Library facilitates formal instruction integrated into the class schedule and hands-on tutorials related to course assignments such as EES1100 — Advanced

[4] Association of College & Research Libraries. Framework for Information Literacy for Higher Education. ACRL, 2016. http://www.ala.org/acrl/sites/ala.org.acrl/files/content/issues/infolit/Framework_ILHE.pdf

Seminar in Environmental Sciences, EES1128 — Biophysical Interactions in Managed Environments, EES2200 — Advanced Seminar in Environmental Sciences (PhD), and EES3001 — Professional Scientific Literacy. Due to the individualized nature of graduate studies, a good deal of instruction for graduate students is also performed by the liaison librarian through one on one individual research skills appointments. The Library, through its liaison librarians, customizes feeds of library resources which appear prominently in Quercus course pages. Research guides such as EES1100's https://guides.library.utoronto.ca/ees1100, EES1128's https://guides.library.utoronto.ca/ees1128, and EES3001's https://guides.library.utoronto.ca/ees3001 are examples of course-specific resources that have been previously created for graduate courses.

Collections: Many college and campus libraries collect materials in support of the M.Sc. in Environmental Science; the largest collections of materials are centrally located in the Gerstein Science Information Centre and Noranda Earth Sciences Library. Collections are purchased in all formats to meet the variety of preferences and styles of our current students and faculty. The University of Toronto Libraries is committed to collecting both print and electronic materials in support of the M.Sc. in Environmental Sciences at the University of Toronto Scarborough.

Journals: The Library subscribes to all 25 of the top 25 journals listed in InCites Journal Citation Reports (JCR)[5] in the subject area of Environmental Sciences. Of these titles, all 25 are available electronically to staff and students of the University. We prioritize acquisition of online journals where possible.

Monographs: The UTL maintains comprehensive book approval plans with 51 book vendors worldwide. These plans ensure that the Library receives academic monographs from publishers all over the world in an efficient manner. In support of the M.Sc. in Environmental Science, monographs are purchased in electronic form where possible, and the Library currently receives all current e-books directly from the following publishers: Springer, Elsevier, and Wiley. In addition to the book approval plans that University of Toronto Libraries maintains, the University of Toronto Scarborough Library also does title-by-title selection in the area of Environmental Science and maintains its own local approval plan for this area of study. In addition to these plans, individual librarian selectors select unique and interesting scholarly material overlooked by standard approval plans. There is also a focus at the UTSC Library in acquiring an increasing number of e-books in order to suit the information-seeking behavior of both students and faculty members in the Department of Physical and Environmental Sciences

[5] 2019 InCites Journal Citation Reports® (Thomson Reuters, 2020)

and Graduate Department of Physical and Environmental Sciences. Librarians will continue to build their partnerships with faculty, especially in their individual collaborations in the development of the research profiles, and approval plans will be continuously adjusted based on the curriculum of the Departments' programs and the research interests of faculty members.

Preservation, Digitization, and Open Access: The UTL supports open access to scholarly communication and research information through its institutional research repository (known as TSpace), its Downsview print repository, its open journal services, subscriptions to open access publications, and support for the preservation of research materials in all formats. In addition to acquiring materials in support of the M.Sc. in Environmental Science, the Library has digitized its monograph holdings published before 1923. These books are available without charge to any Internet user. The UTSC Library also does work in scholarly communications, preservation, and open access through the efforts of the UTSC Scholarly Communications Librarian and the Digital Scholarship Unit.

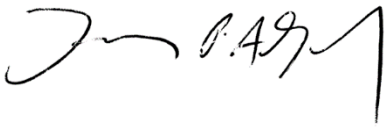
Key Databases: The UTL has subscriptions to all key databases in the area of Environmental Science. These include discipline-specific databases such as GreenFile, GEOBase, the InfoTrac Environmental Issues and Policy eCollection, and Environmental Sciences and Pollution Management. Broader indexes such as Scopus and Web of Science also support research in the program. UTL also subscribes to databases focused on technology, such as Compendex, IEEE Xplore, and INSPEC.

Special Collection Highlight: In 2010, the UTSC Library, in collaboration with faculty and staff, established the Digital Scholarship Unit. The mission of the unit is to create, acquire, preserve, and provide access to digital collections that will inspire and facilitate research and knowledge creation for the purposes of teaching and learning. The early focus of the unit is in the disciplines of the social sciences and humanities with the long-term goal to collaborate and partner with a broad range of disciplines including Environmental Science.

Other Library-departmental engagement: The Liaison Librarian for Environmental Science attends and provides regular updates at all departmental meetings, in addition to regular electronic communications to students and faculty. In order to provide just in time support and be readily available to both students and faculty in the Department, the Liaison Librarian has an office embedded directly in the Department's Environmental Science and Chemistry Building. Advanced research consultations with current undergraduate and graduate students in the Department regularly take place in this space.

Prepared by: Sarah Forbes, Scholarly Communications and Liaison Librarian, May 18, 2021.

Submitted by: Larry Alford, Chief Librarian, University of Toronto Libraries, June 8, 2021.



Appendix D: Student Support Services

All University of Toronto undergraduate and graduate students have access to student services on all three campuses, Mississauga, St. George (downtown Toronto), and Scarborough, regardless of their 'home campus.' The services and co-curricular educational opportunities provide a complement to the formal curriculum by engaging and challenging students to reach their full potential as learners, leaders, and citizens.

At the University of Toronto Scarborough (UTSC) these services are organized by the Office of Student Affairs and the Office of the Vice-Principal Academic and Dean, and support the success of our students from the time they are admitted through degree completion and beyond.

Access*Ability* Services
Provides services and academic accommodations to students with a documented learning, physical, sensory, mental health disability, or medical condition. Advising and referrals for students as well as online services for registration and note taking are available. Access*Ability* Services ensures that policies, practices, procedures, and programs at UTSC are inclusive, and provide equal access for students with disabilities. Access*Ability* also serves a growing campus as a key resource for consulting on accessible design, both physically and pedagogically.

Athletics & Recreation
Strives to create a respectful and inclusive environment that promotes opportunity and overall wellbeing through physical activity. Our home, the Toronto Pan Am Sports Centre (TPASC), is a 300,000 square foot state-of-the-art facility featuring a range of accessible amenities including Olympic-sized pools, a climbing wall, gym and fitness studios, and an indoor track as well as tennis courts, multi-sport fields and more in the valley. As a hub for health living on campus, Athletics & Recreation offers a variety of fitness and instructional programming, organized sports and leagues, as well as aquatics for all levels of physical activity. Highlights include drop-in sports opportunities, learn to play programs, women's only programming, and the popular outdoor recreation program.

Department of Student Life
Offers a range of programming for first-year students, first-generation students, mentorship and leadership development, community outreach, as well as Indigenous, intercultural, and multi-faith programming using an anti-oppressive framework. The Department manages the recognition of approximately 213 campus groups including the facilitation of 16 departmental

student associations as well as liaising with all student societies to ensure compliance with University policy.

Responsibilities include: managing the committee process for allocating funds to student groups involved in various campus life programs and initiatives, ensuring adherence to the risk assessment process for all campus student events, supporting space allocation for clubs and events, representing the University as a partner in the annual Fall Orientation, and support of the Co-Curricular Record.

Health & Wellness Centre

Provides medical, nursing, counselling, health promotion, and education services. Any student with a current student card and a valid health card can use the health and counselling services on campus. Physicians and nurses provide first aid, treatment of minor illnesses, annual check-ups, immunizations, selected over-the-counter medications, referral to specialists, and more. Professional counsellors are equipped to support students with stress management, anxiety, depression, crisis counselling, family problems, relationships, sexuality, bereavement, eating disorders, and other mental health issues. In addition, group therapy and specialized workshops are offered throughout the year. The Health & Wellness Centre also has seven Wellness Peer Programs that promote healthy lifestyle choices in nutrition, sexual health, alcohol, drugs, and tobacco on campus year round with the support of student volunteers.

Centre for Teaching and Learning

1. **The Writing Centre (TWC):** Faculty and Teaching Assistants (TAs) can meet with writing coordinators to advise on teaching writing assignments, and the design and implementation of writing and research paper assignments. After such consultations the writing instructors are willing to deliver specific writing, editing, or research skill instruction within the course, either in-class, or by creating tailored class and online resources. TWC also delivers a limited number of course specific writing clinics to which students bring their drafts to receive tutor and peer feedback.

2. **Video-Capture of Lectures:** Upon faculty request, students are hired to videotape lectures in specific courses so that students in the course can review the class presentations online from remote locations.

3. **Teaching Assistant Training and Graduate Student Professional Skills Development:**
   - General first-time TA Training workshops for new Teaching Assistants.

- Workshops on advanced topics are held for TAs based on TA interest (examples: 'Effective and efficient grading,' 'Responding to students in crisis').
- Graduate Student Professional Development Day.
- Graduate Student Professional Skills Programming — 3 events.
- Graduate Thesis Writing Support Group.
- Writing Support and English Language Development, one-to-one appointments for writing/language skills.

Lesbian, Gay, Bisexual, Transgendered and Questioning
Students are served by a campus-supported Positive Space Committee comprised of allies drawn from all segments of UTSC as well as a student LGBTQ club funded and facilitated independently through the Council on Student Services.

Student Centre
Offers bookable activity spaces for students as well as a food court, a full-service restaurant, and a variety store. It also houses the Office of Student Affairs, the Department of Student Life, the Health & Wellness Centre, The Underground, UTSC Women's & Trans Centre, Fusion Radio, and the Scarborough Campus Students' Union.

Additional Resources for Graduate Students

The Vice-Dean Graduate at UTSC
Provides a range of supports to UTSC graduate students through the Campus Graduate Administrator and the Graduate Programs Assistant. Services include: the administration of the listserv for affiliated graduate students, providing assistance with documentation for the Ontario Student Assistance Program (OSAP) and other provincial student loans, assisting graduate students and faculty with room bookings for PhD Final Oral Exams (FOEs) and Supervisory Committee Meetings held at UTSC, providing information and support for Visiting Graduate Students and their host supervisors at UTSC, and administering UTSC graduate awards and the UTSC Graduate Student Summer Gym Rebate Program for Toronto Pan Am Sports Centre (TPASC).

The School of Graduate Studies on the St. George Campus
Provides registrarial services to all graduate students at the University of Toronto including but not limited to recruitment, admission, orientation, registration, confirmation letters, program progress, PhD final oral exams, and graduation.

The Graduate Awards Office (GAO) at the School of Graduate Studies
Provides administrative support for a wide range of scholarship and financial aid programs.

The Grad Room on the St. George Campus
Is a hub for graduate students to get involved in graduate life, build a community of graduate scholars, and learn and practice new skills in Graduate Professional Development (GPD).

SGS International Graduate Student Portal
Brings together all of the resources available to international students on all three University of Toronto campuses.

Graduate Professional Development Programs at SGS
Offer a range of programs and events for graduate students designed to build professional skills and broaden career networks.

The Graduate Professional Skills Program (GPS)
Is a non-academic program presented by SGS. It consists of a variety of offerings providing doctoral-stream students a range of opportunities for professional skills development. The program focuses on skills beyond those conventionally learned within a disciplinary program, skills that may be critical to success in the wide range of careers that graduates enter, both within and outside academe. GPS aims to help students communicate effectively, plan and manage their time, be entrepreneurial, understand and apply ethical practices, and work effectively in teams and as leaders. GPS offerings are also available locally at UTSC. While the number of GPS offerings continues to grow, there are currently approximately twenty options available as part of the Graduate Professional Skills Workshop Series at UTSC.

The Graduate Centre for Academic Communication
Provides graduate students with advanced training in academic writing and speaking. The Centre offers five types of support designed to target the needs of both native and non-native speakers of English: non-credit courses, single-session workshops, individual writing consultations, writing intensives, and a list of additional resources for academic writing and speaking. UTSC students can also request writing support from the TA and Graduate Student Support Coordinator in the Centre for Teaching and Learning at UTSC. These online or face-to-face consultations can address any type of graduate student writing — from course papers and application materials to research proposals, thesis chapters, and papers for publication.

Appendix E: Comparator Programs

Please list U of T and external comparators; provide a short summary of the programs and highlight any differences between the degree programs and what is proposed.

Institution & Unit	Degree & Program (Including URL)	Program Description & Curriculum	Differences Between This Program & What is Proposed
U of T Comparators			
UTSC — Graduate Department of Physical & Environmental Sciences	MEnvSc — Master of Environmental Science	A 12-month course-based master's with focus on climate change, terrestrial and aquatic systems, and conservation and biodiversity.	The MEnvSc is a course-based, professional program with limited research. The proposed program is a research stream MSc that includes a thesis requirement. The proposed MSc features a May start to support early immersion into research and a is 16-months.
Faculty of Arts and Science — School of Environment	MES — Master of Environment and Sustainability	A 12-month doctoral-stream master's degree culminating in a research thesis. The curricular focus of the program is to provide students with a broad overview of	The MES degree is similarly a course and thesis-based degree. The pedagogical focus is complemetary to our proposed program, but with a focus on sustainability as

Institution & Unit	Degree & Program (Including URL)	Program Description & Curriculum	Differences Between This Program & What is Proposed
		interactions between humans and their environment, and to equip them to better understand sustainability issues from multiple disciplinary perspectives by combining multiple sources of knowledge. (Approved to start in Fall 2022.)	compared to our focus on application of the scientific method toward environmental problems. The targeted students for admission include both B.Sc and B.A students whereas the proposed program is restricted to B.Sc and B.Eng students, which is appropriate for the M.Sc degree designation.
UTM — Institute for Management and Innovation	MScSM — Master of Science in Sustainability Management	A 20-month course-based master's. The curriculum integrates business management, natural science, and social science, all through the lens of sustainability.	The MScSM is a professional, course-based degree with limited research. The program has a different pedogogical focus on sustainability.
Graduate Department of Forestry, John H. Daniels Faculty of Architecture, Landscape, and Design	MFC — Master of Forest Conservation	A 16-month course-based master's. The curriculum focuses on all aspects of forest conservation including sustainable forest management, urban forestry, forest economics, forest	The M.FC degree is a professional course-based program with a significantly different curricular focus. The proposed program is a research stream M.Sc focusing on environmental science.

Institution & Unit	Degree & Program (Including URL)	Program Description & Curriculum	Differences Between This Program & What is Proposed
		governance and policy, forest and wildlife conservation biology, silviculture, and current issues in forest conservation in Canada and around the world.	
Ontario Comparators			
University of Guelph — School of Environmental Sciences	MSc in Environmental Sciences	A two-year master's degree requiring completion of course work and a thesis. This program seeks to develop and train graduate students that possess a high level of knowledge in the field of environmental science, expertise in specific aspects of environmental science (their thesis research focus), training in laboratory and field techniques, and excellence in writing and oral communication.	The proposed program differs in that it has early, formal integration into research, shorter program length, and the May start.

Institution & Unit	Degree & Program (Including URL)	Program Description & Curriculum	Differences Between This Program & What is Proposed
University of Windsor — Great Lakes Institute for Environmental Research	MSc in Environmental Science	A two-year M.Sc program focusing on research with laboratory and field skills, and culminating in a thesis.	The early, formal integration into research and shorter program length in the proposed M.Sc are key distinguishing features.
Nippissing University — School of Graduate Studies	Master of Environmental Sciences/Master of Environmental Studies	A dual science or studies stream master's program with either a two-year thesis option or a one-year research paper option.	A more broadly environmental program servicing both science and social science/humanities. The early, formal integration into research is a key distinguishing feature.
Trent University — Environmental and Life Sciences	MSc in Environmental & Life Sciences	A two-year thesis-based master's program. Research foci are listed as cell biology and genetics, ecology and conservation biology, physical geography, trace contaminant toxicology and chemistry.	The early, formal integration into research and shorter program length in the proposed M.Sc are key distinguishing features.
University of Waterloo — Faculty of Environment	Master of Environmental Studies (MES) in: • Geography • Planning	Either two-year thesis-based or one-year research paper-based master's program offered across different departments. Geography	Different and more diverse disciplinary perspective than in our proposed program. The early, formal integration into research in our proposed

Institution & Unit	Degree & Program (Including URL)	Program Description & Curriculum	Differences Between This Program & What is Proposed
	• Social and Ecological Sustainability • Sustainability Management	offers environmental science as a "graduate research field."	program is a key distinguishing feature.
Canadian Comparators			
McGill University — School of the Environment	Graduate option in Environment	An "option" akin to U of T's graduate collaborative programs. Completing the option includes environmental research, seminars, and two additional courses.	Different from the proposed program because it is not a standalone degree.
UBC	MSc in Resources, Environment and Sustainability	A coursework and thesis-based master's degree. The program is within a problem-focused and curiosity-driven interdisciplinary research institute and graduate program, with interest and expertise in a wide range of topics under the realm of environment and sustainability.	The program has a different subject focus. The early, formal integration into research in the proposed program is a key distinguishing feature.
UBC Okanagan — Earth and Environmental Sciences	MSc in Earth and Environmental Sciences	A two-year coursework and thesis-based master's program. The program focuses	The early, formal integration into research and shorter program length in the

Institution & Unit	Degree & Program (Including URL)	Program Description & Curriculum	Differences Between This Program & What is Proposed
		on the study of Earth dynamics, including its surface, interior, and human impacts.	proposed M.Sc are key distinguishing features.
International Comparators			
Stanford University — School of Earth, Energy and Environmental Sciences	MSc in Earth System Science	A coursework and thesis-based master's degree. The graduate program is offered with foci in: • Atmosphere, Oceans, and Climate • Geology, Geochemistry and Geobiology • Geophysics • Planetary Science • Oceanography	The early, formal integration into research, a lesser course load, and shorter program length in the proposed M.Sc are key distinguishing features.
Massachusetts Institute of Technology — Earth, Atmospheric and Planetary Sciences	Master of Science (S.M.) Program	A two-year coursework and thesis-based program. The master's degree program is geared toward students with undergraduate degrees in geoscience, physics, chemistry, mathematics, or	The early, formal integration into research and shorter program length in the proposed M.Sc are key distinguishing features.

Institution & Unit	Degree & Program (Including URL)	Program Description & Curriculum	Differences Between This Program & What is Proposed
		engineering. Students spend the first year taking classes and the second conducting research and thesis work.	
University of California, Berkeley	Offers an MSc program in Environmental Health Sciences and only a PhD (no MSc) in Environmental Science, Policy, and Management		No comparable program currently exists. The Environmental Health Sciences program is a fundamentally different subject grounded in the health sciences.
ETH Zurich — System-Oriented Natural Sciences	Master in Environmental Sciences	A two-year program that includes coursework, an international research experience and thesis. The program is intended to impart the ability to address complex and interdisciplinary issues at a high scientific level, thus providing the basis for an academic career.	The early, formal integration into research, a lesser course load, and shorter program length in the proposed M.Sc are key distinguishing features.

Appendix F: Student Survey Results

See below.

Survey about Undergraduate Interest in MSc Program in Environmental Science

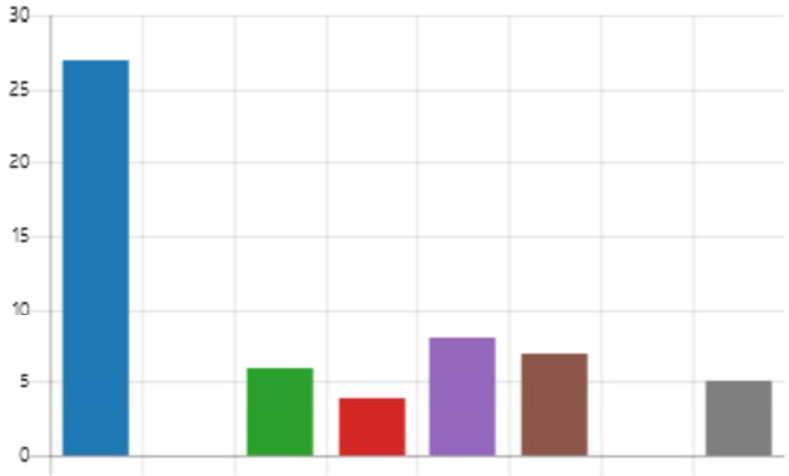
57	03:23	Active	
Responses	Average time to complete	Status	Ideas

1. What year are you in?

First	0
Second	1
Third	17
Fourth	31
Beyond fourth	8

2. Which of the following programs are you enrolled in?

Major in Environmental Science	27
Major in Environmental Studies	0
A minor program in Environm...	6
Specialist in Environmental Bi...	4
Specialist in Environmental Ch...	8
Specialist in Environmental Ge...	7
Specialist in Environmental Ph...	0
I am not enrolled in any Envir...	5



3. Have you had any significant research experience during your undergraduate studies? By significant research experience we mean one or more of the following experiences: volunteering in a professor's lab, being a work-study student, completing a senior thesis, working part-time in a professor's research group, or undertaking a summer research position?

Yes	14
No	41
Other	2

4. If you replied Yes to #3, please explain what research activities you have taken part in during your undergraduate degree:

13

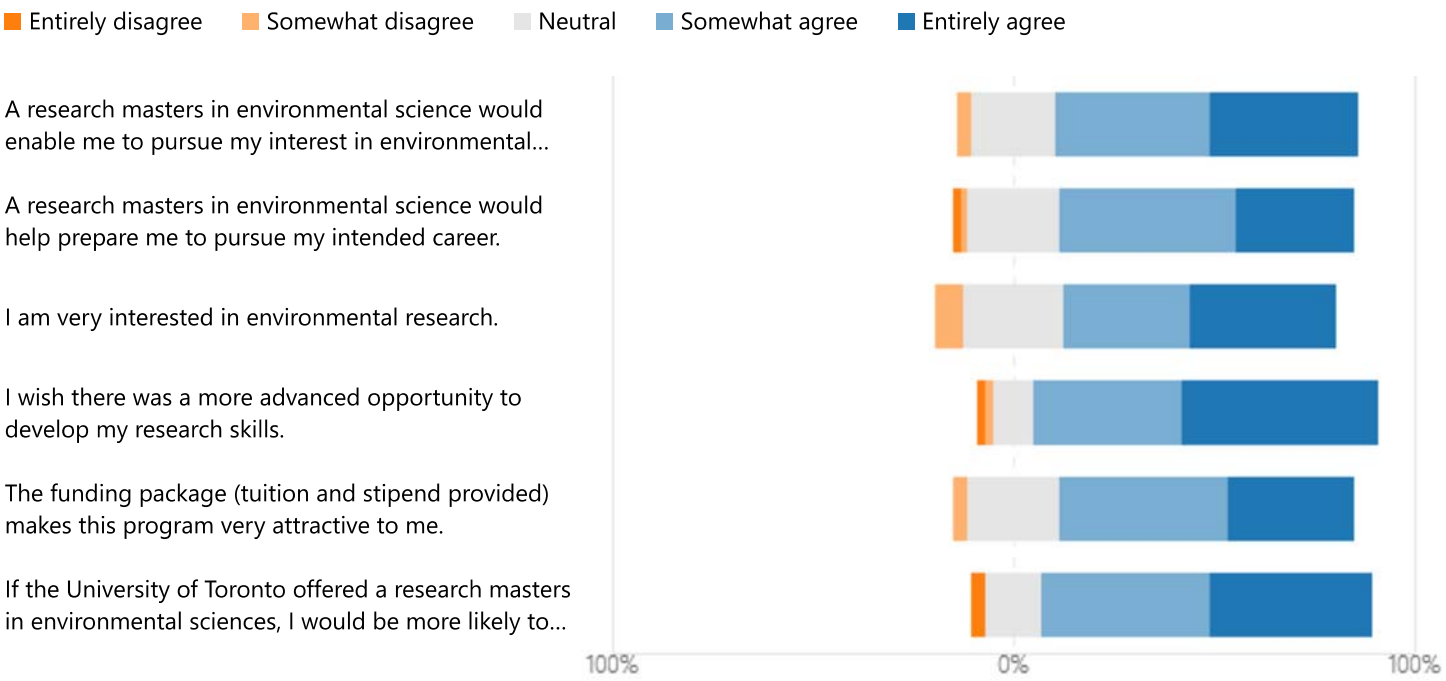
Responses

Latest Responses

5. How likely is it that you will pursue a graduate education after finishing your degree?

definitely not	2
likely not	7
possibly	16
likely	16
definitely	16

6. Please indicate the extent to which you agree or disagree with the following statements about a research-based masters degree in environmental sciences.



7. Would you be interested in applying for this proposed M.Sc. program in Environmental Science?

Survey for Current PhD Students regarding MSc Program in Environmental Science

32	03:40	Active
Responses	Average time to complete	Status

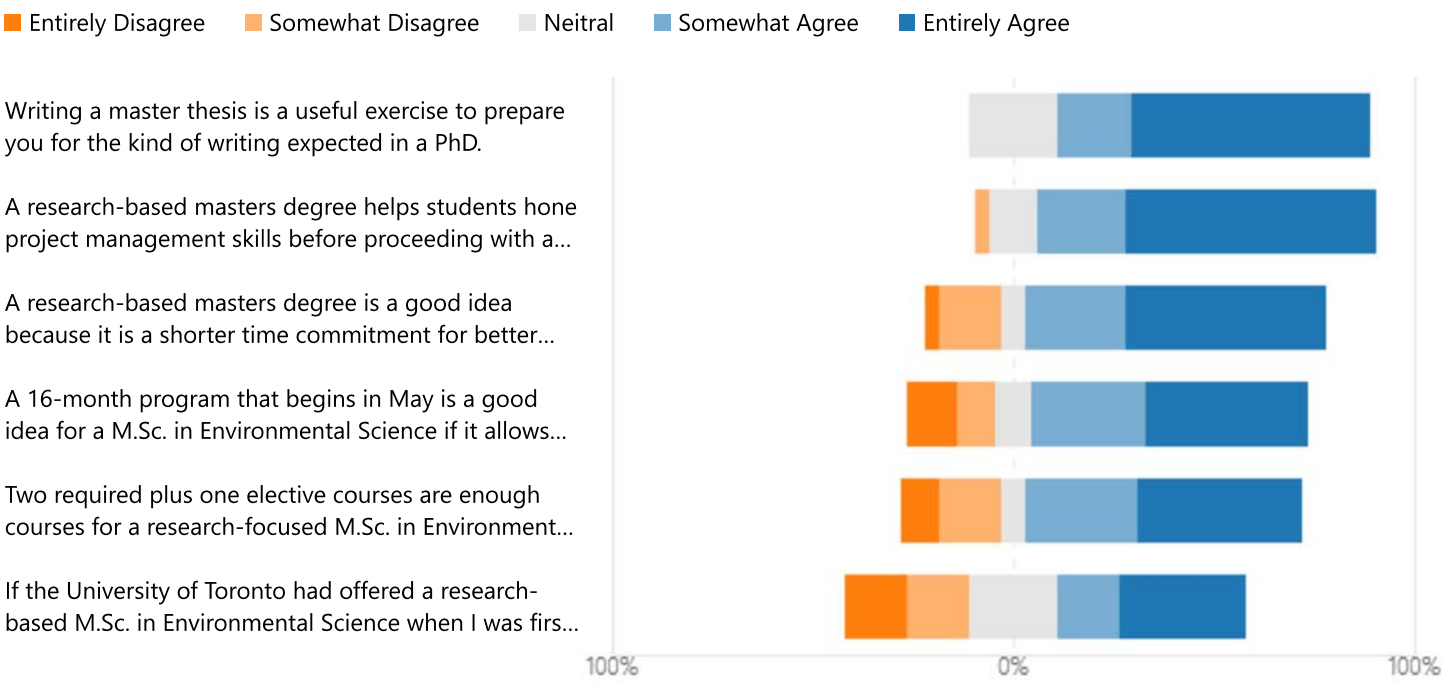
1. Please indicate how long you have been a PhD student for

First year	7
Years 2-3	10
Years 4-5	10
Beyond year 5	5

2. Does your PhD research mostly consist of approaches related to:

Science	24
Social science	2
A mixture of science and socia...	6
Other	0

3. Please indicate the extent to which you agree or disagree with the following statements.



Appendix G: Curriculum Map

See below.

Program Learning Outcomes	Environmental Science Research I	Approaches and Methods in Research	(Possible Elective)	M.Sc. Research Thesis	(Possible Elective)	M.Sc. Research Thesis	Annual Colloqium	M.Sc. Research Thesis
PLO1: Understand the interdisciplinary nature of environmental science founded upon the integration of physical, biological, and information sciences, including ecology, biology, physics, chemistry, plant science, hydrology, soil science/geology, physical geography, and geospatial science; and advance understanding of the systems approach to support advanced critical thinking and synthesis of information across multiple disciplines.		I	D		D			A
PLO2: Critically evaluate the scientific validity of the content and sources of scientific information and recognize knowledge gaps by relying both on the breadth of environmental science knowledge and on the depth of knowledge related to the specific sub-discipline areas of students' research projects. Be able to use this information to critically evaluate the robustness with which inferences can be drawn from past research.		I	D		D			A
PLO3: Understand the multitude of scientific methods required in the study of environmental systems.	I	D		D		D		A
PLO4: Design research projects within the context of established and/or emerging paradigms in environmental science. Specifically, i. Critically identify compelling scientific questions; ii. Gather and/or produce data relevant to testing a hypothesis or in the pursuit of generating new knowledge in environmental science; iii. Properly analyze and interpret data and contextualize new findings in relation to major concepts and methods within environmental science; iv. Formulate a coherent discussion of research findings and provide context for how the research findings advance knowledge in environmental science; v. Critically evaluate the robustness of the key results and articulate strengths and weaknesses of a research project; and, vi. Propose future research directions that build upon the major findings of a completed project.	I	D		D		D		A
PLO5: Apply relevant statistical and mathematical modelling techniques and analytical methods used in environmental science to quantify the precision, accuracy and robustness of research results.	I	D						A

I = Introduced: Key ideas and concepts concentrate on teaching knowledge or skills at an entry-level for the degree.

D = Developing: Students demonstrate learning at an increasing level of proficiency. Instructional and learning activities concentrate on enhancing and strengthening existing knowledge and skills, as well as expanding complexity.

A = Advanced: Students demonstrate learning with an increasing level of independence, expertise and sophistication expected upon graduation. Instructional and learning activities focus on and integrate the use of content or skills in multiple levels of complexity.

PLO6: Produce research of a quality and extent to either merit peer-reviewed publication on its own or contribute significantly to a collaborative publication that is partially conceived, encouraged and overseen by a supervisor.				I		D	D	A
PLO7: Understand their role and responsibilities in a team research setting, and conduct research and interact with team members in an ethical and professional manner.	I	D		D		A		
PLO8: Understand and recognize the integrity of the scientific process.	I	D		D		D		A
PLO9: Write coherently, concisely, and with clarity.		I	D		D			A
PLO10: Give well-organized and focused oral presentations, including the ability to effectively summarize key information.	D	D					A	A
PLO11: Communicate effectively with a range of audiences, including environmental science experts.	I		D		D		A	A
PLO12: Demonstrate basic knowledge of the fundamental role of uncertainty in environmental science research and practice. Specifically, i. Understand the different types of uncertainty and their relative importance for scientists, stakeholders, policy makers, and the public; ii. Recognize that scientific understanding is limited by our abilities to measure, observe and perceive phenomena and that this ability changes as science progresses; iii. Recognize that the interpretation of a particular environmental issue is from an interdisciplinary point of view and that there are inherent limitations in examining issues at different scales and degrees of granularity;	I	D						A

Appendix H: External Appraisal Report

See below.

Master of Science in Environmental Science
External Appraisal Report

Overview

We reviewed the Master of Science in Environmental Science program proposal and met remotely with faculty, staff, and students at the University of Toronto Scarborough (UTSC) campus on the 21st, 22nd and 25th October. Prior to those meetings, we received (i) a copy of the UTSC 2020 Strategic Plan, (ii) a compendium of curriculum vitae for faculty who will be affiliated with the proposed program, (iii) syllabi of existing and new courses for the program, (iv) a link to the UTSC Admissions Viewbook, (v) virtual tours of the UTSC Campus, the Environmental Science and Chemistry Building, and the TRACES analytical laboratory, and (vi) terms of reference for this appraisal report.

Our UTSC host was Dr. Melissa Pullara and during our remote meetings we spoke with:

Professor William Gough, Vice-Principal Academic and Dean
Professor Jessica Fields, Vice-Dean Faculty Affairs, Equity and Success
Professor Mary Silcox, Vice-Dean Graduate and Postdoctoral Studies
Ms. Annette Knott, Academic Programs Officer
Dr. Zahra Bhanji, Director, Office of the VP Academic and Dean
Professor Georgios Arhonditsis, Graduate Department Chair
Professor Carl Mitchell, Associate Graduate Chair
Professor Irena Creed, Vice Principal Research and Innovation
Faculty (Dr. Elyse Caron-Beaudoin, Professor Maria Dittrich, Professor Nicholas Eyles, Professor Marney Isaac, Dr. Igor Lehnherr, Dr. Stuart Livingston, Professor Julian Lowman, Dr. Scott MacIvor, Dr. David MacLagan, Dr. Adam Martin, Dr. Jennifer Murphy, Dr. Karen Smith, Professor Frank Wania, Professor Mathew Wells)
Administrative staff (Scott Ballantyne, Alana Biason, Annie Kostadinova, Liz Pulickeel)
Technical staff (Tony Adamo, Raymond Akbar, Anna Burdy, Chai Chen, Anisa Diljohn-Maraj, Tom Meulendyk, Joanna Ying-Fiss)
Librarians (Angela Hamilton, Sarah Forbes)
Graduate students (Serra-Willow Buchanan, Stephanie Gagliardi, Aisha Javed, Brian Pentz, Raul Salas Reyes, Patricia Semcesen, Shane Sookhan)

Our impression from review of materials and the three days of meetings is that there is an essential need and enthusiastic support for the proposed M.Sc. degree program at UTSC. Faculty affiliated with the proposed program are well-funded and conducting internationally significant research, but they have unfilled supervisory capacity. There appears to be ample demand by high-quality students for M.Sc. research opportunities on the thriving UTSC campus. The question is less whether an M.Sc. in Environmental Science should be created, but rather why does it not exist already. The absence of an interdisciplinary research-focused M.Sc. program is limiting the ability of UTSC faculty to operate at full potential. The financial means and facilities are available to accommodate additional graduate student research; however, faculty are limited by quotas for Ph.D. placements and international students. Early career faculty would benefit from supervision of shorter duration M.Sc. projects and completions leading to publications during their pre-tenure period. Supervision and co-authorship with graduate students are

important to all UTSC faculty who hold NSERC Discovery grants, the renewal of which depends strongly upon evidence of training of 'highly qualified personnel'.

We support creation of a Master of Science in Environmental Science program at the University of Toronto Scarborough campus. Further details underpinning this recommendation are provided in subsequent sections of this appraisal report.

1. Objectives

- *Consistency of the program with the institution's mission and unit's academic plans.*

The proposed Master of Science program is structured to train students to design, execute and disseminate research in environmental science. The program content is science-focused and research-intensive.

The Graduate Department of Physical and Environmental Sciences offers a professional Master of Environmental Science (M.Env.Sc.) and a Ph.D. in Environment Science. The 12-month M.Env.Sc. program is course-based and the majority of students complete an internship during the final 4 months rather than a short duration research project. Direct entry into the Ph.D. program with a B.Sc. degree qualification is possible, but doctoral candidates would benefit from training and experience gained in a research-intensive Master of Science program prior to committing to Ph.D. studies. Creation of the proposed program will address a notable gap that exists in graduate-level programming in environmental science at UTSC.

The science-focused, research-intensive program will expand the range of graduate programs offered at the University of Toronto and contribute to addressing Priorities 1 (high quality student experience and success) and 2 (scholarly prominence in established and emerging areas) in the UTSC Strategic Plan, Inspiring Inclusive Excellence (2020-25). The proposed program is supported by more than 50 faculty system-wide and a further 15 adjunct faculty. It will add much needed research capacity in an established area of strength. The proposed program is distinct from other graduate programs at the University of Toronto, filling a niche that is not currently addressed by graduate programs in environmental studies and management, and sustainability.

- *Clarity and appropriateness of the program's requirements and associated learning outcomes in addressing the academic division's graduate Degree Level Expectations.*

Twelve program learning outcomes (PLOs) are specified in the proposal. The PLOs are clearly defined and appropriate for a Master level degree program. Learning outcomes are linked explicitly to courses and research training. Students are likely to achieve all learning outcomes to an acceptable level but may attain a higher level of proficiency in some areas depending on the nature of their research project (e.g., PLO5 - application of statistics and models).

- *Appropriateness of the degree or diploma nomenclature.*

The program title 'Master of Science in Environmental Science' captures well the level and breadth of research and courses that comprise the proposed program. Entry into the program requires an undergraduate degree in either science or engineering. The program duration and learning outcomes are consistent with a research-based Master of Science degree.

2. Admission Requirements

• *Appropriateness of the program's admission requirements for the learning outcomes established for completion of the program.*

Program admission requirements are appropriate and typical for a research-based Master of Science: a degree in science or engineering, proficiency in English, a written expression of research interests in the field of environmental science, contact with a prospective supervisor, and letters of support, including one from a former supervisor if the applicant has had prior research experience.

In our meetings with UTSC faculty we queried the mid-B grade average requirement, which to us seemed low. We were satisfied with the response that the grade average is a minimum requirement used by graduate programs to provide scope to accommodate applicants who may have achieved moderate grades in an undergraduate program but perhaps have since acquired significant relevant work experience. Given the diversity of individuals that the program will serve, the grade entry requirement is consistent with the UTSC priority of inclusiveness.

Program entry also requires either evidence of a previous supervised research experience at the undergraduate level or completion of ten one-term undergraduate courses at the 300 or 400 level in a relevant area of science or engineering. There appeared to be a preference for the former in our discussions with prospective student supervisors. We concur with the view that a prior research experience will be beneficial for program candidates given the 16-month duration of the program and the need to engage immediately in research during the first four months of the program.

• *Appropriateness of any alternative requirements for admission into the program such as minimum grade point average or additional languages or portfolios, along with how the program recognizes prior work or learning experience.*

To our knowledge, there are no alternative requirements for admission to the proposed program.

3. Structure

• *Appropriateness of the program's structure and regulations to meet specified program learning outcomes and Degree Level Expectations.*

The program structure is focused on conducting original research. The course load requirement is appropriately low (three one-term courses) to provide students with sufficient time to complete the program in 16 months. The structure is consistent with the twelve program learning outcomes, which are focused on training students to design and conduct research, and to disseminate research findings.

• *Rationale for program length in order to ensure that the program requirements can be reasonably completed within the proposed time period.*

The 16-month program length requires full commitment by the student and will thereby enhance program cohort cohesion. Completion of a research-based Master of Science degree is rendered feasible within 16 months by an innovative scheduling approach: beginning each cohort in early summer, with an initial summer term devoted to research, cohort orientation, and integration into laboratory groups. Research-intensive Master of Science programs typically range in duration from 12 to 24 months, with 24 months being more common in our experience. However, research-based programs that have a duration of 12 months do not appear to be unusual within

the University of Toronto system. In comparison, the proposed 16-month program was viewed by UTSC faculty as being more accommodating of student needs and appropriate in length.

Immediate engagement in research reduces the need for required coursework, allows the students to choose elective courses that are relevant to their research goals, and includes a second summer for extending or repeating research, while analyzing data and writing. We see the summer start as the key to making a 16-month program possible for the students. Completing the program in 16 months will allow some students to begin a PhD program in September of the second year, without a gap.

- *The extent to which the program structure and delivery methods reflect universal design principles and/or how the potential need to provide mental or physical health accommodations has been considered in the development of this program.*

The program structure and delivery are both built with flexibility for students and advisors to design for accommodations. The research project is not prescribed at the program level and can be designed or adjusted by individual student-advisor pairs to use particular students' strengths and to accommodate their needs. Students may continue their studies beyond the allocated time period; however, funding is guaranteed only for 12 months. We were reassured that there is a consistent pool of teaching assistantships available for students who need to support themselves through an extra term.

4. Program Content

- *Ways in which the curriculum addresses the current state of the discipline or area of study.*

Students have access to a wide range of relevant courses offered in the UTSC professional M.Env.Sc. degree program. In particular, the core courses, EES 1200H and EES 1201H, will engage students in critical evaluation of the past and current state of environmental science, including research design, major theories, concepts, methods, and intellectual and creative traditions. The unusually broad range of upper-level coursework available for elective courses will allow students to acquire deeper understanding of particular subfields of the very broad interdisciplinary field of environmental science.

- *Identification of any identified unique curriculum or program innovations or creative components and their appropriateness.*

The program begins each year in May, enabling students to begin conducting fieldwork immediately. Students are supported in this early engagement in research through the EES 1200H Environmental Science Research Experience course scheduled in term 1 (May to August). Arrangements for research supervision are finalized before a student begins the program. The May start date is intended to alleviate issues with beginning field research in September. Many types of environmental research need to be conducted during summer months. A May start date also allows M.Sc. students to begin off-cycle with undergraduate programs when supervisors have fewer time pressures associated with teaching duties.

- *For research-focused graduate programs: clarity of the nature and suitability of the major research requirements for degree completion.*

The 16-month program begins in May of each year with students enrolled in EES 1200H which provides instruction in research design and methods. Students also begin field and/or laboratory

work in the first term of studies. EES 1201H continues support for research, as the students gain experience after their first summer, as well as building foundations in history and current approaches to environmental science research, critical thinking, and ethical and professional responsibilities of environmental scientists. The 16-month structure of the program provides an opportunity for a second field season during term 4 if needed.

Preparation of a written thesis and successful defense of the work via an oral examination are typical and appropriate requirements for a Master of Science degree program. These requirements are well suited to help students to work toward Program Learning Outcome 4: Design research projects within the context of established and/or emerging paradigms in environmental science. The degree to which individual students design their own research projects will probably vary among research groups, but EES 1200H will guarantee at least theoretical engagement and classroom experience with research design by all students in the program. Data production, analysis, discussion, evaluation of results and contributions to the field of environmental science are all required in preparation and defense of the written thesis.

- *Evidence that each graduate student in the program is required to take all of the course requirements from among graduate-level courses.*

In our discussions with UTSC faculty and staff, it was confirmed that all courses listed in the program proposal are graduate level and that the 1.5 FCE requirement must be met with graduate courses.

5. Mode of Delivery

- *Appropriateness of the proposed mode(s) of delivery (distance learning, compressed part-time, online, mixed-mode or non-standard forms of delivery, flexible-time options) to meet the intended program learning outcomes and Degree Level Expectations.*

The program will be delivered in-person at the University of Toronto. The majority of students are likely to be based at UTSC, but our understanding from meetings is that students are able to access facilities at the other two campuses of the University of Toronto, especially if faculty at the St. George or Mississauga campuses are members of a student's supervisory committee.

6. Assessment of Teaching and Learning

- *Appropriateness of the proposed methods for the assessment of student achievement of the intended program learning outcomes and Degree Level Expectations.*

Students must successfully complete the 1.5 FCE requirement and prepare and defend a research-based thesis. A preferred outcome is that the research reported in the thesis is sufficient in quality and originality to warrant publication in a peer-reviewed journal. This is a desired outcome and not a requirement for completion of the degree program.

- *Completeness of plans for documenting and demonstrating the level of performance of students, consistent with the academic division's statement of its Degree Level Expectations.*

The Graduate Department of Physical and Environmental Sciences (GDPES) appears to have a well-developed process in place to monitor and document graduate student progress as a result of the M.Env.Sc. and Ph.D. degree programs already administered by the department. The GDPES is well staffed and UTSC has already increased one staff position to coordinate the proposed Master of Science degree program.

7. Resources

• *Adequacy of the administrative unit's planned utilization of existing human, physical and financial resources, and any institutional commitment to supplement those resources to support the program.*

The host administrative unit (Graduate Department of Physical and Environmental Sciences) is located in the modern Environmental Science and Chemistry Building. The recently constructed building has high quality office, lab and administrative space to accommodate the proposed program. The ESC Building houses the TRACES facility which contains an outstanding collection of analytical equipment for teaching and research. The facility is well-staffed and accessible to researchers for modest fees. A Chemical Stores facility that supports teaching and research also is housed in the ESC Building, providing research supplies and services such as waste handling.

UTSC has already made a commitment to increase administrative support for the proposed program. An experienced administrator who currently coordinates the UTSC Ph.D. in Environmental Science will have their position increased from 0.4 to 1.0 to also support the proposed M.Sc. degree program.

• *Participation of a sufficient number and quality of faculty who are competent to teach and/or supervise in the program.*

The teaching and research supervision needs of the proposed program should be met by the existing complement of faculty at the University of Toronto, and, in particular, at UTSC. More than 50 faculty from the three University of Toronto campus are affiliated with the proposed program, spanning the disciplines of chemistry, earth sciences, geography, ecology and evolutionary biology, cell and systems biology, engineering, forestry and physics. The breadth of faculty expertise and their research facilities will ensure ample capacity to supervise graduate research in a broad range of areas in environmental science.

Fifteen adjunct faculty are listed as associated with the program and available to serve on supervisory committees. Their external affiliations are not specified; however, we understood that many are employed in research roles with the provincial and federal governments. Adjunct faculty will contribute additional expertise and breadth to research supervision.

• *Adequacy of resources to sustain the quality of scholarship and research activities of graduate students, including library support, information technology support and laboratory access.*

The University of Toronto has the largest academic library system in Canada and is currently ranked fourth in North America. Faculty and students at UTSC have full access to the system, including teaching, learning and research support services. The librarians that we met with actively collaborate with faculty to support curriculum development and provide instruction to graduate students via seminar courses. The University of Toronto library system is well-funded and equipped to support graduate programs such as the proposed M.Sc. in Environmental Science.

Considerable investment has been made already in research infrastructure on the UTSC campus, including recent construction of the ESC Building that will house the M.Sc. program. The building houses the TRACES facility and faculty research laboratories, which will provide

students with access to a broad range of modern instrumentation. Students in the program also can access research laboratories on the other two University of Toronto campuses. Technician staff for the TRACES laboratory indicated that the facility can be accessed by students seven days per week and that out-of-hours work arrangements also are possible.

Graduate students also have access to cohort space in the ESC Building. The Ph.D. students that we met with indicated that research office space is available to accommodate additional graduate students, which is consistent with statements from faculty that their groups have unfilled capacity.

UTSC has one vehicle and several boats to support field research. The M.Sc. program would benefit from additional investment in research vehicles, but existing resources are adequate to launch the program.

UTSC faculty and students indicated that they also are able to access facilities as needed on the other two University of Toronto campuses.

- *Faculty have recent research or professional/clinical expertise needed to sustain the program, promote innovation and foster an appropriate intellectual climate.*

The program proposal lists >50 University of Toronto faculty who are affiliated with the proposed program. Thirty-one of the research faculty hold appointments in the Graduate Department of Physical and Environmental Sciences. Collectively the individuals produce >150 peer-reviewed publications per year and hold research grants and contracts totaling >$2M annually. Four UTSC teaching-stream faculty are affiliated with the program. In addition to teaching core and elective courses in the program, they also may serve on thesis advisory committees. Details provided in the compendium of CVs confirm that faculty associated with the proposed program are current and active in their respective fields.

- *Where appropriate to the program, financial assistance for students will be sufficient to ensure adequate quality and numbers of students.*

Students are provided with the cost of annual tuition and a $19,000 stipend for living expenses for 12 months of the 16-month program. During the final four months of studies, students can apply for a paid teaching assistantship and needs-based support administered by the Graduate Department of Physical and Environmental Sciences. One year of funding appears to be typical for University of Toronto Master degree programs. Faculty affiliated with the proposed program are well-funded through grants and external contracts, and it is anticipated that many will be able to offer research assistantship support to their students. While it would be desirable to provide 16 months of support to students in the program, it is not uncommon at postsecondary institutions in North America for students to bear some portion of the cost for graduate studies.

- *Supervisory load distribution and the qualifications and appointment status of faculty who will provide instruction and supervision.*

Faculty who will provide instruction and supervision to the students span the ranks of Assistant, Associate and Full Professor. They will submit project descriptions each year and students will be admitted based upon the quality of fit with prospective projects. The majority of UTSC faculty that we spoke with have unfilled capacity in their research groups. It appears unlikely that there will be issues with load distribution, given the intake quota per cohort is 15 students and there are >50 prospective research supervisors. External research funding and research space do

not appear to be limiting factors for UTSC researchers; however, access to graduate students is restricted due to quotas on Ph.D. placements and international student enrolments.

8. Quality and Other Indicators

• *Quality of the faculty (e.g., qualifications, research, innovation and scholarly record; appropriateness of collective faculty expertise to contribute substantively to the proposed program).*

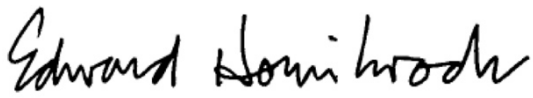
An excellent group of scholars have committed to supporting the proposed M.Sc. program. The breadth of expertise and qualifications of faculty who will serve as M.Sc. research supervisors is outstanding. Amongst the UTSC faculty are two Fellows of the Royal Society of Canada, three Canada Research Chairs and a Sloan Fellow. Similarly impressive are the cross-appointed faculty at the St. George and UTM campuses who also will supervise or serve on graduate committees for students in the proposed program. Collectively, these individuals cover a significant breadth of research areas in environmental science. Amongst the faculty that we met, there was unanimous support and enthusiasm for creation of the proposed program, which will help to ensure its success.

• *Program structure and faculty research that will ensure the intellectual quality of the student experience.*

Faculty at the University of Toronto are conducting world-class research. The breadth of expertise possessed by UTSC faculty and cross-appointed faculty is exceptional. The cohort structure of the program and supervisory committee arrangements will ensure that students receive a high-quality educational experience.

• *The extent to which the program has integrated any elements that enhance the diversity of its curriculum, students or teaching staff.*

UTSC has the good fortune of being situated within one of the most culturally diverse regions of Canada. The well-structured program and considerable resources already allocated to support it will serve a diverse community, attract able students, and encourage retention of excellent faculty at UTSC. The program's funding model will help to achieve these goals through provision of tuition funding and a guaranteed living stipend to high quality students regardless of their personal financial circumstances.



Professor Edward Hornibrook
Dept Earth, Environmental, and Geographic Sciences
University of British Columbia – Okanagan

Professor Sara Hotchkiss
Department of Botany
University of Wisconsin - Madison

Appendix I: Dean's Administrative Response

See below.

UNIVERSITY OF TORONTO SCARBOROUGH

Department of Physical and Environmental Sciences

December 14, 2021

Dr. Susan McCahan
Vice-Provost, Academic Programs
Office of the Vice-President and Provost
University of Toronto

Administrative Response: External Appraisal, Master of Science (MSc) in Environmental Science, Graduate Department of Physical and Environmental Sciences

Dear Susan,

As you know, the Graduate Department of Physical and Environmental Sciences (GDPES) at the University of Toronto Scarborough (UTSC) is proposing a new degree program: Master of Science (MSc) in Environmental Science.

Drs. Edward Hornibrook (Department of Earth, Environment, and Geographic Sciences, University of British Columbia Okanagan) and Sara Hotchkiss (Department of Botany, University of Wisconsin Madison) were commissioned to conduct an external appraisal of the program. A remote site visit was held on October 21, 22 and 25, 2021, and the appraisers met with a wide array of stakeholder groups, including UTSC academic leadership, faculty and staff affiliated with the proposed program, and students. The appraisers submitted their final report on December 10, 2021.

The external appraisal report was sent to the Chair of GDPES, Dr. George Arhonditsis, on December 13, 2021, with a request to share it with faculty, staff and students. This letter has been developed in close consultation with the Chair, and reflects the key elements of the unit response letter, dated December 13, 2021. We recognize the value of the appraisal process, and truly appreciate the care with which the Report was prepared. On behalf of UTSC, I want to thank Drs. Hornibrook and Hotchkiss for their overwhelmingly positive assessment of, and strong support for, the proposed program. As experts in their respective fields, their endorsement reinforces our commitment to the MSc in Environmental Science and highlights its clear value to students, further graduate education, employers, and the University of Toronto as a whole.

As the Chair observes in his letter, in their Report, Drs. Hornibrook and Hotchkiss speak to the "essential need and enthusiastic support for the proposed M.Sc. degree program at UTSC." They further comment on the strong infrastructure that is already in place to support the proposed program, including affiliated faculty, who are well-funded and conducting internationally significant research, but that also have available supervisory capacity, as well as available financial means and facilities to support the program. They further note the existence of strong interest from high-quality students in MSc research opportunities. The Report speaks more expansively to program structure and content, resources, and quality and other indicators, and I will touch briefly on these elements.

Program Structure and Content

The appraisers note that the program content is science-focused and research-intensive. They emphasize that the proposed program is distinct from other programs at the University, and it addresses a notable gap in graduate-level programming in Environmental Science. Moreover, the program will contribute to addressing key priorities of the UTSC Strategic Plan, *Inspiring Inclusive Excellence* (2020-25).

The appraisers indicate the program admission requirements are appropriate, and note the program has well defined learning outcomes that are linked explicitly to courses and research training. They further comment that the learning outcomes, and length of the program are consistent with a research-based Master of Science degree. They agree that the program length is feasible, noting that research-intensive Master of Science programs typically range in duration from 12 to 24 months. They comment that the less typical May start, immediate engagement with research, lower course-load, and flexible program structure, will support students' ability to complete the program within the 16-month timeframe. Finally, the appraisers point to the wide range of relevant courses that are available to students in the proposed program. They also speak to the appropriateness of the program thesis requirement and mode of delivery.

Resources

The appraisers comment on the excellence of the existing facilities to support the program, including the Environmental Science and Chemistry (ESC) Building at UTSC, and the TRACES facility, which contains an outstanding collection of analytical equipment for teaching and research. They highlight the space allocated for graduate students in the ESC Building, including for students in the proposed program. They further comment on the excellence of the University of Toronto library system. The only recommendation in the report is focused on vehicles to support research. The appraisers are clear that existing resources (one vehicle and several boats) are adequate to launch the program, but they feel it would benefit from additional investment in research vehicles. The Dean's Office is supportive of this recommendation, and is currently in discussion with the GDPES to augment the available research vehicles.

The appraisers note that more than 50 faculty from the entire University of Toronto system will support the program, along with a complement of 15 adjunct faculty, spanning the disciplines of chemistry, earth sciences, geography, ecology and evolutionary biology, cell and systems biology, engineering, forestry, and physics. They observe that the program will add much needed research capacity in an established area of strength. The appraisers note that UTSC has already made a commitment to increase administrative support for the proposed program.

The appraisers note that students will receive one-year of funding, which is typical of Masters programs at the University of Toronto. During the final four months of studies, students can apply for paid teaching assistantships and needs-based support administered by the GDPES.

Quality and Other Indicators

The appraisers highlight that faculty affiliated with the proposed program produce >150 peer-reviewed publications each year, and hold research grants and contracts totaling >$2M annually. Among the faculty are two Fellows of the Royal Society of Canada, three Canada Research Chairs, and a Sloan Fellow. The appraisers note that "faculty at the University of Toronto are conducting world-class research", and the "breadth of expertise possessed by UTSC and cross-appointed faculty is exceptional".

In summation, we note that the appraisers are supportive of all aspects of program structure and design, and no areas of concern were raised that might act as an impediment to the program.

Regards,

Dr. William A. Gough
Vice-Principal Academic and Dean
University of Toronto Scarborough

Appendix J: Vice-Provost, Academic Programs' Administrative Response

See below.

UNIVERSITY OF TORONTO

OFFICE OF THE VICE-PROVOST, ACADEMIC PROGRAMS

January 13, 2022

Dr. William A. Gough
Vice-Principal Academic and Dean
University of Toronto Scarborough

Re: Appraisal Report, Proposed New Master of Science in Environmental Science

Dear Bill,

I am very pleased to receive the appraisal of the proposed Master of Science in Environmental Science. Your administrative response to the appraisal nicely summarizes the report and its many positive comments.

You note that the appraisers felt the existing resources to support field research, one vehicle and several boats, are adequate to launch the program, but they feel it would benefit from additional investment in research vehicles. You indicate that your office is supportive of this recommendation, and is currently in discussion with the Graduate Department of Physical and Environmental Sciences to augment the available research vehicles.

I will be very pleased to recommend this new graduate program to governance for approval, following approval at the Divisional level.

Sincerely,

Susan McCahan
Vice-Provost, Academic Programs

cc: Rhonda Martin, Executive Assistant to the VP Dean, University of Toronto Scarborough
Mary Silcox, Vice-Dean Graduate & Postdoctoral Studies, University of Toronto Scarborough
Daniella Mallinick, Director, Academic Programs, Planning & Quality Assurance, Office of the Vice-Provost, Academic Programs
Jennifer Francisco, Coordinator, Academic Change, Office of the Vice-Provost, Academic Programs
Annette Knott, Coordinator, Academic Change, Office of the Vice-Provost, Academic Programs