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Experiential Science

10 - 20 - 30

Northwest Territories Education, Culture and Employment

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1. Introduction

The Experiential Science curriculum was developed in partnership with the Department of Fisheries and Ocean Canada, Parks Canada, Environment & Natural Resources, NWT Northern Geoscience Office, and the Department of Education, Culture and Employment of the Northwest Territories.

The Experiential Science curriculum sets out a vision and foundation statements for the applications of scientific literacy in Northern Canada. Through a series of General and Specific Learning Outcomes students will apply conventions of field and laboratory studies to investigate terrestrial, marine and freshwater systems. Students will also apply traditional Aboriginal knowledge to better understand their local surroundings.

The Experiential Science curriculum provides common educational opportunities and consistency of expectations across jurisdictions. Other potential benefits include a greater harmonization of the science curriculum for increased student mobility, the development of common learning resources, collaboration in professional development and direct links to other government, industry and non-government organizations.

2. A Vision for Scientific Literacy in Northern Canada

Education is a lifelong learning process and the future of our society depends on informed and educated citizens. Experiential Science 10-20-30 is guided by the vision that all Canadian students, regardless of their background, will have an opportunity to develop scientific literacy. Through a variety of experiences including, the classroom, laboratory and field investigations students will develop an understanding of their natural world. Scientific literacy is an evolving combination of knowledge, skills and attitudes reflective of traditional Aboriginal and Western science.

The integration of local Aboriginal knowledge and skills are key components of culture-based education. The two NWT Aboriginal foundation documents, Dene Kede and Inuuqatigiit provide the philosophical approaches and processes for the integration of local language, culture and traditions. These processes ensure that students gain a wide variety of experiences and perspectives to become well-rounded, knowledgeable citizens.

“On the Land” experiences, during field studies, provide opportunities for community Elders to interact directly with the students to share knowledge, skills, attitude, experiences and insight into local cultural heritage. Students will use these attributes to develop inquiry, problem-solving, and decision-making abilities.

A. Experiential Learning:

Experiential learning is a teaching strategy that links field, laboratory and classroom experiences with real life situations and applications. In Experiential Science students are exposed to real life experiences where the theories of science are brought to life through a series of applications. Field and laboratory activities enable students to focus and reflect on a task, which allows them to better understand and transfer knowledge and skills to new applications.

There are four primary steps within the cycle of experiential learning:

B. Concrete Experiences:

Concrete experiences are the initial steps by which data are produced, where the students are actively involved in “doing” something. Activities include, but are not limited to, fieldwork, laboratory experiments, reading, interviewing a subject matter expert (Elder / Scientist), and modelling / role playing.

C. Reflective Observation:

Reflective observations involve the collection of data through observation, critical thought, discussion groups or self-reflection. Activities include, but are not limited to, journaling, record keeping, keeping logbooks, discussions, brain-storming and critical thinking exercises with and without assistance from an instructor.

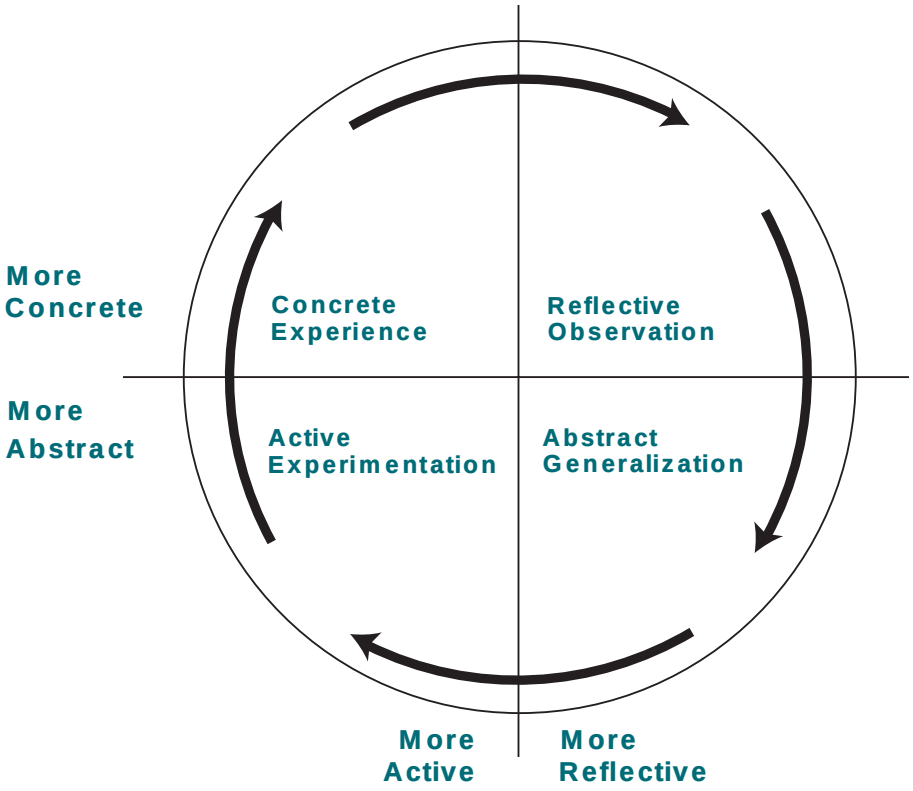
D. Abstract Conceptualization:

Abstract conceptualization is the processing step where conclusions and generalizations are formed from the information collected during the first two steps. Students are given the opportunity to “connect the dots” and make connections to what has been experienced. They can apply this to “real life situations” in both familiar and not so familiar settings. Activities include, but are not limited to public speaking, presenting one’s work, developing and presenting projects, making analogies and building models that represent a system or concept.

E. Active Experimentation:

Active experimentation allows the student to apply the previously acquired knowledge, skills and attitudes to a new cycle of learning by experiencing, designing, testing, and applying new knowledge, skills and attitudes. New experiences build on previous experiences and foster the transferability of knowledge, skills and attitudes. Active experimentation activities include, but are not limited to developing investigative action plans, identifying new skills and knowledge required for tasks, using technology and simulations, investigating and conducting case study reviews and research.

The Experiential Learning Cycle
(John Dewey and David Kolb)



The experiential learning framework, expects students to take initiative, make decisions and be an active accountable member of their learning experiences. Experiential Science encourages students to ask questions, investigate and experiment, be curious and creative, solve problems, reflect on their cultural and past experiences, assume responsibility for their learning and construct meaning of the world around them.

The Experiential Science program provides instructors with opportunities to extend the positive learning environment outside of the classroom and create innovative learning experiences. The learning opportunities have a clear purpose that should connect the experiences with the desired outcomes. Experiential Science allows students to discover and develop their own understanding of concepts. Through practical application, instructors will be encouraged take advantage of spontaneous learning opportunities. The combination of theory and practice will form a solid foundation that will allow students to learn and grow. Concepts, which are not clearly understood, can be further developed through similar experiences enabling students to make connection and better understand the concept.

First hand exposure to accepted practices and conventions of laboratory and field techniques will provide students with academic and employable skills. The very nature of experiential learning allows students to actively participate in their own learning, where events are not predictable and lead to learning from the successes and failures, to be adventurous and effective risk takers. Reinforcing the connections between theory and practical applications can build greater long lasting understanding of concepts, skills and attitudes.

Experiential Science is designed using the systems approach. Students develop an understanding of systems (terrestrial, marine and freshwater) by investigating the interaction between individual components and their role in the grand scheme. The Experiential Science course sequence is rigorous. The diverse learning experiences foster the multiple intelligence approach to learning both in and out of the classroom. Thereby, providing students with numerous methodologies to explore, analyse, evaluate, synthesize, and appreciate the interrelationships between Science, Technology, Society and the Environment. The hands-on minds-on experiences and skills gained will allow students to broaden their scientific knowledge and career portfolios.

3. The Scientific Literacy Needs of Canadian Students and Society

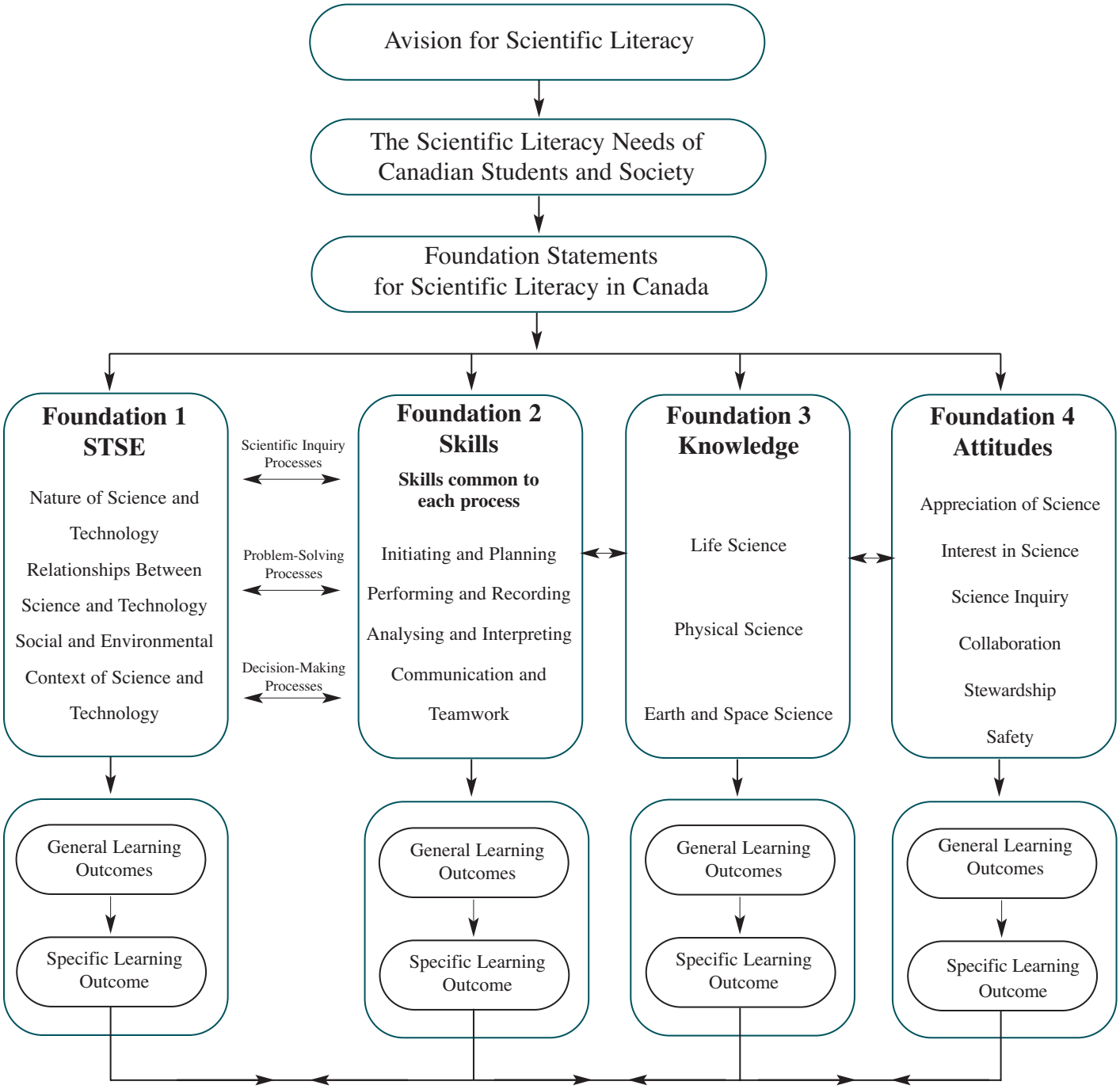
Canada's Northern society is experiencing rapid and fundamental economic, social, and cultural changes that affect the way we live. Canadians as a whole are becoming aware of an increasing global interdependence and the need for a sustainable environment, economy, and society that is respectful of Northern culture, values and history. The emergence of a highly competitive and integrated international economy, rapid technological innovation, and a growing knowledge base will continue to have a profound impact on peoples' lives. Advancements in science and technology play an increasingly significant role in everyday life. Science education will be a key element in developing scientific literacy and in building a strong future for Northern Canada. Consistent with views expressed in a variety of National and International science education documents, the following goals for science education have been established for the purpose of this document. Specifically, science education aims to:

- Encourage students to develop a critical sense of wonder, curiosity, knowledge and understanding by investigating traditional Aboriginal, contemporary science and technological advancements;
- Enable students to use science and technology through direct application to utilize previous knowledge and skills to further develop problem solving and critical thinking abilities;
- Prepare students to critically address science-related societal, economic, ethical, cultural and environmental issues;
- Provide students with a foundation in science that creates opportunities for them to pursue progressively higher levels of study and life long learning;
- Develop in students of varying aptitudes and interests, an awareness of the careers related to science, technology, and the environment; and
- Prepare students for science related professions, occupations and activities appropriate to their interests and abilities.

4. Foundations for Scientific Literacy in Northern Canada

To support the vision for scientific literacy, four foundations were established that reflect the wholeness and interconnectedness of learning that are interrelated and mutually supportive. The learning outcomes in the Experiential Science 10-20-30 curriculum are stated in relation to the following statements.

Conceptual Map for the Framework



Foundation 1: Science, Technology, Society, and the Environment (SSE)

Science, Technology, Society and the Environment (STSE) are the driving force of the curriculum. Many learning outcomes presented in this document flow directly or indirectly from the STSE domain. Students use direct applications and experiences to develop an understanding of the nature of science and technology, of the relationships between Science and Technology, and of the Social and Environmental contexts of Science and Technology. STSE is to be integrated throughout all units and will focus on the three major concepts of:

- Nature of Science and Technology;
- Relationships between Science and Technology; and
- Social and Environmental contexts of Science and Technology.

A. Nature Of Science And Technology

Science is a human and social activity with unique characteristics and a long history that involves men and women from all societies and cultures. Science is also a way of learning about the universe based on curiosity, creativity, imagination, intuition, exploration, observation, replication of experiments, interpretation of evidence, and debate over the evidence and its interpretations. Scientific activity, through direct applications, provides a conceptual and theoretical base that is used in predicting, interpreting, and explaining natural and human-made phenomena.

Technology, like science, is a creative human activity with a long history in all cultures of the world. Technology is concerned mainly with proposing solutions to problems arising from human adaptation to the environment. Hence, the chief concern of technologists is to develop optimal solutions that represent a balance of costs and benefits to society, the economy, and the environment.

The Nature of Science and Technology allows students to refine their understanding of natural phenomena by the application and development of new technology.

B. Relationships Between Science And Technology

By understanding the relationship between science and technology, students will learn to appreciate how they interact, how they develop in a social context and how they are used to improve people's lives.

While there are important similarities between science and technology, there are also important differences. Science and technology differ in both purpose and process. Technology is more than applied science; it draws from many disciplines to solve problems. Throughout history, science and technology have drawn from one another and are inextricably linked.

C. Social And Environmental Contexts Of Science And Technology

The history of science highlights the nature of the scientific enterprise. The historical context serves as a reminder of how cultural and intellectual questions and methodologies of science have influenced global understanding of natural phenomenon.

Scientific knowledge is necessary, but is not in itself sufficient for understanding the relationships among Science, Technology, Society and the Environment, (STSE). Today, the majority of scientists work with industry, where research is more often driven by societal and environmental needs rather than by the pursuit of fundamentals. As technological solutions have emerged, many of them have given rise to complex social and environmental issues. These issues are increasingly becoming part of the political agenda. The potential for science to inform and empower decision-making by individuals, communities and society is central to achieving scientific literacy in a democratic society.

To understand the relationships, it is essential to understand the values inherent to science, technology, a particular society, and the environment. Growth in STSE understandings should involve each of the following elements:

- Complexity of understanding: from simple, concrete ideas to complex, abstract ideas, from limited knowledge of science to more in-depth and broader knowledge of science and the world;
- Applications in context: from contexts that are local, cultural, historical and personal to those that are societal and global;
- Consideration of variables and perspectives: from one or two that are simple to many that are complex;
- Critical judgement: from simple right or wrong assessments to complex evaluations; and
- Decision-making: forming decisions based on limited knowledge, made with teacher / Elder guidance, to decisions based on extensive research, involving personal judgements and made independently without guidance.

Within Social and Environmental contexts of Science and Technology it is expected students will:

- Analyse and explain how science and technology interact and advance each other;

- Analyse how individuals, society and the environment are interdependent with scientific and technological endeavours;
- Evaluate social issues related to the applications and limitations of science and technology; and
- Explain decisions in terms of advantages and disadvantages for sustainability, from a variety of perspectives.

Foundation 2: Skills

Experiences will help students develop the skills required for scientific and technological inquiry to:

- solve problems,
- communicate scientific ideas and results,
- work collaboratively, and
- make informed decisions.

Students will develop and use a variety of skills when answering questions, solving problems, and making decisions. While these skills are not unique to science, they play an important role in the development of scientific understanding and in the application of science and technology. The skills listed are not intended to imply a linear sequence or a single set of skills for a scientific investigation. However, each investigation is unique and requires a particular mix and sequence of skills to complete the task. Skills are developed and refined through a series of context-based applications based on recognized scientific conventions and protocols.

The skills are divided into four broad areas and are integrated throughout the entire program of studies:

A. Initiating and Planning:

Are the skills required for questioning, recognizing and identifying problems, and developing preliminary ideas and plans.

B. Performing and Recording:

Are the skills for carrying out an action plan, by gathering evidence, by observations and by manipulating materials and equipment in the classroom, laboratory or during field studies.

C. Analysing and Interpreting:

Are the skills required for examining information, for processing and presenting data through various methods of interpretation, evaluation, and applying the results to solve a problem.

D. Communication and Teamwork:

Are essential at every stage where ideas are being developed, tested, interpreted, debated, and agreed upon. Teamwork is a collaborative process in society, the classroom, the laboratory and the field to develop and apply scientific ideas.

Interaction Between the Four Skill Sets

As students advance, the skills they develop are applied in an increasingly demanding context. Growth in skills may involve each of the following elements:

- Range of application: from limited to a broad range of applications;
- Complexity of application: from simple, direct applications to applications that involve abstract ideas and complex interactions and judgements;
- Precision of measures and manipulations: from coarse measures and manipulations to those that are precise;
- Use of current and appropriate technologies or tools: from working with simple tools to a more broad array of specialized and precise tools or technologies;
- Degree of independence and structure: from working with instructor guidance or a structured situation to working independently without guidance;
- Awareness and control: from following a predetermined plan to an approach using metacognition and strategic thinking; and
- Ability to work collaboratively: from working as an individual to working as part of a team in a variety of contexts.

Foundation 3: Knowledge

A. Knowledge

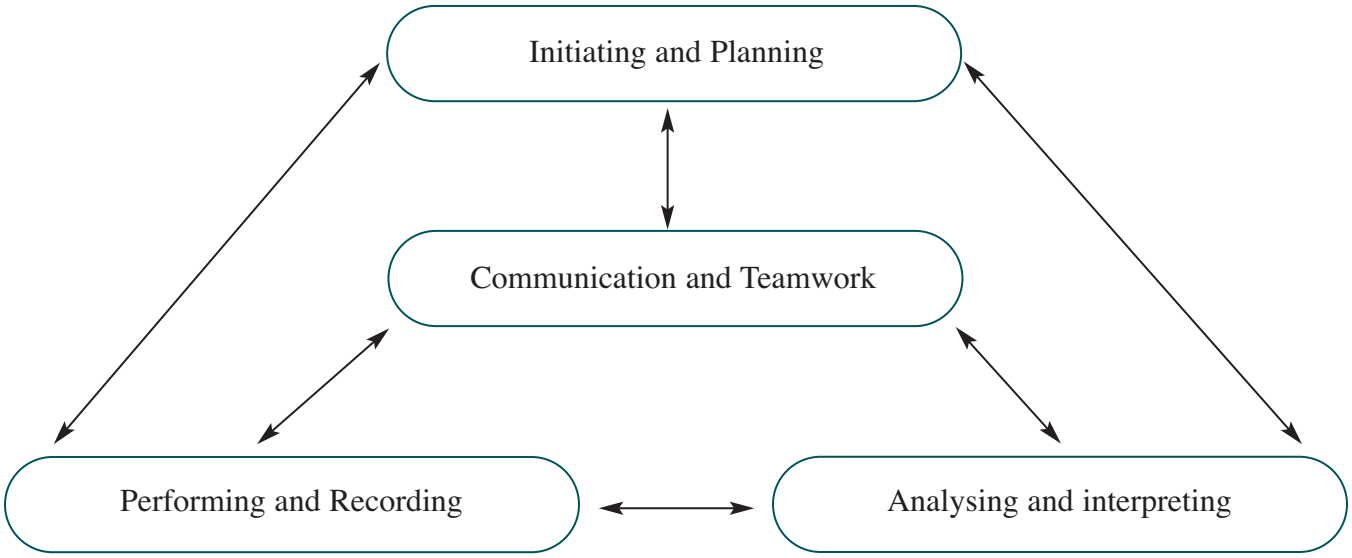
The Knowledge foundation focuses on the subject matter of science, including the theories, models, concepts, and principles that are essential to an understanding of science. Knowledge pertinent to the disciplines of Life, Physical and Earth sciences will be integrated throughout the program of studies using the systems approach.

The concepts in Life Science, Physical Science, and Earth Science, are introduced through contexts-based, “hands-on minds-on” experiences. Students develop and apply scientific knowledge and understanding to interpret, integrate, and extend their conceptual understanding by linking science disciplines. The pedagogical approach of context-based learning and the unifying concepts provide students with a clear understanding of scientific processes.

B. Unifying Concepts, Linkages Among Science Disciplines

The unifying concepts of Constancy and Change, Energy, Similarity and Diversity, and Systems and Interactions are useful ways to create linkages among science disciplines and key ideas. The integration of different scientific disciplines builds on the knowledge foundation to support student understanding by creating connections. The unifying concepts are meant to integrate big ideas as a way to provide a context for explaining, organizing, and connecting experiences to

Interactions among the four areas of skills



theoretical knowledge. They are instructional tools that cut across disciplines and apply as well to mathematics, technology, business, and politics.

C. Constancy and Change

The concepts of constancy and change are fundamental processes of the natural and technological world. Through observations, students learn that some characteristics of materials and systems remain constant over time whereas other characteristics change. Through formal and informal studies, students develop an understanding of the nature of things, and of the processes and conditions in which change takes place.

D. Energy

The concept of energy provides a framework for the understanding of natural phenomena, materials, and the process of change. Energy, whether transmitted or transformed, is the driving force of both movement and change in the environment. Students learn to describe energy in terms of its causes and effects.

E. Similarity and Diversity

The concepts of similarity and diversity provide a framework for organizing our experiences and making useful distinctions between events. Students utilize accepted procedures and protocols for describing, classifying objects and summarizing results enabling them to share ideas and to reflect on their own experiences.

F. Systems and Interactions

The ability to think about the whole in terms of its parts and alternately about the parts in terms of how they relate to one another and to the whole is an important part of understanding and interpreting the world around us. A system is a collection of components that interact with one another so that the overall effect is much greater than that of the individual parts.

Foundation 4: Attitudes

Attitudes refer to aspects of behaviour that are modelled and reinforced by selective approval. Attitudes are not acquired in the same way as skills and knowledge. Mastery of an attitude cannot be observed at any particular moment in time, but is evidenced by regular, unprompted expression of the behaviour. Attitude development is a lifelong process that involves experiences at home, the school, the community, the land and in society. The development of positive attitudes plays an important role in a student's growth. As students develop intellectually and cognitively their readiness for responsible application grows with their experiences.

Students will be given opportunities to develop attitudes that support the responsible acquisition and application of scientific, cultural and technological knowledge to the mutual benefit of self, society, and the environment. The attitudes foundation focuses on six ways in which science education can contribute to attitudinal growth.

A. Appreciation of Science

Students will be encouraged to appreciate the role and contributions of our ancestors and use of science in their lives, and to be aware of its limitations and impacts. Science education contributes to attitudinal growth when students are given opportunities to examine how science impacts their lives daily and over the long term.

B. Interest in Science

Science education contributes to attitudinal growth when students are involved in investigations and activities that are hands on, interactive and stimulate their interest, imagination and curiosity. Innovative learning opportunities create the motivation required for learning and encourages an interest in science-related studies or careers.

C. Scientific Inquiry

Hands-on laboratory and field studies will support attitudes such as active inquiry, problem solving, and decision-making. Positive attitudinal growth can be developed, reinforced, and extended when students have opportunities to experience open-mindedness, flexibility, critical-mindedness, have respect for evidence, take the initiative, display perseverance, and are creative and inventive.

D. Collaboration

Collaborative activities provide students with opportunities to work in group situations on real-life problems. Through field, laboratory and class activities students will be given opportunities to develop a sense of interpersonal responsibility, openness to diversity, respect for multiple perspectives, and an appreciation of the efforts and contributions of others.

E. Stewardship

Effective and reflective stewardship is critical when applying science and technology to society and the natural environment. Student activities encourage responsible action toward "living" things and the environment that are culturally, ethically and morally sound. Students consider issues related to sustainability and being a good steward, from a variety of perspectives.

F. Safety

Attitudinal growth for safety is demonstrated when students assess and manage potential hazards, then apply safety and ethical procedures to ensure a safe working environment. Students acquire field safety skills by incorporating local traditional Aboriginal knowledge and survival skills practiced by local Elders and other subject matter experts, before and during activities. Understanding safe outdoor practices in the local area provides students with the opportunity to gain insight into legends, stories and practices that have been used for centuries to ensure a safe physical and spiritual journey. "Knowing" the land, being observant, reassessing situations and having a contingency plan will help to ensure a safe working environment for all.

5. Assessment and Evaluation

The terms assessment and evaluation are often used interchangeably, but are quite different in their process. For the purposes of this document assessment and evaluation will be defined as:

Assessment: is the process of collecting relevant information about a student's performance as it relates to achievement of the curricular outcomes.

Evaluation: refers to the process of analysing student information collected through a variety of assessment strategies, over time and under a variety of circumstances. This allows the instructor to gain a better understanding of the degree of knowledge, skills and attitudinal outcomes acquired by the student and also to respond to the instructional needs of the student.

Assessment must reflect the curricular outcomes. Instructors must assess students using a variety of evaluation strategies that reflect the expected depth of performance and understanding. Assessment must be on going, be reflective of authentic contexts and methodologies, with clearly stated expectations. Opportunities for students to self reflect and judge the quality of their own work, based on the evaluation criteria, is critical to becoming an independent learner.

The use of formal and informal formative assessment strategies with milestones for project development, allows students to make corrections along the way. This process leads to greater success, understanding and encourages learning. Experiential Science, by its nature, lends itself to a wide variety of formative assessment and evaluation strategies. Field, laboratory and classroom activities provide ongoing opportunities to assess how well a student has met the outcomes.

Summative evaluation should be used to report on the level of student achievement where students have an opportunity to demonstrate their acquired knowledge, skills and attitudes in a variety of ways. Summative assessment must include performance-based assessments to evaluate practical skills and applications of techniques, along with paper and pen assessments of multiple responses, extended and open responses.

Assessment techniques, should always match the style of learning and instruction employed. At all times students should know the purpose of the task, methods of the task, and the marking criteria for the task. This can be accomplished through

the use of scoring rubrics and performance based scoring checklists that enable students to reflect and self evaluate their work prior to final submission.

6. Program Organization and Format

A. Course Outline

The program of studies for Experiential Science 10-20-30 uses the systems approach to investigating geological and environmental ecology. In Experiential Science 10 students will investigate the terrestrial system. In Experiential Science 20 students will investigate the marine system. In Experiential Science 30 students will investigate the freshwater system. There are common themes throughout the course series that allow students to build connections and gain an understanding of how systems interact.

Each course is designed for 125 instructional hours, including laboratory and fieldwork. Instructors are to ensure that sufficient blocks of time are available to conduct fieldwork and laboratory investigations. An investment of additional time for fieldwork would allow students to enrich their experiences and gain further insight into the various systems in situ. Approximately ten percent of allotted time should be given to assess field, laboratory, presentation and project performance skills.

Grade 10 Terrestrial Systems

Unit	Title	Emphasis	Suggested Time Allocation
1	Geology & Geomorphology	Nature of Science	40 hrs
2	Climate and Climatology	Science & Technology	30 hrs
3	Terrestrial Ecology	Science Technology, Society & the Environment	30 hrs
4	Populations and Resource Management	Science Technology, Society & the Environment	25 hrs

Grade 11 Marine Systems

Unit	Title	Emphasis	Suggested Time Allocation
1	Introduction to Oceanography	Nature of Science	30 hrs
2	Ocean Ecology	Science & Technology Society & the Environment	35 hrs
3	Habitats, Population Dynamics and Management	Science Technology, Society & the Environment	40 hrs
4	Petrology and the Ocean Environment	Science Technology	20 hrs

Grade 12 Freshwater Systems

Unit	Title	Emphasis	Suggested Time Allocation
1	Structural Geology	Science & Technology	30 hrs
2	Introduction to Limnology	Nature of Science	35 hrs
3	Freshwater Ecology and Population Dynamics	Science Technology, Society & the Environment	40 hrs
4	Freshwater Resource Management, Governance and Ethics	Science Technology, Society & the Environment	20 hrs

B. Unit Format

Unit Organization

In Experiential Science, there are four primary units of study for each course. Each unit has the following components:

Unit Overview

The unit overview introduces the content and suggests a developmental approach.

Focusing Question

The focusing question provides a context for introducing the unit and engages students in the investigative process.

Key Concepts

Key concepts identify major ideas to be developed in each unit. Some of the key concepts may be addressed in additional units of the same course, as well as at other grades. The intended scope and treatment of these concepts is indicated by the specific learning outcomes.

Learning Outcomes

There are two levels of outcomes in this program of studies:

General Outcomes

The general outcomes identify the big picture ideas and expectations for each unit. For Foundations 1 and 2 (STSE and Knowledge), the outcomes are combined and unique to each unit. For Foundations 3 (Skills) and Foundation 4 (Attitudes), the outcomes are common to all units and are integral to fostering the understanding of the content and applications within a context.

Specific Outcomes

The specific learning outcomes detail the required breadth and depth of what is expected of the student. The skills and attitudes are inherent within the emphasis, context, convention and application of the outcome.

7. Unit Emphases

Each unit of study begins with an overview and a set of focusing questions that identify a context for study. In defining the context, one of the three areas of emphasis is identified for each unit and acts as a focal point.

A. Nature of Science Emphasis

In these units, student attention is focused on the processes by which scientific knowledge is developed and tested and on the nature of scientific knowledge itself. The skills emphasized in these units are the skills of scientific inquiry. Developing the Nature of Science, as a program emphasis, is accomplished by incorporating the following concepts and skills.

i. Concepts

a. The goal of science is to gain knowledge and understanding of the natural world.

b. Scientific knowledge and theories develop through formation of hypotheses, collection of evidence through experimentation and the ability to provide explanations.

c. Scientific knowledge results from peer review and replication of the research of others.

d. Scientific knowledge is subject to change as new evidence comes to light and as laws and theories are tested and subsequently restricted, revised or reinforced.

e. The process of scientific investigations includes:

i.) Identifying the theoretical basis of the investigation.

ii.) Clearly defining and stating the boundaries of the research question or idea to be tested.

iii.) Designing the investigation.

iv.) Evaluating and selecting means to collect and record evidence.

v.) Analyzing the evidence and providing explanations based upon scientific theories and concepts.

f. Scientific paradigms are conceptual investigations that help organize, interpret and explain findings where:
   i.) Concepts, models and theories are often used to interpret and explain observations, and in predicting future observations.
   ii.) Conventions of mathematics, nomenclature and notation provide a basis for organizing and communicating scientific theories, relationships and concepts.

g. Scientific inquiry is limited to certain questions.

ii. Skills (focus on scientific inquiry)

a. Initiating and Planning
   i.) Identify questions to investigate.
   ii.) Define and delimit questions to facilitate investigations.
   iii.) Make a prediction or a hypothesis based on available evidence, background information or theory.
   iv.) Evaluate and select appropriate procedures and instruments for collecting evidence and information, using recognized sampling procedures and protocols.

b. Performing and Recording
   i.) Carry out procedures, controlling the major variables, and adapt or extend procedures, if needed.
   ii.) Use appropriate instruments effectively and accurately for collecting data.
   iii.) Select and collect information from various print and electronic sources.
   iv.) Organize and integrate data using a format that is appropriate to the task or experiment.
   v.) Select and use apparatus safely and apply Workplace Hazardous Materials Information System (WHIMIS) procedures to handle and dispose of materials.

c. Analysing and Interpreting
   i.) Compile and display results by hand or computer, using a variety of formats.
   ii.) Interpret patterns and trends in data, and infer and calculate linear and nonlinear relationships among variables.
   iii.) Predict the value of variables, by interpolation or extrapolation from graphic data.
   iv.) Identify and explain sources of error; and evaluate the relevance, reliability and adequacy of data and data collection methods.
   v.) State a conclusion, based on experimental data and explain how the evidence gathered supports or refutes a hypothesis, prediction or theory.

d. Communication and Teamwork
   i.) Work cooperatively with team members to develop, carry out a plan and trouble shoot problems as they arise.
   ii.) Select and use appropriate numeric, symbolic, graphical and linguistic modes of representation to communicate findings and conclusions.
   iii.) Evaluate individual and group processes used in planning and carrying out investigative tasks.

B. Science and Technology Emphasis

Seek solutions to practical problems by developing and testing prototypes, products and techniques to meet a given need. The skills emphasized are those of problem solving and critical thinking in combination with the skills of scientific inquiry. Developing Science and Technology, as a program emphasis, is accomplished by incorporating the following concepts and skills.

i. Concepts

a. The goal of technology is to provide solutions to particular problems.

b. Technological development may involve creation of prototypes, testing, and applications of knowledge from related scientific and interdisciplinary fields.

c. Technological problems often have multiple solutions, involving different designs, materials and processes, with and without predictable consequences.

d. Scientific knowledge may lead to new technologies that may lead to new scientific discoveries.

e. The process of technological development includes:
   i.) Clearly defining and delimiting the problems to be solved.
   ii.) Establishing criteria to assess the technological solution.
   iii.) Identify the constraints and trade-offs to a potential solution.
   iv.) Developing designs and prototypes.
   v.) Testing and evaluation of designs and prototypes based on established criteria.

f. The products of technology are devices, systems and processes that meet given needs, understanding that these products cannot solve all problems.

g. The appropriateness, risks and benefits of technologies needs to be assessed for each potential application from a variety of perspectives, including sustainability.

ii. Skills (Focus on problem solving)

a. Initiating and Planning

i.) Define practical problems.

ii.) Identify questions to investigate arising from practical problems.

iii.) Assess and propose alternative solutions to a given practical problem, select one and develop a plan.

iv.) Evaluate and select appropriate procedures and instrumentation for collecting data and information to solve problems.

b. Performing and Recording

i.) Research and synthesize information relevant to a given problem, from various print and electronic sources.

ii.) Construct and test a prototype device or system, and troubleshoot problems as they arise.

iii.) Select and use tools and apparatus safely.

c. Analysing and Interpreting

i.) Identify and troubleshoot problems, and refine the operation of prototype devices.

ii.) Evaluate design prototypes on the basis of self-developed criteria; i.e. function, reliability, safety, effective use of materials, impact on the environment.

iii.) Identify and evaluate potential applications of results.

iv.) Identify new questions and problems that arise from what they have learned.

d. Communication and Teamwork

i.) Work cooperatively with team members to develop and carry out a plan and troubleshoot problems.

ii.) Assess and recommend an approach to solving a given problem, based on results of the investigation.

iii.) Evaluate individual and group processes used in planning and carrying out problem-solving tasks.

C. Social and Environmental Context Emphasis

Student attention is focused on issues and decisions relating to how science and technology are applied. Skills emphasis is on the use of research and inquiry skills to make informed decisions. Students seek and analyse information and consider a variety of perspectives when developing a conclusion. Developing the Social and Environmental context, as a program emphasis, is accomplished by incorporating the following concepts and skills.

i. Concepts

a. Science and technology are developed to meet societal needs and expand human capacity.

b. Science and technology are influenced and supported by society to meet societal needs.

c. Science and technology have both intended and unintended consequences for humans and the environment.

d. Society provides direction for scientific and technological development where:

i.) Canada supports scientific research and technological development for a sustainable society, economy and environment.

ii.) Decisions regarding the application of scientific and technological development include social, cultural, environmental, ethical and economic considerations.

iii.) Society supports scientific and technological development by recognizing accomplishments, publishing and disseminating results, plus providing financial support.

e. Scientific and technological activity may arise from, and give rise to, personal and social values such as accuracy, honesty, perseverance, tolerance, open mindedness, critical mindedness, creativity and curiosity.

f. Science and technology provide opportunities for a diversity of careers based on post-secondary studies, for the pursuit of hobbies and interests, and for lifelong learning.

ii. Skills (focus on the use of research and inquiry skills to inform the decision making process)

a. Initiating and Planning

i.) Identify science related issues.

ii.) Identify questions to investigate arising from science and technology related issues.

iii.) Assess, use or develop appropriate procedures and instrumentation for collecting relevant data and information.

b. Performing and Recording
   i.) Research and synthesize information relevant to a given question, problem or issue.
   ii.) Identify data and information, from print and electronic sources, which are relevant to the issue.
   iii.) Select and integrate information, from various print and electronic sources, or from several parts of the same source.
c. Analysing and Interpreting
   i.) Apply given criteria for evaluating evidence and sources of information.
   ii.) Assess the risk and benefits of scientific and technological developments by incorporating a variety of perspectives.
   iii.) Identify new questions and problems that arise from what was learned.
   iv.) Identify and evaluate potential applications of results from a variety of scientific, technological and environmental perspectives.
d. Communication and Teamwork:
   i.) Work cooperatively with team members to develop, carry out a plan and troubleshoot problems as they arise.
   ii.) Assess potential decisions and make recommendations for viable solutions.
   iii.) Make clear and logical arguments to defend a given decision on an issue, based on findings.
   iv.) Evaluate individual and group processes used in investigating an issue and in assessing alternative decisions.

8. Teaching of Experiential Science

The Experiential Science 10-20-30 curriculum is designed to support the development of a student's attitudes, skills, and knowledge needed for developing problem-solving and decision-making abilities, for becoming lifelong learners, and for maintaining a sense of wonder about the world around them, in short, to develop scientific literacy.

Scientific literacy is supported by instructional environments that engage students in active inquiry, problem solving, decision-making through experiential learning. Aboriginal and local knowledge are the key starting points for all investigations. This process enables students to acquire background information and understanding from Elders and other subject matter experts to better understand the immediate area. Diverse learning experiences, inside and outside the classroom, involve activities that are set in meaningful contexts using recognized protocols. It is through these contexts that students discover the significance of their cultural heritage and science to appreciate the relationships between the Nature of Science, Science and Technology, Science, Technology, Society and the Environment.

To facilitate instructional planning, resource materials are designed to reflect factors such as, the student's prior learning, the dynamics of the classroom and the nature of the local environment. Although the particular contexts of study may vary by region, the overall scope and focus will normally include the following broad areas of emphasis:

a. A science inquiry emphasis, where students address questions about the nature of things, involving broad exploration as well as focussed investigations;
b. A problem solving emphasis, where students seek answers to practical problems requiring the application of science knowledge in new ways; and
c. A decision-making emphasis, where students identify questions or issues and seek science knowledge that will address the question or issue.

Each of these three areas of emphasis provides a potential starting point for engaging in an area of study. These studies may involve a variety of learning approaches, including an emphasis on field studies for developing specific investigations, and for applying the skills and knowledge learned.

To achieve the vision of scientific literacy, Experiential Science 10-20-30 students must become increasingly engaged in the planning, development, and evaluation of their own learning activities. In the process, they should have the opportunity to work collaboratively with other students, to initiate investigations in and out of the classroom, to communicate their findings, and to complete projects that demonstrate their learning.

Notes:

Experiential Science 10 – Terrestrial Systems

Course Overview

Experiential Science 10 is comprised of four major units that focus on the Terrestrial system from a geological and ecological perspective.

Unit 1 Geology and Geomorphology, investigates the features and processes that shape the surface and subsurface features of the earth. The geology component builds on the basic understandings of geological time, mineral and rock formation and identification, landforms and glaciology. The unit emphasis is on the Nature of Science with many exploratory hands-on field and laboratory activities.

Unit 2 Climatology and Meteorology, investigates the long and short-term effects of weather to interpret past, present and future climatic events. This unit incorporates Aboriginal and Western knowledge and skills to investigate, collect, analyse and interpret meteorological trends and addresses the many issues of climate change. The unit emphasis is on Science and Technology that require field and laboratory activities.

Unit 3 Ecology of the Land, investigates the basic principles of ecology and community dynamics through a series of field and laboratory exercises. This unit incorporates Aboriginal and Western knowledge and skills to investigate the abiotic and biotic factors which control the terrestrial system. The unit emphasis is on Science, Technology, Society and the Environment (STSE) that allows students to make connections locally and globally.

Unit 4 Resource Management and Populations Dynamics, investigates and monitors local populations of plants and animals that enables students to assess resource management practices and governance to ensure a sustainable future. This unit incorporates Aboriginal and Western knowledge and skills required to assess and manage natural resources. The unit emphasis is on STSE that requires students to conduct a variety of field and laboratory studies.

Unit Emphasis and Suggested Time Allocations:

The unit emphasis indicates the primary focus of the unit and directs the process for learning. The times suggested for each unit are a general guideline. Regional differences and local conditions may provide instructors with unique opportunities for more in-depth study of a particular section. Field and laboratory investigations should be seen as an investment, for gaining a better understanding of the learning outcomes. Opportunities for extended periods of field study would allow students to interact with Elders and other subject matter experts in a more natural setting that foster greater insight into the connectedness of the terrestrial system.

Grade 10 Terrestrial Systems

Unit	Title	Emphasis	Suggested Time Allocation
1	Geology & Geomorphology	Nature of Science	40 hrs
2	Climate and Climatology	Science & Technology	30 hrs
3	Terrestrial Ecology	Science Technology, Society & the Environment	30 hrs
4	Populations and Resource Management	Science Technology, Society & the Environment	25 hrs

Unit 1: Geology and Geomorphology
(Emphasis: Nature of Science)

Overview:

Geological processes shape the Earth and the terrain around us over time. The evidence of these changes exists below and at the surface of the Earth. Some of this evidence is billions of years old while other evidence of geological process may be occurring in front of us. It is the role of geoscientists to plan, collect, analyse and interpret their findings to construct meaningful understanding of the geological process at work and make predictions about future events. This unit builds upon the basic understanding of earth science from previous years and extends it to a more in-depth understanding of the geological process as it relates to geological time, minerals, rock formation and identification, the formation of landforms, the processes for studying earth science and related career links.

Focusing Question:

What geological processes shape the Earth around us and what are the results of these processes?

Key Concepts:

- Geological Time and Earth Dynamics
- Mineral and Rocks Formation and Identification
- Fundamentals of Geology
- Fundamentals of Geomorphological and Glaciation
- Traditional Aboriginal Legends and Stories That Interpret Earth Processes
- Related Career Links and Occupations in Geosciences.

A. General Learning Outcome:

Students will investigate geological time and earth dynamics.

Specific Learning Outcomes:

1. Students will gain an understanding of geological time by:

a. Constructing simple models to illustrate the relative time of the Earth's history and identify the major geological eras and key indicators.

b. Investigating and recording the local Aboriginal global perspective of the geological history of the Earth.

c. Investigating and demonstrating the processes and indicators used for dating rock and rock structures and discuss their limitations including:

i. Relative-Age Dating

a.) Principle of Uniformitarianism ("the Present is the key to the Past")

b.) Principle of Original Horizontality

c.) Principle of Superposition

d.) Principle of Cross-cutting Relationships

ii. Absolute-Age Dating

a.) Radiometric dating (Carbon-14)

b.) Dendrochronology (tree rings)

c.) Seasonal climatic changes (varves)

d.) Distinctive sedimentary layers (key beds)

d. Researching and creating a possible timeline of local geological events.

2. Students will gain an understanding of Earth dynamics by:

a. Explaining and illustrating or modelling the internal layers and boundaries of the Earth including:
   i. Inner core
   ii. Outer core
   iii. Mantle
   iv. "Moho" discontinuity
   v. Crust

b. Describing, explaining and illustrating or modelling the evidence and technology used to study the dynamic forces of the Earth's:
   i. Crustal plate activity and the Theory of Plate Tectonics, as it pertains to:
      a.) Continental drift from Pangaea to present day
      b.) Seafloor spreading and geomagnetic symmetry
      c.) Dynamic interactions and types of plate boundaries (divergent, convergent, transform)
      d.) Plate motion and convection currents
   ii. Volcanic activity and the formation, structure and composition of:
      a.) Magma (mafic, intermediate, felsic)
      b.) Intrusions (pluton, batholith, stock, sill, laccolith, lopolith, dyke)
      c.) Types of volcanoes (shield, cinder-cone, composite) based on:
         i.) Environment of formation
         ii.) Material composition
         iii.) Internal and external structures
   iii. Earthquake activity and the processes of investigating:
      a.) Forces of stress (compression, tension, shear) and how these produce faults (reverse, normal, strike-slip)
      b.) Seismic waves (P, S, surface) and how they travel through different media
      c.) Measurement of seismic events (magnitude and intensity)
   iv. Mountain building, as it pertains to:
      a.) Formation and the processes of building mountains (isostasy and isostatic rebound)
      b.) Convergent boundary mountains (Oceanic-Oceanic, Oceanic-Continental, Continental-Continental)
      c.) General types of mountains (Divergent, Uplift, Fault-Block, Volcanic)

c. Researching and presenting information on traditional Aboriginal legends to explain Earth processes including volcanoes, earthquakes and mountain building.

B. General Learning Outcome:

Students will investigate mineral and rock formation and their classification and identification processes.

Specific Learning Outcomes:
3. Students will gain an understanding of minerals and rocks by:

a. Reviewing the basic structures of atoms, elements, molecules and compounds.

b. Investigating common minerals (including the six basic rock-forming minerals) through laboratory activities and field studies to:
   i. Define a mineral
   ii. Describe the origin of minerals from various sources including:
      a.) Magmatic (hydrothermal solutions)
      b.) Metamorphism
      c.) Weathering and decomposition
   iii. Use the known physical properties of minerals to identify and recognize mineral samples in the laboratory and in the field including:
      a.) Color
      b.) Lustre
      c.) Streak
      d.) Hardness
      e.) Crystal habit
      f.) Cleavage
      g.) Fracture
      h.) Specific gravity
      i.) Magnetism
   iv. Describe and model the basic crystalline structure that exist in minerals and identify representative examples of:
      a.) Isometric (cubic)
      b.) Tetragonal
      c.) Hexagonal
      d.) Orthorhombic
      e.) Monoclinic
      f.) Triclinic
   v. Research and describe the major mineral groups based on chemical composition:
      a.) Silicates
      b.) Carbonates
      c.) Oxides
      d.) Sulphides
   vi. Construct a basic field guide of common minerals to be used for field identification activities.
c. Investigating common rocks through laboratory activities and field studies to:
   i. Define a rock.
   ii. Differentiate between a rock and a mineral
   iii. Describe and model the three basic rock types:
      a.) Igneous
      b.) Sedimentary
      c.) Metamorphic
   iv. Compare and contrast the rock types in terms of their:
      a.) Texture
      b.) Composition
      c.) Mode of formation
   v. Relate the basic rock types to the rock cycle.
   vi. Use physical properties to identify and classify common rock samples.

4. Students will gain an understanding of igneous rocks by:

a. Reviewing the three general compositions of magma as:
   i. Mafic
   ii. Intermediate
   iii. Felsic
b. Investigating, through laboratory and field studies, how the crystallization process and cooling rates relate to the appearance of a sample of igneous rock.
c. Classifying representative samples to construct a basic field guide and collection of igneous rocks as:
   i. Intrusive (plutonic)
   ii. Extrusive (plutonic)
d. Researching and describing the known economic mineral deposits in Northern Canada associated with igneous rocks (e.g. kimberlite – diamond deposits).

5. Students will gain an understanding of sedimentary rocks by:

a. Explaining, describing and modelling the processes and formation of sedimentary rocks, including:
   i. Erosion
   ii. Deposition
   iii. Compaction
   iv. Lithification
   v. Bedding
   vi. Fossil formation
b. Classifying representative sedimentary rocks to construct a basic field guide and collection of sedimentary rocks as:
   i. Clastic (fine, medium, coarse grained)
   ii. Chemical (evaporates or organic).
c. Researching and describing the known economic mineral deposits in Northern Canada associated with sedimentary rocks (e.g. Pine Point deposit).

6. Students will gain an understanding of metamorphic rocks by:

a. Explaining and illustrating the formation processes and how the effects of heat, pressure and exposure time result in different textures in metamorphic rocks which are:
   i. Foliated
   ii. Non foliated (Un-foliated)
   iii. Porphyroblastic (recrystallized)
b. Classifying representative samples, through laboratory and field studies, to construct a basic field guide and collection of metamorphic rocks.
c. Researching and describing the known economic mineral deposits in Northern Canada associated with metamorphic rocks (e.g. Shear zone-hosted gold deposits in Yellowknife)

7. Students will gain an understanding of how local Aboriginal groups utilize minerals and rocks by:

a. Researching using a variety of methods, including discussions with Elders or other subject matter experts, how minerals and rocks are used for shelters, tools, utensils, and games .
b. Researching how minerals and rocks are used for artwork and ornamentation by local artisans.

8. Students will gain an understanding of weathering and erosion processes by:

a. Illustrating, explaining and demonstrating in the laboratory or field:
   i. Mechanical weathering
      a.) Temperature (frost wedging)
      b.) Pressure (exfoliation)
   ii. Chemical weathering
      a.) Water (hydrolysis)
      b.) Oxygen (oxidation)
      c.) Carbon dioxide
      d.) Acid precipitation (leaching)
   iii. Variables that affect the rate of weathering
      a.) Climate
      b.) Rock type and composition
      c.) Surface area
      d.) Topography
b. Defining the terms "erosion" and "deposition" to describe the process of erosion and discuss the role of gravity in the process.
c. Describing the forces of erosion including:
   i. Running water
   ii. Wind
   iii. Ice (seasonal ice and glaciers)
   iv. Plants, animals, and humans
d. Explaining the processes and illustrating or modeling soil development and composition and, through field or lab experiments interpret a soil profile.
e. Comparing and contrasting weathering and erosion and relate both processes to the rock cycle.

C. General Learning Outcome:

Students will investigate glacial and periglacial (ice) processes and related landforms.

Specific Learning Outcomes:
9. Students will gain an understanding of glacial and periglacial processes by:

a. Explaining and illustrating the processes of glacial formation including:
   i. An Aboriginal explanation and historical accounting of glaciation
   ii. Define the term "glacier"
   iii. Establish the connection between glaciers and the hydrologic and rock cycles
   iv. Define the transformation from snow to glacial ice
   v. Investigate the mechanical properties of ice
b. Describing, illustrating and modelling glacial life cycle processes including:
   i. Zone of accumulation
   ii. Equilibrium line (snow line)
   iii. Zone of ablation

c. Describing, illustrating and modelling glacial movement including the concepts and processes of:
   i. Plastic flow
   ii. Basal sliding
   iii. Internal shearing
   iv. Crevasses
   v. Ogivies
   vi. Glacial surges
d. Investigating, recording and explaining the locations and types of prominent glaciers in Canada to demonstrate the:
   i. Classification of glaciers
   ii. Morphology of glaciers
   iii. Uses of glaciers by Aboriginal groups to acquire food.
e. Explaining the two main processes of glacial erosion:
   i. Abrasion
   ii. Plucking / quarrying
f. Researching and modeling the glacial processes of:
   i. Transportation of material
   ii. Deposition of materials (including glacial drift and glacial till)
   iii. Stratification and "sorting" of glacial sediments
g. Explaining and investigating through field investigations or lab experiments, periglacial processes such as:
   i. Freezing and thawing
   ii. Ice segregation and frost heaves
   iii. Up-freezing stones
   iv. Frost sorting
   v. Periglacial mass movement and slope deposits
h. Explaining, illustrating and modelling the characteristics of permafrost and frozen ground by investigating:
   i. Formation of permafrost
   ii. Characteristics of permafrost
   iii. Distribution and thickness of permafrost in northern Canada and their local area.
   iv. Ground ice
   v. Taliks
   vi. Ice lenses
   vii. Ice wedges and ice wedge polygons

10. Students will gain an understanding of glacial and periglacial landforms by:

a. Researching and discussing with Elders or other subject matter experts, the importance of local glacial land forms to Aboriginal culture and survival.
b. Investigating, describing and modelling representative depositional landforms composed of stratified glacial drift material including:
   i. Eskers
   ii. Kames
   iii. Kettles
   iv. Terraces
   v. Outwash plains

c. Investigating, describing and modelling depositional landforms composed of glacial till material such as:
   i. Moraines (ground, recessional, terminal, lateral, and medial)
   ii. Drumlins
   iii. Glacial erratics
d. Describing and modelling or illustrating erosional landforms including:
   i. Arêtes, Cols and Horns
   ii. Cirques, tarns
   iii. Hanging valleys
   iv. Glacial troughs, fjords
   v. Roche moutonnee
   vi. Glacial striations
   vii. Fluting
e. Conducting field investigations locally or using representative data available (topographic maps, aerial photos, etc.) to catalogue and map geomorphological features.
f. Explaining, illustrating and modelling the developmental processes of periglacial landforms, such as:
   i. Pingos
   ii. Palsas
   iii. Thermokarst topography
   iv. Patterned ground

D. General Learning Outcome:

Students will gain experience in basic field mapping techniques and investigate careers and career profiles related to geology and geomorphology.

11. Students will gain an understanding of basic field mapping techniques by:

a. Researching and discussing with local Elders or other subject matter experts, traditional methods of navigation used.
b. Developing and producing (using GIS imagery) a detailed surface map of local surface geological features in:
   i. Plan view
   ii. Cross section view

12. Students will gain an understanding of careers and occupations related to geology and geomorphology by:

a. Researching and preparing a career and occupational profile related to the geology and mining industries in the Northwest Territories and throughout Canada.

Unit 2: Climatology and Meteorology
(Emphasis: Science & Technology)

Overview:

The forces of weathering and erosion are continuously shaping the Earth's surface. The evidence of these processes can be seen on a variety of scales in both time and space all around us. While meteorology and climatology are closely related, the processes used to study these naturally occurring phenomena are quite different. Meteorologists tend to study the atmospheric trends and events in real time and use instrumentation to collect data and make short-term predictions. Climatologists on the other hand tend to investigate long-term climatic events and trends to interpret past, present and future events. Both groups of scientists will use similar technologies and incorporate local Aboriginal knowledge and experiences to plan, investigate, collect, analyse and interpret their findings. This unit builds on the basic understandings of climatology and meteorology from previous years and focuses on methodologies and technology.

Focusing Question:

How do the processes for climate and weather affect our lives, locally and globally?

Key Concepts:

- Atmospheric Composition and Dynamics
- Atmospheric Energy Transfer
- Climactic Changes
- Traditional Weather and Climate Change Indicators.
- Technology Used to Monitor and Assess Weather and Climate Change
- Careers in Climatology and Meteorology

A. General Learning Outcome:

Students will investigate the composition, structure, dynamics and energy transfer mechanisms of the atmosphere.

Specific Learning Outcomes:

1. Students will gain an understanding of the composition, structure and dynamics of the atmosphere by:

a. Comparing and contrasting the sciences of meteorology and climatology.
b. Distinguishing between the terms "air" and "atmosphere" and describing the composition of air (names and percentages of atmospheric gasses).
c. Modeling and representing the vertical structures of the atmosphere (layers and temperature profiles) including:
   i. Troposphere
   ii. Stratosphere
   iii. Ozone layer
   iv. Mesosphere
   v. Thermosphere
   vi. Exosphere

d. Describing and illustrating basic weather profiles, their interactions, cause and effect of:
   i. Temperature (versus heat)
   ii. Dew point
   iii. Atmospheric pressure gradients forming / transforming fronts
   iv. Temperature inversion
   v. Wind
   vi. Relative humidity
   vii. Conditions for cloud formation
e. Identifying basic cloud types in photographs and in the field.
f. Collecting and reading local and national weather data, daily (keeping a weather journal), using basic weather instrumentation or a local ground station to analyse trends (including how humans and animals react to changes in weather).
g. Investigating how local Elders or other subject matter experts, "read" the signs to predict short or long term weather patterns and events.
h. Predicting local, short term, weather patterns based on data collected and comparing this to the 48-hour projection from Environment Canada and local Elders.
i. Describing the factors and illustrating the processes that affect global weather patterns, and their affect on northern climates, such as:
   i. Air masses and fronts
      a.) Continental polar and Arctic
      b.) Maritime polar
      c.) Cold fronts
      d.) Warm fronts
      e.) Stationary fronts
   ii. The Coriolis Effect
      a.) Trade winds
   iii. Upper atmospheric currents and near surface winds
      a.) Hadley cell
      b.) Westerlies
      c.) Jet stream
      d.) Troughs and ridges

2. Students will gain an understanding of the relationships between energy transference and the atmosphere by:

a. Researching and investigating local Aboriginal indicators of seasonal change.
b. Describing, illustrating and modeling energy transfer mechanisms including:
   i. Energy transfer between the sun and the Earth's surface and the atmosphere:
      a.) Radiation
      b.) Conduction
      c.) Convection

ii. Temperature profiles and the relationship between:
  a.) Latitude and altitude
  b.) Land and water interactions (freshwater and oceans as heat sinks)
  c.) Atmospheric circulation patterns
  d.) Local considerations and their effect
iii. Atmospheric moisture cycles and processes for:
  a.) Evaporation and condensation
  b.) Relative humidity
  c.) Dew, frost, fog, rain, freezing rain, hail, snow
  d.) Cloud growth and development
iv. Solar radiant energy profile on the Earth's surface during:
  a.) Winter
  b.) Spring
  c.) Summer
  d.) Autumn

B. General Learning Outcome:

Students will investigate the natural cyclical nature of climate change, the human factors and technologies that allow scientists to study and make predictions about climate change.

Specific Learning Outcomes:
3. Students will gain an understanding of climate change and climatology by:

a. Discussing climate change with local Elders or other subject matter experts, to determine how weather patterns have changed over their lifetime and record the impact of climate change on traditional hunting and gathering activities.
b. Researching and explaining current theories through which climate change is believed to occur.
c. Investigating and presenting evidence of human effects on weather and atmospheric pollutants.
d. Describing and modelling methods used to study polar climatology such as:
  i. Reading sediment cores in various aquatic and terrestrial systems.
  ii. Reading vegetative profiles in trees and soil samples.
  iii. Collecting ice cores to determine the chemical properties and temperature profiles of historic climatic events
  iv. Global Warming trends of the past 5,000 years including:
    a.) Factors affecting climate change
    b.) Atmospheric conditions and turbidity as indicators
    c.) Solar radiation and absorbing gas concentrations
    d.) Variations in solar output
    e.) Ice – Albedo feedback mechanisms and its effects on the atmosphere.
  v. Predicted outcomes of global warming using electronic forecasting models and simulations in a variety of contexts (including the Sim Earth on-line program)
  vi. Consult with Elders and local community members to document what they feel may be some of the potential future outcomes if climate change continues.
e. Becoming "actively aware" of current climate change issues by:
  i. Taking the "One Ton" challenge (www.climatechange.gc.ca/onetonne)
  ii. Reading and discussing the Kyoto Accord
f. Investigating the use of GIS processes and satellite imaging to gain information on monitoring climate change in an area.

C. General Learning Outcome:

Students will investigate careers and career profiles related to climatology and meteorology.

Specific Learning Outcomes:

4. Students will gain an understanding of careers and occupations related to climatology and meteorology by:

a. Investigating (using electronic media) and listing careers and occupations in climatology and meteorology that are available locally and across Canada.

Notes:

Unit 3: Ecology of the Land

(Emphasis: Science, Technology, Society & the Environment (STSE))

Overview:

Ecology is the study of the relationship between organisms and their environment where organisms interact with their environment within the context of the ecosystem. To investigate the relationship between organisms and their environment, ecologists conduct experimental studies in the laboratory and in the field. This unit focuses in on the abiotic and biotic factors that affect and limit plant and animal populations, their distributions and productivity in the north. Through a series of field, laboratory and case studies students will investigate the distribution, abundance and general productivity of representative plant and animal populations. Local monitoring programs for indicator species, on established study sites, will enable students to collect, use, interpret and present data. The process of modelling and the use of technology will also be used to demonstrate the relationship between an organism and its environment and the methodologies employed in ecological studies.

Focusing Question:

How do organisms interact and react with each other, their ecological community and humans?

Key Concepts:

- Concepts and Principles of Ecology
- Aboriginal Ecological Practices
- Limiting Factors
- Populations and their Interactions
- Ecological Communities
- Technology Used to Monitor and Evaluate Ecology
- Careers and Occupations Related to Ecology

A. General Learning Outcome:

Students will investigate the basic concepts and principles of ecology as they relate to abiotic and biotic limiting factors.

Specific Learning Outcomes:

1. Students will gain an understanding of ecology by:

a. Discussing with local Elders, hunters or naturalists on a field expedition, their perspectives on ecology, such as their beliefs, values and understanding of the circle of life.

b. Investigating the basic concepts and components of ecology, including:

   i. Habitats

   ii. Populations

   iii. Communities

   iv. Ecosystems

c. Investigating the basic principles and field study approaches used for ecological studies.

d. Illustrating the connectedness of the following terms for the process of studying ecology.
   i. Fact
   ii. Theory
   iii. Hypothesis
   iv. Law
   v. Extrapolation/Interpolation
   vi. Experiment
e. Applying the Scientific Method through the design and application of basic, local ecological field investigations.

2. Students will gain an understanding of abiotic and biotic limiting factors by:

a. Investigating and explaining the methods of dispersal and distribution of representative plants and animals in the Arctic.
b. Explaining behavioural mechanisms and evolution of habitat preferences as it relates to the Theory of Habitat Selection.
c. Investigating sub-Arctic and Arctic species interrelationships and interactions between:
   i. Predator – prey relationships
   ii. Disease and parasitism
   iii. Intra and interspecies competition for resources.
d. Researching and discussing with local Elders and hunters or other subject matter experts.
   i. Predator – prey relationships
   ii. Disease and parasitism
   iii. Intra and interspecies competition for resources.
e. Investigating the upper and lower limits of representative species as it relates to limiting factors of representative / indicator species of plants and animals, including the parameters of:
   i. Temperature
   ii. Water
   iii. Physical / Chemical Factors
   iv. Climate Change (including discussions with Elders or other subject matter experts, on the changes they have seen over their lifetimes).
f. Explaining and illustrating the critical role of nutrient cycling in an ecosystem, including:
   i. Carbon cycle
   ii. Nitrogen cycle
   iii. Oxygen cycle
   iv. Phosphorous cycle
g. Explaining and illustrating using mapping techniques, the geographical ranges and abundance of representative sub-Arctic and Arctic plants and animal species in relation to their limiting factors.
h. Researching and discussing, with local Elders or subject matter experts, changes in local populations and distribution of plants and animals and the link to changes in limiting factors.

B. General Learning Outcome:

Students will investigate and use simple models to gain useful information on a population.

Specific Learning Outcomes:

3. Students will gain an understanding of populations by:

a. Defining and illustrating the parameters that determine a population.
b. Studying populations and population densities of plants and animals by:
   i. Estimating experimentally using simple models.
   ii. Conducting field investigations in an established study plot.
c. Analyzing vital statistical data, from a variety of sources including local Elders or other subject matter experts, of a representative sub-Arctic and Arctic mammal population to determine its:
   i. Age
   ii. Gender
   iii. Density

4. Students will gain an understanding of population growth by:

a. Explaining and investigating the factors that determine the growth and regulation of a population in northern Canada.
b. Investigating time lag models for population growth and applying this information to make predictions of possible future events or outcomes.
c. Investigating traditional legends that explain or interpret predator-prey models.
d. Describing representative northern species interactions with regard to:
   i. Competition
   ii. Predation
   iii. Mutualism
   iv. Disease and parasitism:
      a.) Effects on an individual and or a population(s)
      b.) Mortality rates and changes in population

5. Students will gain an understanding of distribution and abundance of a population at the community level by:

a. Defining, explaining and modelling what a community is by investigating:
   i. Dynamic relationships between representative populations in northern Canada (plants, birds, mammals, insects)
   ii. Community change and succession (including fire)
   iii. Community biodiversity
   iv. Community equilibrium
   v. Disturbance of a community
b. Conducting field investigations to determine the biodiversity of a local ecological community.
c. Explaining and illustrating representative examples of the Arctic ecosystem metabolism processes of:
   i. Primary production
   ii. Secondary production

6. Students will gain an understanding of how technology is used to investigate and monitor plant and animal populations and communities by:

a. Conducting field studies using:
   i. GIS processes and satellite imagery
   ii. A variety of mapping techniques
   iii. A variety of sampling techniques
   iv. Monitoring and tagging processes (simulations)

7. Students will gain an understanding of careers and occupations in the field of ecology by:

a. Investigating career and occupations related to ecology that are available to them in their jurisdiction and throughout Canada.

Notes:

Unit 4: Resource Management and Population Dynamics
(Emphasis: Science, Technology, Society and the Environment (STSE))

Overview:

Resource management is a process that requires a great deal of understanding about the ecology and ecological processes of an ecosystem. Resource management requires field and laboratory studies to investigate, monitor and evaluate the status of resources and how best to ensure a sustainable environment. Through a series of investigations students will collect data on the ecology of the tundra, taiga and northern boreal forest. This will include investigations of the traditional Aboriginal uses of plants and animals, wildlife management techniques and resource monitoring. This information will enable students to gain a better understanding of local management practices and governance to ensure a sustainable future. Field study plots will further enable students to monitor local populations, practice conservation strategies and evaluate the human impact on the environment and its resources. By applying wildlife and forest management practices students will study and develop a local conservation strategy to ensure a sustainable future. The emphasis of this unit is STSE.

Focusing Question:

How are science, management techniques and governance used to better understand and manage natural resources for a sustainable future?

Key Concepts:

- Ecology of the Tundra, Taiga, Northern Boreal Forest
- Plant Succession Processes
- Traditional Aboriginal Uses of Plants and Animals
- Resource and Wildlife Management
- Monitoring Populations
- Conservation Biology
- Human Impact on the Environment
- Sustainability
- Governance and Resources
- Careers and Occupations Related to Resource Management and Population Dynamics

A. General Learning Outcome:

Students will investigate tundra, taiga and northern boreal forest ecology and the process of succession.

Specific Learning Outcomes:

1. Students will gain an understanding of the ecology of the tundra, taiga and northern boreal forest by:

a. Investigating, describing, and mapping representative plant distribution of Arctic and sub Arctic indicator species used to monitor climate change.

b. Establishing a study plot(s) to monitor indicator species of plants for climate change and to conduct ecological field studies.

c. Conducting field investigations to identify, catalogue, and determine the relative distribution of vegetation in a study area.

d. Discussing with Elders or other subject matter experts, the historical practices and locations of various food sources, their relative abundance and cycles of availability.

e. Collecting, pressing, and classifying representative plants from the local area (including those used by local cultures for ceremonial, food and medicinal purposes).

f. Investigating and describing the animal distribution of Arctic and sub Arctic indicator species in a study area.

2. Students will gain an understanding of the principles of plant succession by:

a. Describing and explaining the general processes of plant succession, including:
   i. Pioneer community
   ii. Climax community
   iii. Primary succession
   iv. Secondary succession
b. Conducting a field survey of a local vegetated area to monitor plant succession.
c. Summarizing how plant species diversity, population and niche availability change through succession and with major disturbances.
d. Comparing and contrasting the species diversity of old and new growth forests.

B. General Learning Outcome:

Students will gain an understanding of resource management issues and practices including the use of technology and the value of conservation to society.

3. Students will gain an understanding of basic wildlife management and practices by:

a. Investigating the wildlife management practices of representative species (birds and mammals) using traditional Aboriginal and contemporary methods, including the parameters of:
   i. Home range
   ii. Territory
   iii. Range
   iv. Emigration, immigration and migration
b. Investigating through research and describing the traditional and contemporary harvesting practices of representative northern populations of land mammals (caribou, moose, deer, wood buffalo, musk ox, elk) and birds (geese, ducks, grouse, ptarmigan) with regard to:
   i. Regulating populations
   ii. Concept of optimal yield
   iii. Pest control

4. Students will gain an understanding of how technology is used to investigate and monitor populations and communities by:

a. Conducting field studies using available technology to:
   i. Gather and interpret data from GIS / satellite sources.
   ii. Identify and monitor populations or communities.
   iii. Sample representative plants and animals
   iv. Tag and monitor for long and short-term study

5. Students will gain an understanding of conservation biology by:

a. Using case studies or research information on a sensitive habitat or endangered species to build a case for conservation.
b. Investigating, researching and discussing with Elders or other subject matter experts, the historical Aboriginal practices of natural resource (plant and animal) conservation, husbandry and harvesting techniques to ensure the sustainability of a population.
c. Investigating, researching or discussing with scientists, the practices of natural resource (plant and animal) conservation, husbandry and harvesting techniques to ensure the sustainability of a population.

6. Students will gain an understanding of human impact on an ecosystem by:

a. Researching and discussing with Elders or other subject matter experts, how the traditional practices and uses of materials limit the impact of humans on an ecosystem.
b. Defining and explaining the concept of loss of habitat and its impact on an ecosystem.
c. Comparing and contrasting current ecological footprints with a traditional "living off the land" ecological footprint.
d. Conducting and presenting an ecological footprint assessment of one's self and ways in which individuals can reduce their ecological footprint in their community.
e. Conducting an environmental review of one's home or community (including any recycling projects available).

C. General Learning Outcome:

Students will gain an understanding of the basic processes to ensure sustainable resources.

7. Students will gain an understanding of the foundations of a sustainable future, economics and ethics by:

a. Describing how environmental stressors and disturbances can affect indicator species and ecosystems.
b. Discussing, describing and illustrating the accumulation effect of environmental stressors on migratory and non-migratory species (e.g. caribou, geese, moose) as a result of contact with humans and industry.
c. Investigating the uses of renewable resources in the sub-Arctic and Arctic to reduce the ecological footprint with regard to:
   i. Plants
   ii. Animals
   iii. Renewable sources of energy
   iv. Cost effectiveness
d. Describing current conservation strategies and the need for environmental reviews and public consultations.
e. Researching and developing a media promotion campaign that would encourage people to gain an appreciation of the "Beauty of the Land" and the need to preserve it for future generations.

8. Students will gain an understanding of how technology is used to investigate, manage and use resources in a sustainable manner by:

a. Conducting field studies of local resources using:
   i. GIS processes and satellite imagery
   ii. A variety of mapping techniques
   iii. A variety of sampling techniques
   iv. Monitoring and tagging processes

9. Students will gain an understanding of the governance of land-based resources in northern Canada by:

a. Investigating and describing the role of governments (at various levels) in the local environmental, social and economic decisions relating to land-based resource development:
   i. Municipal (including local Hunter and Trapper Associations)
   ii. Territorial
   iii. Federal
b. Investigating land claims issues of governance and the use of resources of a region.
c. Comparing and contrasting traditional and current laws for land based resource management.

10. Students will gain an understanding of balancing cultural values and a sustainable future by:

a. Investigating, documenting, and explaining the historical values, traditions and practices of harvesting from the land including changes in values and traditions over time, and how new technology and present day pressures impact wildlife management strategies and harvesting practices.
b. Providing examples of how governments and local peoples identify and enforce the protection of natural resources through the development of parks, heritage sites, and enforcement legislation.
c. Evaluating, comparing and contrasting the pros and cons of Eco-tourism.
d. Discussing, using a "Town Hall" forum, the environmental impact of a human activity as a function of both population and lifestyle for a given scenario.
e. Investigating industrial impact by building a case for or against the development of an industrial complex or project, proposed for a given area (oil/gas, mine, road, pipeline development, etc).
f. Researching, investigating and building a case study on the processes and procedures for mine and or toxic waste reclamation at an industrial or military site in northern Canada.

11. Students will gain an understanding of careers and occupations in the field of resource management, law, mediation and environmental reclamation by:

a. Researching and investigating careers and occupations related to resource management, law, mediation and environmental reclamation that are available locally and in northern Canada.

Experiential Science 20 – Marine Systems

Course Overview:

Experiential Science 20 is comprised of four major units that focus on the Marine system.

Unit 1 Introduction to Oceanography, investigates the basic properties of salt water, ocean dynamics and seafloor geomorphology. The unit emphasis is on the Nature of Science, which provides the introductory knowledge and skills for understanding basic ocean dynamics.

Unit 2 Ocean Ecology, investigates basic marine ecology, energy flow, species diversity and human interactions with this environment. The ecology section builds on the concepts of ecology, nutrients, role of organisms, food webs, bioaccumulation and human interactions with the environment. The unit emphasis is on the Nature of Science, which provides the introductory knowledge and skills for introductory ocean ecology.

Unit 3 Habitats, **Population Dynamics and Management**, investigates the various marine habitats, species interactions, population dynamics and community interactions through field and laboratory investigations. The habitat, population dynamics and management sections builds on the concepts of how particular habitats function within the great framework of the oceans and the impact of human interactions. The unit emphasis is on Science, Technology, Society and the Environment that requires students to conduct a variety of field and laboratory studies. Unit 4 Petrology and the Ocean Environment, investigates petroleum resources, their deposits, extraction, production and potential environmental impact. This unit builds on the background understanding of the exploitation of renewable and non-renewable resources enabling students to access information and be informed decision makers. The unit emphasis is on Science, Technology, Society and the Environment.

Unit Emphasis and Suggested Time Allocations:

The unit emphasis indicates the primary focus of the unit and directs the process for learning. The times suggested for each unit are a general guideline. Regional differences and local conditions may provide instructors with unique opportunities for more in-depth study of a particular section. Field and laboratory investigations should be seen as an investment, for gaining a better understanding learning outcomes. Opportunities for extended periods of field study would allow students to interact with Elders and other subject matter experts in a more natural setting, which would foster greater insight into the connectedness of the ocean system.

Note:

Unit 3 Habitats, Population Dynamics and Management investigate numerous ocean habitats. To ensure that there is sufficient time to investigate the learning outcomes only four sections are mandatory and additional units are optional;

- Governance and Resource Management,
- Open Oceans,
- Two habitats of local interest.

Grade 11 Marine Systems

Unit	Title	Emphasis	Suggested Time Allocation
1	Introduction to Oceanography	Nature of Science	30 hrs
2	Ocean Ecology	Science & Technology Society & the Environment	35 hrs
3	Habitats, Population Dynamics and Management	Science Technology, Society & the Environment	40 hrs
4	Petrology and the Ocean Environment	Science Technology	20 hrs

Unit 1: Introduction to Oceanography
(Emphasis: Nature of Science)

Overview:
Oceanography is a multi-disciplinary study that incorporates biology, chemistry, physics and earth science to gain a better understanding of the ocean. This unit examines mostly the abiotic factors that drive the oceans. It is the role of oceanographers to plan, collect, analyse and interpret data to construct meaningful understanding of the ocean processes and to make predictions about future events. Through a series of laboratory investigations students will gain an understanding of the chemical and physical properties of water, formation of the oceans, ocean dynamics and ocean geomorphology. This unit builds upon the basic understanding of oceans from previous years and extends it to a more in-depth analytical understanding of the oceanic processes. The Nature of Science is the emphasis of this unit.

Focusing Question:
What are the chemical, geomorphological and physical characteristics that make the oceans a dynamic environment?

Key Concepts:
- Formation and Properties of Saltwater
- Chemistry of Saltwater
- Ocean Systems and the Water Cycle
- Ocean Dynamics
- Ocean Geomorphology
- Oceans and the Environment
- Careers and Occupations Related to Oceanography

A. General Learning Outcomes:

Students will investigate the formation of water on Earth and the basic properties and chemistry of salt water.

Specific Learning Outcomes:

1. Students will gain an understanding of the processes resulting in the formation of water on Earth by:

a. Researching and summarizing the various theories on the origin of the oceans and sources of ocean water (including the sources and processes that control the amount of salt in the oceans).

2. Students will gain an understanding of the basic properties of fresh and saltwater by:

a. Comparing and contrasting the characteristics of fresh and salt water in terms of salinity, density, cohesion and adhesion.
b. Investigating and listing relative concentrations of common ionic and molecular compounds found in saltwater in descending order (sodium chloride, calcium chloride and their respective ions) and mapping these common ions back to the periodic table indicating their ionic state and relationships.
c. Investigating and examining the interrelation of density vs. salinity vs. temperature of saltwater.
d. Analyzing the salinity of water samples taken from various locations along a freshwater to saltwater traverse (or from stock solutions) to establish a salinity profile (e.g. lake to river to ocean), using accepted testing protocols and procedures.
e. Determining the salinity of an unknown sample and make conjecture about its source based on a known salinity profile.

3. Students will gain an understanding of saltwater chemistry by:

a. Conducting basic experiments from a water column to determine the qualitative and quantitative values and constructing representative profiles of:
   i. Alkalinity
   ii. Salinity
   iii. Ammonia nitrate
   iv. Carbon dioxide
   v. Dissolved oxygen
   vi. Nitrate nitrogen
   vii. pH
   viii. Temperature

4. Students will gain an understanding of the role of dissolved solids and turbidity in an aquatic environment by:

a. Defining the term “dissolved solids” to describe and explain the role of dissolved solids in marine ecology.
b. Sampling and analysing the amount of dissolved solids in various saltwater samples from local sources or stock solutions using accepted procedures and protocols.
c. Defining the term “turbidity” and investigate the potential processes responsible for turbidity at a particular site (cursive/recursive data).
d. Conducting simple experiments in the field or laboratory, using a Secchi disk or light, to determine the relative turbidity of a water column.
e. Investigating the rate of sediment deposition using data collected from an estuary or coastal area (or simulation) to illustrate varying degrees of turbidity as it occurs seasonally.

5. Students will gain an understanding of heat transfer within and between the hydrosphere and the atmosphere by:

a. Describing, explaining and drawing a representation of the water (hydrological) cycle, on a local scale (including a description of heat transfer within the cycle).
b. Conducting and modelling simple experiments, which demonstrate the water cycle in a cold weather ocean.
c. Performing laboratory experiments to demonstrate the heat capacity of fresh and salt water and its role as a heat sink.
d. Investigating, describing and illustrating the process of heat transfer between the atmosphere and hydrosphere, within an ocean system, and report on how this impacts on the traditional hunting and gathering practices of Aboriginal peoples.

B. General Learning Outcomes:

Students will investigate the marine currents and ocean dynamics.

Specific Learning Outcomes:
6. Students will gain an understanding of water masses and currents in ocean systems by:

a. Describing (in general terms) and plotting on a global map:
   i. Water masses
   ii. Ocean currents.
b. Designing a simulation, using an aquarium, to demonstrate current formation and patterns.
c. Explaining and illustrating using block diagrams, the conveyor belt system (including the importance of conveyor belt systems to ecological and meteorological stability).
d. Investigating and mapping regional water currents in the Arctic Ocean and adjacent bodies of water to gain an understanding of the conveyor belt system.
e. Discussing with local Elders or other subject matter experts, local currents, their effect on traditional activities throughout the year and their predictability.

7. Students will gain an understanding of mixing within surface and subsurface marine currents by:

a. Investigating and explaining the processes which generate or suppress waves in the open ocean such as:
   i. Fetch
   ii. Wind speed
   iii. Wind speed duration
   iv. Depth of water column
   v. Geographical features
   vi. Thickness of ice
b. Constructing and using a wave tank to model, compare and contrast, the properties of waves in:
   i. Open conditions
   ii. Broken sea ice conditions
   iii. Interface conditions with solid ice

c. Conducting a simple experiment to demonstrate the circular movement of water due to the Coriolis effect including the determination of the intensity of circular water movement and how this would apply to oceans on a global scale. E.g. increased energy input results in stronger currents.
d. Investigating, explaining and modelling the processes and importance of an Echman Spiral to the mixing of the vertical water column.
e. Investigating and describing how technology can be used to study ocean currents (satellite images, false / real colour images and Global Ocean Observing Systems).

8. Students will gain an understanding of Arctic Ocean dynamics by:

a. Presenting meteorological data from a given time frame that illustrates seasonal energy input trends (including modelling how the tilt of the Earth qualitatively affects the energy input seasonally).
b. Illustrating and reporting on the potential impact of changes in energy input into a marine system and the effect on the dynamics of the system, using software simulations.(eg.SIMEARTH).
c. Describing and demonstrating the albedo effect using simple field or laboratory models to illustrate the qualitative reflective index and heat absorption capacity of representative surfaces, such as: barren land, open water, ice / snow covered surfaces.
d. Consulting with community Elders or other subject matter experts, to develop a presentation on the tools and strategies used for safe ocean travel throughout the seasons.
e. Plotting and describing, on polar projections, the major types and distribution of sea ice found in the Arctic Ocean, such as:
   i. Single year / annual ice
   ii. Multi-year ice
   iii. Ice flows
   iv. Ice bergs
f. Investigating and documenting Arctic ocean ice growth data / patterns over the past fifty years for general trends including constructing simple models to demonstrate the trends and potential future outcomes of ice formation.
g. Researching and presenting a case study on the potential global impact and importance of polar ice to global oceans, the biosphere, and the historical and cultural importance of ice for northern Aboriginal peoples (including consultation with Elders or other subject matter experts, to determine how variations in ice patterns affect community life in the Arctic).

C. General Learning Outcomes:

Students will investigate marine geomorphology and the effect of tides on the marine system.

Specific Learning Outcomes:

9. Students will gain an understanding of seabed geomorphology by:

a. Describing, explaining, and modeling representative seabed geomorphological features such as:
   i. Seafloor
   ii. Continental shelf / shelf
   iii. Canyons
   iv. Abyssal plains
   v. Basins
   vi. Slope
   vii. Seamount
b. Identifying and locating general geomorphological features using hydrological maps of the Arctic Ocean and its approaches (including an investigation of the various technologies used to study seafloor morphology).

10. Students will gain an understanding of how tides work and their effect on a local environment by:

a. Illustrating, through simple models:
   i. How the relative gravitational forces of the Moon and the Sun cause daily, monthly, and seasonal tidal bulges in oceans
   ii. How geography accentuates tidal forces to create extreme tides (including specific areas in Canada, such as Iqaluit, NU and the Bay of Fundy, NS).

b. Interpreting and applying tide charts to determine the tidal cycle and range of tides over a month long period for a given location.

c. Interviewing community Elders or other subject matter experts, to develop a presentation on the significance of tidal fluctuation throughout the seasons to Aboriginal culture, including the seasonal cycles.

11. Students will gain an understanding of the careers and occupations related to oceanography by:

a. Researching and preparing a career and occupational profile related to oceanography in the NWT and Canada.

Notes:

Unit 2: Ocean Ecology
(Emphasis: Nature of Science)

Overview:

Ecology is the study of the relationship and interactions between organisms and their environment within the context of the ecosystem. To investigate the relationship between organisms and their environment, ecologists conduct experimental studies in the laboratory and the field. This unit focuses in on the abiotic and biotic factors that affect and limit plant and animal populations, their distributions and productivity in the ocean. Through a series of field, laboratory and case studies students will investigate distribution, abundance and general productivity of representative plant and animal populations. Local monitoring programs for indicator species, on established study sites, will enable students to collect, use, interpret and present data. Students will use modelling and technology to demonstrate how the relationship between an organism and its environment can be employed in ecological studies. The emphasis of this unit is on the Nature of Science.

Focusing Question(s):

How do organisms interact with each other, their ecological community and humans to survive?

Key Concepts:

- Fundamentals of Arctic Marine Ecology
- Classification
- Life Cycles
- Field Study Methods
- Role of Organisms in an Ecosystem
- Human Impact
- Careers and Occupations Related to Ocean Ecology

A. General Learning Outcomes:

Students will investigate species relationships, nutrient cycles and representative food webs.

Specific Learning Outcomes:

1. Students will gain an understanding of basic Arctic marine ecology by:

a. Reviewing the working definitions of and the relationships between:
   i. Species
   ii. Population
   iii. Community
   iv. Ecosystem
   v. Biodiversity

b. Describing, explaining and illustrating general biological energy transfer processes in the Arctic marine environment by modelling representative Arctic marine food webs (including how biodiversity contributes to ecosystem stability).

c. Illustrating and explaining the general cycling of matter, biotic and abiotic, in the Arctic marine environment including:
   i. Carbon
   ii. Oxygen
   iii. Nitrogen
   iv. Silicates

2. Students will gain an understanding of nutrient and energy flow in a local ecosystem by:

a. Investigating and describing the nutrient cycle of the local ecosystem by illustrating the flow of:
   i. Carbon
   ii. Nitrogen
   iii. Oxygen
b. Describing and illustrating representative local food chains and a food web of the Arctic ecosystem including sources of food traditionally used by Aboriginal peoples.

B. General Learning Outcomes:

Students will investigate the role of representative marine species and the protocols for collecting ecological data.

Specific Learning Outcomes:
3. Students will gain an understanding of the diversity of the marine species in the ecosystem by:

a. Investigating the role of taxonomy and its application to the study of ecology by:
   i. Investigating the Lamarckian classification structure.
   ii. Listing and sorting representative local species when conducting field studies.
   iii. Collecting and cataloguing representative samples of Arctic marine flora and fauna using recognized protocols, to create a local taxonomic key, species check list and collection.
   iv. Sketch representative micro and macro marine species to develop a pictorial taxonomic key.
b. Investigating the role of micro-organisms in an Arctic marine system by:
   i. Describing and illustrating the general roles of bacteria and the key indicators for the presence of bacteria.
   ii. Describing and illustrating the ecological roles of:
      a.) Phytoplankton
      b.) Zooplankton
      c.) Life-cycle trends of phytoplankton and zooplankton
   iii. Explaining the role of ice algae and spring blooms to the overall productivity of the system.
c. Investigating the role of intertidal zones by:
   i. Conducting a field study, with transects, to:
      a.) Identify and map the supralittoral to sub literal zone, including zones of freezing
      b.) Collect, catalogue and preserve samples and determine the relative abundance and zonal profiles of flora and fauna using recognized protocols.
   ii. Conducting a simulated field study of representative intertidal profiles of various slopes, where students predict the location and relative abundance of representative flora and fauna based on previous profiles.
   iii. Comparing the tidal ranges experienced by different northern communities and discussing how this would affect traditional activities such as harvesting molluscs, hunting or travelling on ice.

iv. Comparing and contrasting the adaptive features of representative intertidal flora and fauna, which allow them to survive in the Arctic.

v. Developing a basic food web diagram based on their intertidal study.

d. Investigating the role of representative benthic (ocean bottom) and pelagic (open ocean) invertebrates by:

i. Determining the key morphological characteristics and typical life cycles of representative invertebrates such as: molluscs, bivalves, gastropods, crustaceans and echinoderms

ii. Developing a food web highlighting representative invertebrates and their relationship to other species.

iii. Consulting with Elders or other subject matter experts to determine how invertebrates are used by humans and their importance to local culture.

e. Investigating the role of marine fishes by:

i. Describing and explaining the key characteristics and habitat preferences of major representative species in the Arctic Ocean and adjacent waters including anadromous species.

ii. Investigating and plotting the key migration routes of representative fishes in northern Canada.

iii. Comparing and contrasting the life cycle of anadromous and marine fishes.

iv. Illustrating a food web highlighting representative fishes and their relationship to other species.

v. Researching and discussing with Elders or other subject matter experts, the importance of various fish species to local communities, the predictability of fish behaviour, and harvesting techniques.

vi. Discussing in a "Town Hall" forum, the importance of fish to Arctic society from commercial, non-commercial and traditional points of view including the ecological practices used to ensure sustainability for future generations (using case studies of representative fish populations to evaluate past, present and future fish stocks in northern waters).

f. Investigating the role of marine mammals by:

i. Identifying, describing and plotting the distribution of the key marine mammal species found in Arctic water and its approaches.

ii. Describing and explaining the key behavioural characteristics and habitat preferences of major representative species in the Arctic Ocean and adjacent waters (including illustrating migration routes and seasonal patterns of key marine mammals).

iii Consulting with Elders or other subject matter experts to determine how marine mammal behaviour is used to ensure survival of the community (e.g. migration routes, feeding areas, seasonal patterns).

iv. Describing and explaining the key adaptive morphological features for survival of:

a.) Whales

b.) Seals

c.) Walrus

d.) Polar bears

v. Describing and discussing the behavioural and life cycle events of representative Arctic marine mammals and the necessity of a stable and predictable ecosystem

vi. Illustrating a food web highlighting representative fishes and their relationship to other species.

g. Investigating the role of marine seabirds by:

i. Identifying, describing and plotting the distribution of key marine seabird species found in Arctic water and those found locally (including the location of key breeding colonies in and around the Arctic Ocean).

ii. Describing and explaining:

a.) Key behavioural characteristics, habitat preferences and migratory routes of representative seabird species in the Arctic Ocean and adjacent waters.

b.) Key adaptive morphological features for survival of representative seabirds.

iii. Conducting a real or simulated bird survey in a particular region using recognized protocols.
iv. Investigating, describing and illustrating the primary life cycle events of representative Arctic marine seabirds and the necessity of a stable and predictable ecosystem (food, open water, etc.)
v. Illustrating a food web highlighting representative seabirds and their relationship to other species.

C. General Learning Outcomes:

Students will investigate the impact of humans and industry on the Arctic marine system and the careers and occupations related to marine resource management.

Specific Learning Outcomes:

4. Students will gain an understanding of the impact of contaminants on Arctic ecosystems by:

a. Defining the term "bioaccumulation" to describe, explain and illustrate the general processes and mechanisms of bioaccumulation in the Arctic marine ecosystem, including organic chlorides and heavy metals.
b. Researching and presenting a case study on the effects of representative toxins on the biological "health" of marine species, the level of toxins in traditional foods, and the impact of toxins on the health of humans in northern Canada. E.g. NWMB Inuit Bowhead Knowledge study.
c. Developing a model, which demonstrates the bioaccumulation process and the migration of toxins through the marine environment and potential transference to humans (including an investigation of the known sources and pathways of contaminants in areas of the Arctic).
d. Presenting a research project on a contaminated site to:
   i. Investigate and describe the various reclamation and remediation processes for cleaning up contaminants in a specific area.
   ii. Explain the past and present historical use of the site being studied
   iii. Develop a reclamation plan in accordance with Territorial and Federal environmental regulations.
   iv. Develop a before and after model of the reclaimed site.
   v. Present a "Green Plan" for the site reclamation in a "mock" public forum.

12. Students will gain an understanding of the careers and occupations related to marine habitats and resource governance and management by:

a. Researching and preparing a career and occupational profile related to the marine resources in the NWT and across Canada.

Unit 3: Habitats, Population Dynamics and Management
(Emphasis: Science, Technology, Society and the Environment (STSE))

Overview:

Habitat ecology is the study of the relationship and interactions between organisms and their environment within the context of the ecosystem. To investigate the relationship between organisms and their environment, ecologists conduct experimental studies in the laboratory and the field. This unit focuses in on the abiotic and biotic factors that affect plant and animal populations, their distributions and productivity in the ocean. Through a series of field, laboratory and case studies students will investigate distribution, abundance and general productivity of representative plant and animal populations. Local monitoring programs for indicator species, on established study sites, will enable students to collect, use, interpret and present data.

Population dynamics and resource management is a process that requires a great deal of understanding about the ecology and ecological processes of an environment. Understanding population dynamics and resource management requires field and laboratory studies to investigate, monitor and evaluate the status of resources and how best to ensure a sustainable population within an environment. This will include investigations of the traditional Aboriginal uses of marine plants and animals, management techniques and resource monitoring. This information will enable students to gain a better understanding of the local management practices and governance to ensure a sustainable future. Field study plots will further enable students to monitor local populations, practice conservation strategies and evaluate the human impact on the environment and its resources. The emphasis of this unit is STSE.

Note:

Unit 3 Habitats, Population Dynamics and Management investigate numerous ocean habitats. To ensure that there is sufficient time to investigate the learning outcomes only four sections are mandatory, remaining sections are optional;

- Governance and resource management,
- Open oceans,
- Two habitats of local interest.

Focusing Question:

How do ecological studies of habitats, populations and resource management ensure a sustainable future?

Key Concepts:

- Open Ocean Habitat
- Marine Coastal Areas
- Estuaries
- Fjords
- Polynyas
- Salt Marches and Lagoons
- Tidal Flats
- Population Dynamics
- Governance and Resource Management
- Careers and Occupations Related to the Study of Habitats, Population Dynamics and Ocean Resource Management

A. General Learning Outcomes:

Students will investigate marine habitats and gain an understanding of the mechanisms that support the plants and animals living in it.

Habitat: Open Ocean

Specific Learning Outcomes:

1. Students will gain an understanding of the open ocean habitat by:

a. Describing the general characteristics of an open ocean.

b. Investigating the relationship between the geomorphological features of the open ocean seafloor and the distribution of species found in these areas.

c. Developing a species profile and catalogue of representative plankton, vertebrates (mammals, fishes, birds) and invertebrates (free swimming and benthic) that live in an open ocean habitat including:

   i. Representative species life history.

   ii. Basic mechanisms for survival and reproductive behaviour that allow pelagic (vertebrates and invertebrates) organisms to survive throughout the seasons.

d. Researching and plotting areas of high productivity in open oceans based on biological (species diversity / season migratory uses) and or geographical indicators, such as: upwellings, polynyas, current patterns, and ice-free zones.

e. Comparing and contrasting the seasonal productivity of an open ocean in the Arctic with a warm water ocean (e.g. Pacific or Indian ocean) including the technology used to study this habitat.

f. Illustrating representative food chains and a food web of pelagic and benthic species including sources of food traditionally used by Aboriginal peoples.

g. Investigating and discussing with community Elders or other subject matter experts, to document:

   i. How open oceans have changed over time.

   ii. How changing ice conditions and microclimates can impact the biological diversity of an ecological community and affect the traditional Aboriginal way of life (consider: seal breeding grounds, polar bear migration, establishment of polynyas).

2. Students will gain an understanding of open ocean population dynamics by:

a. Explaining the role of contributing factors which control a population including;

   i. Natality

   ii. Immigration

   iii. Mortality

   iv. Emigration

   v. Survivorship and

   vi. Age distribution

b. Investigating, and discussing with community Elders or other subject matter experts the general population trends of a representative species over time.

c. Investigating and modelling methodologies and techniques for determining the natality, immigration, mortality, emigration, survivorship and age distribution of various representative population.

d. Researching the environmental impact of human activities on the ecology and population dynamics of representative open ocean species (e.g. garbage, pollution, year round use of sea-lanes).

e. Comparing and contrasting the risks and benefits to society and the environment of applying scientific knowledge and technology to increase human activities in Arctic water. E.g. larger ships with icebreaking capacity, use of the NW passage, increased deep-sea resource exploration.
f. Discussing, using a mock "Town Hall" forum, the pros and cons of a commercial activity in Arctic waters and the needs for a sustainable economy and ecosystem. Include an evaluation (comparing and contrasting) of the historical and contemporary harvesting practices of open ocean species.

Habitat: Marine Coastal Areas

Specific Learning Outcomes:

1. Students will gain an understanding of marine coastal areas by:

a. Describing the general characteristics of a coastal habitat.
b. Conducting research and field studies to:
   i. Describe, map or model the geomorphological features of the coast, including transition zones.
   ii. Create a species profile and catalogue of plants and animals that live or use this habitat.
   iii. Discuss how major coastal features affect marine plant and animal distribution.
   iv. Discuss with Elders or other subject matter experts, how and why the coastal area(s) have changed over time.
c. Explaining, describing and illustrating (creating simple models):
   i. The dynamic effects of erosion and deposition on coastal areas due to wave action, ice movement, ice growth, and permafrost melting on a seasonal and long-term basis.
   ii. The use of modern technology to study and assess Arctic coastal regions.
   iii. How changing coastlines can impact entire communities and their traditional way of life. E.g. Tuktoyuktuk and Paulatuk coastal erosion rates, Holman Island.
d. Researching and discussing with Elders or other subject matter experts, how local coastal areas are used by Aboriginal people. E.g. food sources, materials, ice formation, seasonal traditional sites. Connect this to a representative food chain and food web of a typical coastal area.

2. Students will gain an understanding of coastal population dynamics by:

a. Investigating, and discussing with community Elders or other subject matter experts the general population trends of representative species over time.
b. Investigating and modelling methodologies and techniques for determining the natality, immigration, mortality, emigration, survivorship and age distribution of various representative populations.
c. Evaluating, using a mock "Town Hall" forum or public hearing, the risks and benefits of coastal alteration (pollution, building retaining walls, dredging, sewage treatment facilities, large-scale housing developments) to the ecology of the habitat, population shifts and the traditional activities of the coastal peoples.

Habitat: Estuaries

Specific Learning Outcomes:

1. Students will gain an understanding of estuaries by:

a. Describing the general characteristics of an estuary habitat

b. Researching and or conducting field studies of a representative estuary to:
   i. Describe and model the geomorphological features of a typical estuary, the adjacent transition landforms, and its annual cycles.
   ii. Create a species profile and catalogue of plants and animals that live or use this habitat.
   iii. Describe, in a variety of ways, a representative food web of an estuary ecosystem including sources of traditional food and resources used by Aboriginal peoples.
   iv. Investigate an estuaries' subsoil profile to gain information on the biological and geological history of the area.
c. Discussing the productivity of an estuary and its biological importance, including an explanation of the biological and geological role of estuaries.
d. Researching and discussing with Elders or other subject matter experts, to understand:
   i. How and why the local estuarine environment has changed over time
   ii. How this has impacted local traditional activities
   iii. The locations of estuaries (plotted on a regional map)
   iv. Why these ecosystems warrant special protection
   v. How estuaries are used by Aboriginal peoples (e.g. food, materials, seasonal traditional sites)
e. Investigating the alteration of an estuary by:
   i. Reviewing case studies to investigate how alteration can impact entire biological communities and affect traditional ways of life.
   ii. Conducting simulations of estuary growth and change using scale models
   iii. Describing how technology and historical data are used to monitor changes.

2. Students will gain an understanding of estruine population dynamics by:

a. Investigating, and discussing with community Elders or other subject matter experts the general population trends of a representative species over time.
b. Investigating and modelling methodologies and techniques for determining the natality, immigration, mortality, emigration, survivorship and age distribution of various representative populations.
c. Investigating and modelling the potential environmental impact of human activities (garbage, pollution, encroachment and development resulting in the altering of cycles including water flow) on the ecology, population dynamics and traditional activities of peoples who depend on an estuary. E.g. draining, dredging, encroachment, hydro dams construction, roads. Include the presentation of evidence for or against the alteration (dams, climate change, altering flood cycles) of an estuary ecosystem.

Habitat: Fjords

Specific Learning Outcomes:

1. Students will gain an understanding of fjord ecology by:

a. Describing the general characteristics of a fjord habitat

b. Researching and or conducting field studies of a representative northern fjord to:

i. Describe, record and model the geomorphological features of a typical fjord and the adjacent transition landforms.

ii. Create a species profile and catalogue of plants and animals that live or use this habitat.

iii. Describe the primary features of a fjord and how these features affect plant and animal distribution.

iv. Discuss with Elders or other subject matter experts, how fjords are used for traditional activities and the significance of this ecozone.

v. Plot fjord distribution on a map of the Canadian Arctic.

vi. Describe the unique flow of nutrients through the fjord ecosystem including a representative food web describing sources of food and resources traditionally used by Aboriginal peoples.

vii. Conduct simulations of a fjord environment, using scale models to determine the rate of water exchange and the behaviour of waves.

2. Students will gain an understanding of population dynamics by:

a. Investigating, and discussing with community Elders or other subject matter experts the general population trends of representative species over time.

b. Investigating and modelling methodologies and techniques for determining the natality, immigration, mortality, emigration, survivorship and age distribution of various representative populations.

c. Researching, using a variety of sources, the environmental impact of oil spills if one were to occur in a fjord or sound. E.g. Case study of the Exxon Valdez disaster.

d. Investigating how industrial effluent can have long-term ecological implications for a fjord ecosystem. E.g. Tailings pond collapse at the Nanasivik mine site.

Habitat: Polynyas

Specific Learning Outcomes:

1. Students will gain an understanding of polynyas by:

a. Describing the general characteristics of a polynya habitat

b. Researching, investigating and modelling a representative polynya to:

i. Describe the dynamic effects responsible for creating a polynya

ii. Identify and predict (using bathymetric charts) potential areas where upwellings might occur

iii. Plot the areas where polynyas occur in the Canadian Arctic and investigate why these phenomena exist in particular areas.

iv. Compare local knowledge and or other sources of information, to predict the occurrence of polynyas.

v. Demonstrate how the strength of a current or upwelling can dramatically affect the size and predictability of a polynya.

vi. Create a species profile and catalogue the organisms that live or use this habitat throughout the year.

vii. Describing and illustrating representative food chains and a food web in a polynya including sources of food traditionally used by Aboriginal peoples and the annual productivity of a polynya.

viii. Discuss the unique features of this system and how it supports the survival of various marine organisms.

ix. Discuss, evaluate and defend why polynyas are unique and warrant special protection
x. Compare and contrast the productivity and species diversity of a polynya to an open ocean throughout the seasons

c. Researching and discussing with Elders or other subject matter experts, the predictability of a polynya and how this impacts local traditional activities.
d. Researching and conducting a laboratory / field studies to:
   i. Discuss with Elders or other subject matter experts, how polynyas are used to ensure the survival of Aboriginal peoples (e.g. food, materials, seasonal traditional sites).
   ii. Investigate how increased human activities in a polynya could impact on the entire biological community and affect the traditional way of life.
   iii. Investigate how technology and historical data are used to monitor the activity of a polynya.

2. Students will gain an understanding of polynya population dynamics by:

a. Investigating, and discussing with community Elders or other subject matter experts the general population trends of representative species over time.
b. Investigating and modelling methodologies and techniques for determining the natality, immigration, mortality, emigration, survivorship and age distribution of various representative populations.
c. Researching to:
   i. Compare and contrast the environmental impact of human activities on the ecology and traditional activities of peoples who live near polynyas. E.g. tanker traffic, over use from hunting, ecotourism.
   ii. Gain information on the biological, geographical and historical aspects of a polynya and the surrounding area. E.g. Foxx Basin and surrounding communities
   iii. Investigate the effects of an oil spill on a polynya ecosystem through laboratory experiments.

Habitat: Salt Marshes and Lagoons

Specific Learning Outcomes:

1. Students will gain an understanding of salt marshes and lagoons by:

a. Describing the general characteristics of salt marsh and lagoon habitats.
b. Researching and conducting field studies to:
   i. Describe and model the geomorphological features (including the adjacent transition landforms).
   ii. Create a species profile and catalogue of plants and animals that live and or use salt marsh and lagoon habitats.
   iii. Describe and illustrate the primary features of this habitat and discuss how these features affect plant and animal distribution and habitat selection (e.g. adaptations to variations in salinity, pH, and dry seasons).
   iv. Present the adaptive features of a plant or animal that allows them to survive in this ecosystem.
   v. Demonstrate the ecological roles of salt marshes and lagoons and their role as a geochemical stabilizer.
c. Researching and discussing with Elders or other subject matter experts, during field investigations to:
   i. Describe and present representative food chains and a food web of salt marshes and lagoons
   ii. Determine how salt marshes and lagoons are used by Aboriginal peoples (e.g. food, materials, seasonal traditional sites)
   iii. Determine how and why salt marshes and lagoons have changed over time and how the changes impact local traditional activities
   iv. Plot the distribution of these habitats, locally, to illustrate areas of productivity based on biological (species diversity/seasonal migration) and geographical (topography, tidal ranges, storm surges, river flooding) indicators.
   v. Determine why specific salt marshes and lagoons warrant special protection

d. Describing and applying the protocols and technology used to study, monitor and assess salt marsh and lagoon habitats

2. Students will gain an understanding of salt marsh and lagoon population dynamics by:

a. Investigating, and discussing with community Elders or other subject matter experts the general population trends of representative species over time.
b. Investigating and modelling methodologies and techniques for determining the natality, immigration, mortality, emigration, survivorship and age distribution of various representative populations.
c. Investigating and discussing how the alteration or destruction of salt marshes and lagoons can impact entire biological communities, traditional ways of life, and seasonal bird migration success. Include an evaluation (compare and contrast) of the risks and benefits to society and the environment of applying scientific knowledge and technology to alter salt marsh and lagoon habitats. E.g. draining, dredging, encroachment, ecotourism.

Habitat: Tidal Flats

Specific Learning Outcomes:
1. Students will gain an understanding of tidal flats by:

a. Describing the general characteristics of a tidal flat habitat.
b. Researching and conducting field studies to:
   i. Describe and model the geomorphic features (including the adjacent transition landforms).
   ii. Create a species profile and catalogue of plants and animals that live or use the tidal flat habitat.
   iii. Illustrate a representative food web of tidal flats including sources of traditional food and resources used by Aboriginal peoples.
   iv. Describe and illustrate the primary features of this habitat and discuss how these features affect plant and animal distribution and habitat selection (e.g. adaptations to variations in salinity, freezing, and ice compression).
   v. Present the adaptive features of a plant or animal that allow them to survive in this habitat.
   vi. Plot tidal flat distribution to illustrate areas of productivity based on biological (species diversity/seasonal migration) and geographical (topography, tidal ranges, storm surges) indicators.
   vii. Discuss with Elders or other subject matter experts, how tidal flats are used by Aboriginal peoples (e.g. food, materials, seasonal traditional sites)
c. Describing and applying the protocols and technology used to study, monitor and assess tidal flat habitats.

2. Students will gain an understanding of population dynamics associated with tidal flats by:

a. Investigating, and discussing with community Elders or other subject matter experts the general population trends of representative species over time.
b. Investigating and modelling methodologies and techniques for determining the natality, immigration, mortality, emigration, survivorship and age distribution of various representative population.

c. Investigating using cases studies, how GIS technologies are used to assess long-term change and short term catastrophic such as an oil spill or extremes in weather.

Governance and Resource Management

B. General Learning Outcomes:

Students will gain an understanding of the issues of governance and management, and careers and occupations relating to marine habitats and resources.

Specific Learning Outcomes:

1. Students will gain an understanding of marine regulatory bodies by:

a. Identifying, and explaining:
   i. The roles and mandate of the Department of Fisheries and Oceans.
   ii. The roles and responsibilities of local, territorial, and federal governments in governing Canada's oceans.
b. Explaining and discussing the environmental regulatory process for developments that could potentially impact on the ocean habitats.
c. Establishing a mock panel to develop an Integrated Management Plan (IMP) based on a case study related to the Arctic environment including an explanation of the processes and rationale for the establishment of an IMP.
d. Explaining and describing the role of the Marine Mammal Act and documenting how different organizations and groups have come together to set and evaluate the goals for a sustainable ecology and economy.
e. Explaining and discussing the role of the Migratory Bird Act, and the provisions for subsistence hunting.
f. Investigating and analyzing international treaties, policies, and agreements currently in place and how these could affect future events in the Canadian Arctic (e.g. whaling treaties, shipping regulations).
g. Explaining the role of governments; including land claims agreements, in the monitoring and protection of coastal areas.
h. Developing a proposal to support a Marine Protected Area for an environmentally sensitive area in the Canadian Arctic including an explanation of the rationale and protocols for the establishment of Marine Protected Areas.

2. Students will gain an understanding of marine mammal and fish stock management processes to ensure sustainable development by:

a. Investigating case studies methodologies for marine mammal management to:
   i. Evaluate the effectiveness / sustainability of a management plan and the role of the *Marine Mammal Act*.
   ii. Provide an alternate plan for managing a resource to ensure sustainability.
b. Investigating Subsistence / Sport Fishing to:
   i. Conduct a survey to determine the number and types of fish that are harvested locally.
   ii. Discuss the changes in fish stocks with local Elders or other subject matter experts to gain information about variations in fish stocks over time and the monitoring processes used to document these changes.
   iii. Examine and discuss the local, Territorial and Federal regulations that govern the harvesting of fish.
   iv. Determine if fish harvesting (subsistence, sport, commercial) practices in their local area are significant enough to affect local fish populations.
   v. Investigate the possibility of sport or commercial fishing as a viable means of promoting economic growth in their

community including a review of the relevant sections of the *Fisheries Ac*t and associated regulations with respect to sport fishing.

c. Investigating Commercial Fishing to:

i. Discuss the relevant sections of the Fisheries Act and associated regulations with respect to commercial fishing.

ii. Research and evaluate commercial fishing in the Arctic to determine the species that are harvested, their populations and quotas (including an examination of current practices) to evaluate the sustainability of fish stocks.

iii. Explain the monitoring and evaluation process that ensures a sustainable fish stock for future generations.

3. Students will gain an understanding of the careers and occupations related to marine habitats and resource governance and management by:

a. Researching and preparing a career and occupational profile related to the marine resources in the NWT and across Canada.

Notes:

Unit 4: Petrology and the Ocean Environment
(Emphasis: Science & Technology)

Overview:

Petrology is a branch of geology that deals with the origin, occurrence, and structures of rocks. It is the role of petrologists to plan, collect, analyze and interpret their findings to construct meaningful understanding of the geological strata and make predictions about petroleum deposits. This unit builds upon the basic understanding of petroleum geology from previous years and extends it to a more in-depth understanding of the geological, social and environment issues of the petroleum industry working in or close to an aquatic environment. The emphasis of this unit is Science & Technology.

Focusing Question:

How do we discover, extract, refine and use petroleum products and what is their impact on society?

Key Concepts:

- Renewable, Non-Renewable and Recyclable Resources
- Petroleum Resource Deposits
- Production of Petroleum Products
- Environmental Impact of the Petroleum Resource Industry
- Careers and Occupations Related to the Petroleum Resource Industry

A. General Learning Outcomes:

Students will gain a general understanding of the petroleum industry including the processes involved in manufacturing petroleum products, the environmental impact of this industry and the careers available related to the petroleum resource industry.

Specific Learning Outcomes:

1. Students will gain an understanding of the petroleum resources industry by:

a. Distinguishing, explaining and defining renewable, non-renewable, and recyclable resources.

b. Describing and illustrating using block models, the sequence of events through which the following petroleum resource deposits are believed to have formed:

   i. Gas (methane) hydrate deposits

   ii. Mackenzie Valley oil and gas deposits

   iii. Beaufort Sea oil and gas deposits

   iv. Oil sands deposits (Northern Alberta)

   v. Lignite coal deposits

c. Illustrating and modelling to explain the importance of host rock characteristics in creating petroleum resource reservoirs/traps (include rock types, structures, porosity and permeability)

d. Identifying and describing the technologies and techniques used to gain information about the location and extent of on-shore and offshore petroleum resource deposits including a plot (on a circumpolar map) of known locations of potential and existing deposits.

2. Students will gain an understanding of the processing of petroleum resources by:

a. Describing, illustrating and modelling the methods of extraction employed in the development of a petroleum resource deposit.
b. Explaining how a variety of factors (including but not limited to: price, concentration, accessibility/transportation, size, and environmental considerations) determine the feasibility of a petroleum resource deposit.
c. Describing and illustrating the separation step of the refining process of petroleum resources into useable commodities including experimenting to demonstrate simple distillation of a mixture in solution.

3. Students will gain an understanding of the environmental issues surrounding the petroleum resource industry by:

a. Describing and discussing the environmental impact of petroleum resource development and production in terms of:
   i. Transportation of oil and gas products.
   ii. Man-made islands and surface alteration.
   iii. Oil and gas leaks/spills, including potential distribution by ocean currents.
   iv. Accumulative effects on marine and land mammals.
   v. Effects of H2S on the local environment (burn-off of sour gas).
   vi. Other current issues related to the topic.
b. Employing research and group discussions to:
   i. Propose strategies for the conservation of petroleum resources.
   ii. Evaluate the feasibility of the proposed strategies.
   iii. Discuss the pros and cons of the various strategies – those in place now and those proposed for the future (including the short and long-term value of petroleum resource conservation).
c. Evaluating alternative renewable forms of energy (e.g. wind, geothermal, solar, biomass, heat pumps) by considering:
   i. Availability
   ii. Cost and efficiency
   iii. Environmental impact
   iv. Other relevant “cultural” considerations

4. Students will gain an understanding of the careers and occupations related to the petroleum resource industry by:

a. Researching and preparing a career and occupational profile related to the petroleum resource industry in the NWT and across Canada.

Experiential Science 30 – Freshwater Systems

Course Overview:

Experiential Science 30 is comprised of four major units that focus on Freshwater Systems.

Unit 1 Structural Geology, investigates the forces acting within the earth, which shape and reshape the earths crust. To gain further insight into structural geology the study of plate tectonic and seismology incorporates the disciplines of physics, chemistry and mathematics to identify and document Earth structures. It is the role of structural geologists to construct meaningful understanding of the geological process at work and make predictions about future events. Through a series of field and laboratory investigations students will experience field-mapping techniques to document, analyse and present their findings. The emphasis of this unit is science and technology.

Unit 2 Introduction to Limnology, is the study of water chemistry, physiology, flora and fauna in a freshwater system. Limnologists conduct field and laboratory studies to better understand the relationships between the abiotic and biotic factors that affect freshwater drainage basins and associated populations in the freshwater environment. Through a series of field, laboratory and case studies students will investigate and monitor local lakes and rivers. The emphasis of this unit is the Nature of Science.

Unit 3 Freshwater Ecology, is the study of the relationship between an aquatic environment and the organisms that inhabit the environment. Ecologists conduct field and laboratory investigations to understand the abiotic and biotic relationships in an aquatic environment to assess the health of the system and make predictions of future events. Through a series of field, laboratory and case studies students will investigate distribution, abundance and general productivity of representative flora and fauna in an established study site. The emphasis of this unit is Science, Technology, Society and the Environment.

Unit 4 Resource Management, incorporates the understanding of ecology and ecological processes to ensure a healthy and sustainable habitat or population. Resource management requires field and laboratory studies to investigate, monitor and evaluate the status of resources and how best to ensure their use for a sustainable future. Incorporating the traditional Aboriginal uses of freshwater plants and animals, management techniques and resource monitoring will allow students to gain a better understanding of the local management practices and governance. Field study plots enable students to monitor local populations, practice conservation strategies and evaluate the human impact on the environment and its resources. The emphasis of this unit is Science, Technology, Society and the Environment.

Unit Emphasis and Suggested Time Allocations:

The unit emphasis indicates the primary focus of the unit and directs the process for learning. The times suggested for each unit are a general guideline. Regional differences and local conditions may provide instructors with unique opportunities for more in-depth study of a particular section. Field and laboratory investigations should be seen as an investment, for gaining a better understanding of learning outcomes. Opportunities for extended periods of field study would allow students to interact with Elders and other subject matter experts in a more natural setting which would foster greater insight into the connectedness of Freshwater systems.

Grade 12 Freshwater Systems

Unit	Title	Emphasis	Suggested Time Allocation
1	Structural Geology	Science & Technology	30 hrs
2	Introduction to Limnology	Nature of Science	35 hrs
3	Freshwater Ecology and Population Dynamics	Science Technology, Society & the Environment	40 hrs
4	Freshwater Resource Management, Governance and Ethics	Science Technology, Society & the Environment	20 hrs

Unit 1: Structural Geology

(Emphasis: Science & Technology)

Overview:

Structural geology is the branch of geology that deals with the description, representation and analysis of geological structures. The forces acting within the earth are responsible for shaping and reshaping the Earth's crust. The primary theory to explain structural geology is the Theory of Plate Tectonics. To gain further insight into structural geology the branch of seismology investigates Earth movement. Seismology incorporates the disciplines of geology, physics, chemistry and mathematics. It is the role of structural geologists to plan, collect, analyse and interpret their findings to construct meaningful understanding of the geological process at work and make predictions about future events. This unit builds upon the basic understanding of geological structures from previous years and extends it to a more in-depth understanding of the geological process and resulting structures. Through a series of field and laboratory investigations students will experience field-mapping techniques to document, analyse and present their findings. The emphasis of this unit is Science and Technology.

Focusing Question(s):

How do the forces of the Earth shape the crust and how do we study these processes?

Key Concepts:

- Fundamentals of Plate Tectonics
- Fundamentals of Seismology
- Structures Resulting from Earth Movement
- Mapping Structural Features
- Careers and Occupations Related to Structural Geology

A. General Learning Outcomes:

Students will investigate the Theory of Plate Tectonics and the mechanisms involved in crustal plate movement.

Specific Learning Outcomes:

1. Students will gain an understanding of the Theory of Plate Tectonics by:

a. Investigating and describing the Theory of Plate Tectonics.
b. Identifying the evidence that supports the Theory of Plate Tectonics, including:
   i. Location of volcanoes and earthquakes
      a.) Plotting the areas of major/current tectonic activity on a world map ("Ring of Fire")
      b.) Plotting the locations of tectonic activity in the Arctic (e.g. Liard River hot springs, Axle Heiberg Island geothermal vents)
   ii. Ocean floor spreading
      a.) Investigating current research that helps explain possible causes of crustal plate movement.
      b.) Constructing models that demonstrate how convection circulation of molten material provides the driving force of plate tectonics.
   iii. Paleontological patterns in plant and animal distribution
      a.) Collecting evidence from the fossil record and or rock types that support the notion of crustal plate motion and continental drift.

2. Students will gain an understanding of the mechanisms of plate tectonics by:

a. Describing, illustrating and modelling, using block diagrams, the general characteristics of plate boundaries:
   i. Divergent
   ii. Convergent – collision, subduction
   iii. Transform – sliding
b. Describing the origins and "life cycle" of magma and its correlation to volcanic activities resulting from:
   i. Rift eruptions (divergent plate boundaries)
   ii. Subduction zone eruptions (convergent plate boundaries)
   iii. Hot spots (intra-plate settings)
c. Describing and illustrating the geologic formations that occur at crustal plate boundaries and including:
   i. Island arcs/trenches (ocean-ocean boundary)
   ii. Volcanic mountain ranges (ocean-continent boundary)
   iii. Folded mountain ranges (continent-continent boundary)
d. Investigating the process of seafloor spreading by:
   i. Describing and illustrating the tectonic activity that takes place at these locations
   ii. Illustrating and constructing a paleomagnetic map of normal and reversed polarity in seafloor rock strata
   iii. Discussing and drawing conclusions about the evidence that supports the process of seafloor spreading

3. Students will gain an understanding of regional plate tectonics by:

a. Plotting and modelling, using block models, to illustrate examples of landforms that exist in northern Canada resulting from magmatic activity including:
   i. Magma calderas,
   ii. Uplifted Mountains (e.g. Nahanni Mountain Range)
   iii. The formation of geothermal vents / hot springs (e.g. Liard River system)

B. General Learning Outcomes:

Students will investigate seismology and the mechanisms involved in Earth movement.

Specific Learning Outcomes:

4. Students will gain an understanding of seismology by:

a. Defining and differentiating the terms:
   i. Seismology
   ii. Seismograph
   iii. Seismogram
b. Explaining and describing the characteristics of inner and outer core, mantle and crust of the Earth including:
   i. Density
   ii. Composition
   iii. Thickness
   iv. The Mohorovicic ("Moho") discontinuity.
c. Explaining and demonstrating, using models, to illustrate the Elastic-Rebound Theory including (deformation vs. time graph):
   i. Elastic deformation
   ii. Ductile deformation
   iii. Elastic limit
   iv. Failure
   v. Fault
   vi. Epicentre
   vii. Focus.

5. Students will gain an understanding of earthquakes by:

a. Illustrating, using block diagrams and models, the relationship between the focus of an earthquake, its epicentre and seismic wave fronts.
b. Explaining and illustrating, how the energy from earthquakes is transmitted through the Earth by seismic waves, including:
   ii. Longitudinal = P-waves
   iii. Transverse = S-waves
   iv. Surface = L-waves
c. Describing and illustrating the different modes of travel, travel times and types of motion associated with each type of seismic wave (P, S, and L-waves).
d. Constructing a cross sectional diagram of the Earth, to illustrate and explain how P-waves and S-waves move through the various internal layers and indicate those areas where the waves do not travel (shadow zones).
e. Consulting with Elders or other subject matter experts to understand the traditional explanations of earthquakes and related activities.

6. Students will gain an understanding of methods and technologies used to study earthquakes by:

a. Consulting with Elders or other subject matter experts on traditional methods of earthquake prediction (animal behaviour or past events).
b. Summarizing the historical use of the seismograph and its contribution to the understanding of the internal structures of the Earth.

c. Designing and constructing a working model of a seismograph (seismometer) to explore how the movement of seismic energy is measured and recorded.
d. Constructing an earthquake table to test and record (using the student-built seismograph), scale models under different seismic conditions.
e. Comparing and contrasting earthquake magnitude and intensity and the scales used to measure each. Include tables showing the expected results for each scale and present your findings to the class:
   i. Magnitude - Richter Scale or Moment Magnitude Scale
   ii. Intensity – Modified Mercalli scale
f. Researching, plotting and explaining the importance of:
   i. Seismic stations located in Canada
   ii. Seismic risk zones in Canada
f. Conducting a seismic risks analysis for your local area using:
   i. Geographic location
   ii. Topography
   iii. Ground strength
   iv. Rock types
   v. Proximity to faults
   vi. Design of buildings
g. Investigating and explaining various contemporary methods of earthquake prediction including:
   i. Dilatancy data, (strain accumulation)
   ii. Seismic gap
   iii. Changes in hydrostatic pressure in gas wells

C. General Learning Outcomes:

Students will investigate structural geology and the structures that result from Earth movement.

Specific Learning Outcomes:
7. Students will gain an understanding of structural geology by:

a. Defining and illustrating, using clay, block models and graphs, the terms and geological processes of:
   i. Deformation
      a.) Plastic (ductile)
      b.) Brittle
   ii. Force
      a.) Stress
         i.) Compressional,
         ii.) Tensional, and
         iii.) Shear
      b.) Strain
b. Comparing and contrasting the three major structures resulting from brittle deformation:
   i. Fractures
   ii. Faults
   iii. Joints

c. Conducting field or laboratory investigation to measure the strike and dip of a plain or rock surface and become familiar with the mapping symbols used on field maps.
d. Constructing block models to illustrate the various types of faults:
   i. Dip-slip
      a.) Normal,
      b.) Reverse,
      c.) Thrust
   ii. Strike-slip
      a.) Left lateral,
      b.) Right lateral
      c.) Transform faults
e. Explaining, using block models, the compressional, tensional, and shear forces that result in the three major types of faults.

8. Students will gain an understanding of structural landforms by:

a. Recognizing and identifying, from maps, photographs, diagrams or models, examples of:
   i. Dome
   ii. Basin
   iii. Anticline
   iv. Syncline
   v. Horst
   vi. Graben
b. Researching and developing a working definition of the term *unconformity*.

D. General Learning Outcomes:

Students will investigate the field skills required to document Earth structures and the careers and occupations related to structural geology and seismology.

Specific Learning Outcomes:
9. Students will gain an understanding of the use of field mapping to gain geological information of a study area by:

a. Researching previous field work to develop a historical profile
b. Conducting a field or laboratory investigation to collect:
   i. Surface information from maps
   ii. Surface features from the field
   iii. Subsurface structures, from:
      a.) Diamond drill hole data
      b.) Cross-section data
c. Creating 3D models to illustrate the interrelationships between surface (plan) maps, cross sections and the subsurface structures present.
d. Developing a geological profile of the area.

10. Students will gain an understanding of careers and occupations related to structural geology by:

a. Researching and preparing a career and occupational profile related to structural geology for positions available in the NWT and Canada.

Unit 2: Introduction to Limnology
(Emphasis: Nature of Science)

Overview:

Limnology is the study of water chemistry, physiology, flora and fauna in a freshwater system. Limnologists conduct field and laboratory investigations to study the chemistry and physiology of freshwater systems to better understand their relationship to the flora and fauna of their environment. The role of the limnologists is to plan, collect, analyse and interpret their findings to construct meaningful understanding of the freshwater ecosystems and make predictions about future events. This unit focusses on the abiotic and biotic factors that affect freshwater drainage basins and associated plant and animal populations, their distributions and productivity in the freshwater environment. Through a series of field, laboratory and case studies students will investigate lake and river morphology, chemistry and life cycles along with plant and animal distribution, abundance and general productivity of the freshwater system. Local monitoring programs for indicator species, on established study sites, will enable students to collect, use, interpret and present data. The emphasis of this unit is the Nature of Science.

Focusing Question:

How does the study of limnology allow us to monitor and assess a freshwater ecosystem?

Key Concepts:

- Fundamentals of Freshwater
- Description of Freshwater Catchments
- Morphology of Freshwater Systems
- Description of Lentic (still water) Systems
- Description of Lotic (moving water) Systems
- Process of Eutrophication
- Careers and Occupations Related to the Field of Freshwater Studies

A. General Learning Outcomes:

Students will investigate the characteristics of freshwater ecosystems and catchments.

Specific Learning Outcomes:

1. Students will gain an understanding of the physical and chemical characteristics of water and their importance to an aquatic system by:

a. Investigating the unique density characteristics of water.
b. Investigating the properties of water that allow it to exist as a solid, liquid or gas.
c. Investigating the viscosity properties of water.
d. Investigating specific heat / heat capacity as a temperature buffer.
e. Investigating the absorption of radiant energy.
f. Investigating surface tension.
g. Investigating the solvent properties of water.

2. Students will gain an understanding of inland waters and catchments of northern Canada by:

a. Investigating and plotting on a map the land area of the major catchment zones affecting northern Canada.
b. Determining the area of each catchment.
c. Identifying and labelling major lakes and rivers in each catchment.
d. Investigating and creating a geological overlay map of major rock and mineral types for each catchment area.
e. Listing key ions found in each rock and mineral type (indicators of pH)
f. Identifying and plotting key topographical features for each catchment area.
g. Determining the general resident time of water in each catchment

3. Students will gain an understanding of freshwater system morphology by:

a. Describing and investigating the movement of water through a catchment basin
   i. Surface systems
      a.) Precipitation, topography and run off
      b.) Streams, lakes, wetlands, rivers to ocean
   ii. Subsurface systems
      a.) Infiltration in soil
         i.) Permafrost,
         ii.) Discontinuous permafrost,
         iii.) Different soil types
      b.) Percolation rates
      c.) Groundwater,
         i.) Surface
         ii.) Unconfined aquifer
      d.) Confined aquifer
b. Describing and illustrating the general morphological characteristics of a lake.
c. Describing and illustrating the general zones found in a typical lake.
d. Describing and illustrating the general morphological characteristics of a stream and river.
e. Describing and illustrating the general zones found in a typical stream and river.
f. Researching catchment resident time for a watershed, using a variety of methods.
g. Conducting a field investigation to map the general characteristics of a lake and stream / river study site using recognized protocols.

4. Students will gain an understanding of lentic ecosystems (still water) by:

a. Describing the origins, formation, general physical characteristics, and structure of:
   i. Glacial lakes
   ii. Coastal lakes
   iii. Tectonic lakes
   iv. Riverine lakes
   v. Volcanic lakes
   vi. Karst Lakes

b. Drawing storyboards, to illustrate the formation and general life cycle of a local lake.

c. Indicating, using standard GIS protocols (satellite, aerial photographs, map (1:50,000)), the distribution of lake types in a 100 km radius of the local community.

5. Students will gain an understanding of the physical and chemical characteristics responsible for lake stratification, mixing and morphology by:

a. Investigating the general features that lead to lake stratification such as;

i. Thermoclines:

a.) Describing lakes as heat sinks

b.) Demonstrating representative seasonal vertical profiles

c.) Illustrating and explaining the general concept of turnover.

ii. Chemoclines:

a.) Describing and explaining a chemocline

b.) Illustrating and explaining the variations and strengths of chemoclines as a function of depth

c.) Describing the Chemical composition of representative chemoclines.

d.) Plotting lakes of Canada which have unique chemoclines

e.) Represent vertical profiles of Salt / ion concentration of representative lakes.

iii. Wave structures and lake behaviour in relation to:

a.) Fetch dynamics and the behaviour waves

b.) Surface waves, their creation and propagation

c.) Surface currents (convergent and divergent)

d.) Seiches and seasonal trends

e.) Other Mechanisms responsible for the mixing of lakes

iv. Describing and illustrating the general characteristics of northern lakes including:

a.) Meromictic

b.) Amictic

c.) Cold monomictic

d.) Dimictic

e.) Discontinuous cold polymictic

f.) Cold polymictic

v. Investigating the effects of climate change on aquatic systems including changes in:

a.) Ice duration and thickness

b.) Stratification and mixing

c.) Light transmission

i.) Surface

ii.) Subsurface

d.) Heat transfer

b. Describing and illustrating the relative nutrient status / productivity of representative lake types in Canada;

i. Oligotrophic

ii. Mesotrophic

iii. Eutrophic

c. Investigating and researching the typical nutrient and productivity levels to classify these as oligotrophic, mesotrophic or eutrophic lakes.
   i. Meromictic
   ii. Amictic
   iii. Cold monomictic
   iv. Dimictic
   v. Discontinuous cold polymictic
   vi. Cold polymictic

6. Students will gain an understanding of lotic ecosystems (moving water) by:

a. Describing and illustrating the physical characteristics, structure and formation of:
   i. Rivers and streams
   ii. Flood plains
b. Conducting a field study, in an established area, to plot the physical features and general topography of a lotic system.
c. Comparing and contrasting data, from the established study site, to document changes that have occurred and use this data to predict future trends.
d. Describing and demonstrating the processes of nutrient and sediment transport through a lotic system.
e. Comparing and contrasting the relative productivity of rivers of varying size, velocity and grade.

7. Students will gain an understanding of northern wetlands by:

a. Conducting a field study to describe and illustrate:
   i. Topographical features
   ii. Physical characteristics (biotic / abiotic)
b. Investigating and describing the form and function of wetlands in an ecosystem including, bogs, fens, marshes, and swamps.
c. Research and describe the general nutrient status / productivity of a wetland above and below the tree line.

8. Students will gain an understanding of lotic and lentic biogeochemical cycles, by:

a. Conducting a field study to test study plot water samples for:
   i. pH
   ii. Alkalinity
   iii. Carbon dioxide
   iv. Dissolved oxygen
   v. Hardness (buffering capacity)
   vi. Nitrates
   vii. Phosphates
   viii. Turbidity
b. Creating a model or pictorial representation to represent the role of organic and inorganic carbon in a freshwater system.
c. Investigating using case studies, to explain the connection between the carbon cycle and global warming.
d. Describing and representing oxygen levels in terms of:
   i. Solubility vs. temperature

ii. Dissolved oxygen content in vertical profile
iii. Annual oxygen cycles and productivity

e. Describing and representing phosphorous levels in terms of:
   i. Organic and inorganic transformation
   ii. Annual cyclic concentrations
   iii. A limiting factor and its effect on annual productivity.

f. Describing and representing nitrogen levels in terms of:
   i. Transformation processes
   ii. Annual cycles and concentrations
   iii. A limiting factor and its effects on productivity
   iv. A case study on the impact of human induced changes on regional and global nitrogen cycles.

g. Describing and representing iron, manganese and sulphur in terms of:
   i. Annual cycles and concentrations
   ii. A limiting factor and productivity

9. Students will gain an understanding of the significance of light in lotic and lentic systems by:

a. Describing and using experimental models to demonstrate qualitative variations rates of absorption and transmission of light as they relate to turbidity and depth of the water column.

b. Conducting field investigations or laboratory experiments to model light penetration in a water column by:
   i. Using a Secchi disc to determine the depth of light penetration.
   ii. Investigating seasonal variations in light concentrations.
   iii. Investigating the effect of ice depth and snow cover on the transmission of light.
   iv. Interpreting representative quantitative data to explain the seasonal variation in primary productivity.
   v. Describing the annual light budget at the equator, mid-latitude and at high latitudes to explain primary productivity cycles.

10. Students will gain an understanding of the process of eutrophication by:

a. Describing and illustrating the processes of aging of lakes, ponds and, waterways

b. Investigating the acceleration of eutrophication due to climate change.

c. Investigating through a case study, the effects of human influences on the acceleration of eutrophication.

11. Students will gain an understanding of careers and occupations related to limnology by:

a. Researching and preparing a career and occupational profile related to limnology for positions available in the NWT and Canada.

Notes:

Unit 3: Freshwater Ecology

(Emphasis: Science, Technology, Society & the Environment (STSE))

Overview:

Freshwater ecology is the study of the relationship between an aquatic environment and the organisms that inhabit the environment. Ecologists conduct field and laboratory investigations to better understand the relationships that exist in the aquatic environment to determine the health of the system and make predictions of future events. This unit focuses on the abiotic and biotic factors that affect plant and animal populations, their distribution and productivity. Through a series of field, laboratory and case studies students will investigate the distribution, abundance and general productivity of representative flora and fauna. Local monitoring programs, for indicator species, on established study sites will enable students to collect, use, interpret and present data. The emphasis of this unit is Science, Technology, Society and the Environment.

Focusing Question:

How can the study of freshwater ecology broaden our understanding of this environment and ensure a sustainable future?

Key Concepts:

- Fundamentals of Freshwater Ecology
- Collection and Classification of Freshwater Flora and Fauna
- Population Ecology
- Careers and Occupations Related to Freshwater Ecology

A. General Learning Outcomes:

Students will investigate the fundamentals of freshwater ecology.

Specific Learning Outcomes:

1. Students will gain an understanding of "What is freshwater ecology"?

a. Explaining the basic principles of freshwater ecology.
b. Conducting field investigations to apply the basic approaches to studying freshwater ecology.

2. Students will gain an understanding of aquatic flora and fauna by conducting a series of field studies to investigate and collect data from a study plot for:

a. Phytoplankton to:
   i. Apply various recognized sampling techniques to collect samples.
   ii. Conduct laboratory exercises to identify types of plankton.
   iii. Determine the relative population of species in the study plot.
   iv. Catalogue the diversity and population density of species to acquire base line / long term data.
b. Zooplankton to:
   i. Apply various recognized sampling techniques to collect samples.
   ii. Conduct laboratory exercises to identify types of plankton.
   iii. Determine the relative population of species in the study plot.
   iv. Catalogue the diversity and population density of species to acquire base line / long term data.

c. Bacteria to:
   i. Identify the presence of bacteria using various sampling techniques.
d. Benthic plants to:
   i. Apply various recognized sampling techniques to document population data and catalogue samples.
   ii. Conduct field and laboratory exercises to identify types of benthic plants and their distribution.
   iii. Determine the relative population of species in the study plot.
   iv. Catalogue the diversity and population density of species to acquire base line / long term data.
e. Zoobenthos to:
   i. Apply various recognized sampling techniques to document population data and catalogue samples,
   ii. Conduct field and laboratory exercises to identify types of zoobenthos and their distribution.
   iii. Determine the relative population of species in the study plot
   iv. Catalogue the diversity and population density of species to acquire base line / long term data.
f. Aquatic insects to:
   i. Apply various recognized sampling techniques to document population data and catalogue samples,
   ii. Conduct field and laboratory exercises to identify types of aquatic insects and their distribution.
   iii. Estimate the relative population of species in the study plot
   iv. Catalogue the diversity and population density of species to acquire base line / long term data.
g. Fish and water birds to:
   i. Apply various recognized sampling techniques to document population data and catalogue samples.
   ii. Conduct field and laboratory exercises to identify types of fish and aquatic birds and their distribution (seasonal).
   iii. Estimate the relative population of species in the study plot.
   iv. Catalogue the diversity and population density of species to acquire base line / long term data.

3. Students will gain an understanding of long term ecological studies by:

a. Documenting field and laboratory using recognized protocols.
b. Collating and summarize field and laboratory data from the study plot.
c. Analyse data over a number of years to identify any potential trends that may exist in the study plot.
d. Present their findings to a group, using a variety of media.

B. General Learning Outcomes:

Students will investigate population ecology.

Specific Learning Outcomes:
4. Students will gain an understanding of population ecology by:

a. Investigating and identifying common limiting factors in a freshwater aquatic system.
b. Explaining and describing population growth and regulation including:
   i. Limiting factors
   ii. Predator – prey relationships
   iii. Parasitism
   iv. Inter- intra species competition
   v. Human and non-human environmental influences.

5. Students will gain an understanding of species-species interactions by:

a. Identifying the species of plants and animals found in their study plot.
b. Constructing a model to illustrate a food web using all of the species found / identified in the study plot.
c. Discussing and evaluating the ecological stability of the study area.

6. Students will gain an understanding of population distribution by:

a. Investigating the geographical distribution of species found in their study plot or geographical region.
b. Plotting the distribution of these species on a series of maps to construct overlays.
c. Investigating the seasonal distribution of migratory species in the region.

7. Students will gain an understanding of fish ecology by:

a. Identifying the species of fish found in the region.
b. Plotting the distribution and range of fishes found locally.
c. Describing and illustrating the specific habitat requirement of fish species found locally.

8. Students will gain an understanding of careers and occupations related to freshwater ecology by:

a. Researching and preparing a career and occupational profile related to freshwater ecology for positions available in the NWT and across Canada.

Notes:

Unit 4: Freshwater Resource Management
(Emphasis: Science, Technology, Society & the Environment)

Overview:

Resource management is a process that requires a great deal of understanding about the ecology and the ecological processes which ensure the health and sustainability of a habitat or population. Resource management requires field and laboratory studies to investigate, monitor and evaluate the status of resources and how best to ensure their use for a sustainable environment. This will include investigations of the traditional Aboriginal uses of freshwater plants and animals, management techniques and resource monitoring. Students will gain a better understanding of the local management practices and governance to ensure freshwater resources for future generations. Field study plots will further enable students to monitor local populations, practice conservation strategies and evaluate the human impact on the environment and its resources. The emphasis of this unit is Science, Technology, Society & the Environment.

Focusing Question:

How can freshwater resources be managed to ensure a sustainable future for generations to come?

Key Concepts:

- Foundations of freshwater management
- Impact of resource extraction and the freshwater environment
- Ethical issues concerning freshwater resource management
- Careers and occupations related to freshwater resource management

A. General Learning Outcomes:

Students will investigate the philosophy of freshwater resource management.

Specific Learning Outcomes:

1. Students will gain an understanding of water management by:

a. Explain the role of government agencies in the monitoring and protection of waterways.
b. Investigating the processes for monitoring water levels and analysing water samples.

2. Students will gain an understanding of fisheries and fisheries management by:

a. Explaining the role of government agencies in the regulation and monitoring of fish stocks.
b. Investigating the various techniques used to assess and monitor a fish stock.
c. Using data from a case study, with a given scenario, to assess a fish stock over a given period of time.
d. Interpreting case study data to predict the biomass of indicator species in a specific region.

B. General Learning Outcomes:

Students will investigate governance and ethics relating to freshwater resources.

Specific Learning Outcomes:

3. Students will understand the foundations of a sustainable future, economics and ethics by:

a. Investigating the renewable resources that can be managed by humans including:
   i. Describing and illustrating how the freshwater resources of the region (local watershed) are used and managed by people.

ii. Developing a management program that would ensure that freshwater is available for future generations.
iii. Describing and illustrating the origins, distribution and consumption rates of the municipal water supply.
iv. Using municipal populations projection / data to estimate the future water needs of the community in 10, 20, 50 years from now.
v. Describing and explaining water conservation practices regionally and locally.
vi. Describing and plotting the location of dam sites and the affected watershed.
vii. Researching and presenting findings, to a mock board of inquiry, on the impact of dam construction and their effect on the environment and on traditional lifestyles / subsistence living.
viii. Describing the local management practices for sport and commercial fisheries.
ix. Investigating and evaluating the economic, ethical and long-term implications of various water management boards' decisions.

4. Students will gain an understanding of non-renewable resources extraction and the role of freshwater by:

a. Investigating the environmental impact processes required for mineral and petroleum resource development / operations / transportation.
b. Describing the roles and responsibilities of the Water Board.

C. General Learning Outcomes:

Students will investigate the issues and impacts of contaminants on the freshwater system and the ethics of freshwater resource management.

Specific Learning Outcomes:
5. Students will gain an understanding of contaminants in freshwater by:

a. Investigating natural contaminants and their sources.
b. Illustrating and describing the fate of natural contaminants in solution and as they precipitate into the sediment.
c. Investigating the sources of man-made contaminants.
d. Illustrating and describing the effects of bioaccumulation of man-made contaminants in an aquatic environment.
e. Researching and presenting, the historical perspective of the effects / concerns of bioaccumulation of toxin(s) in your region.
f. Discussing the pros and cons of industrial development in an environmentally sensitive watershed including:
   i. Possible toxins
   ii. Biodegradation of toxins
   iii. Bioaccumulation.
   iv. Environmental health issues
   v. Aquatic management concerns
   vi. Long and short term economic benefits to the community.

6. Students will gain an understanding of ethical issues concerning freshwater resources by:

a. Discussing the need and ways of balancing one's cultural values and to ensuring a sustainable future
b. Researching and discussing, with elders or other subject matter experts, the historical values and traditions used by Aboriginal people of harvesting the freshwater ecosystems to ensure sustainability.
c. Comparing and contrasting the traditional values and practices of harvesting fish, and the cost benefits to the ecosystem and economy of ecotourism vs. industrial harvesting of a fish stock.
d. Preparing a defence to support the advantages or disadvantages of ecotourism to the local economy.

7. Students will gain an understanding of careers and occupations related to freshwater resource management by:

a. Researching and preparing a career and occupational profile related to freshwater resource management for positions available in the NWT and across Canada.

Notes: