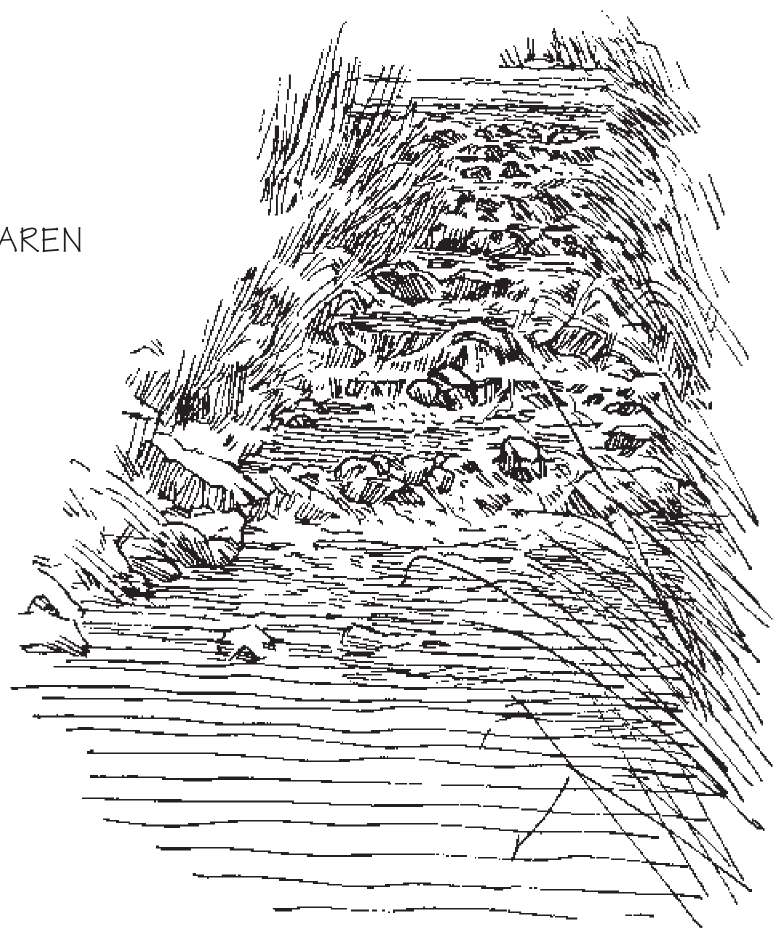
WATER STEWARDSHIP

A GUIDE FOR TEACHERS, STUDENTS, AND COMMUNITY GROUPS



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Canadian Cataloguing in Publication Data
McClaren, Milton.
Water Stewardship

Includes bibliographical references: p.
ISBN 0-7726-2309-0

1. Water quality management - Study and teaching - British Columbia. 2. Water conservation - Study and teaching - British Columbia. I. Fulton, Kim II. McMahen, Chris. III. British Columbia. Ministry of Environment, Lands and Parks. IV. Title

TD227.B7M32 1994. 333.91'16'0710711 C94-960383-X

Acknowledgements

Water Stewardship Steering Committee

The project was guided by a Steering Committee comprised of representatives of the Ministry of Environmental, Lands, and Parks (MOELP) and others with expertise in water stewardship. The committee was comprised of:

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Pilot Project Participants

The following teachers and their classes participated in the pilot project. We wish to acknowledge their efforts, dedication, and creative energy. We also acknowledge the help and support from administration, custodial staff, and teachers not "officially" in the project, but who assisted in action projects and supported the work of project teachers.

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Doug Gillett	Okanagan Mission Secondary	Kelowna
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Financial Support

Contributions from the Habitat Conservation Fund, B.C. 21, Forest Renewal B.C., Habitat Management, Fisheries Branch, and Water Management Branch of the Ministry of Environment, Lands, and Parks are gratefully acknowledged.

Editing and Layout

Thanks to Deborah Hodge, Burnaby B.C., for her work in editing the final copy.
Thanks to Dennis Smith, Simon Fraser University Excite Centre for his work in layout, design, art work, and desktop publishing.
Thanks to Lynne Fulton for her work proofreading.

The development of this handbook and the projects conducted from 1992 to 1994 were made possible by the funding support of the Ministry of Environment, Lands, and Parks of British Columbia. Ministry personnel also provided administrative services, and advice on technical aspects of the project.

Simon Fraser University's Faculty of Education provided the use of the Kelowna Tele-Learning Centre, administrative support, and computing services as well as materials and supplies basic to the success of the project.

The Fisheries Branch of MOELP played a pivotal role in initiating and sustaining the project.

Thanks are also extended to the administrative officers of Simon Fraser University, the Ministry of Environment, Lands, and Parks, and of Armstrong-Spallumcheen, Vernon, Central Okanagan, Summerland, and Penticton School Districts, who provided support for the project in a number of ways. The members of the Project Steering Committee also offered their time, expertise, and moral support throughout the project. Their dedication to Water Stewardship was an essential element in the production of the handbook and in carrying out the activities of the project.

Special thanks are extended to Richard Kool, Environmental Education Coordinator for the Ministry of Environment, Land, and Parks, and to Theresa Southam, Environmental Consultant, for their championship of the programme from conception to completion.

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Foreword

"We travel together, passengers on a little spaceship, dependent on its vulnerable supplies of air, water, and soil ... preserved from annihilation only by the care, the work, and I will say, the love we give our fragile craft."
Adlai Stevenson

When humankind ventured into the space between our Moon and the Earth, one of the most majestic, awe inspiring sights ever seen, came into view for the first time. Those few travellers, cramped in their narrow capsules, saw the Earth as an entire blue, green, and white sphere suspended against the darkness. When the first lunar expedition orbited the Moon and saw the first Earthrise, the contrast between the dry sterility of the Moon and the teeming lively surface of Earth became especially vivid. Without water, there could be no life, no humankind, no dreams, no inventions, no venturing. Perhaps the planet Earth could more aptly be called the planet Water!

—We are water.

Introduction

Clean water is key to life on our planet — all living species require water. Without water, we would certainly perish. Given the significance of water for life, it seems strange indeed that we often treat our watery world so badly.

Water Stewardship is a growing idea among people who share the goal of keeping water safe and available for the world's animals and plants.

Water Stewardship means taking care of water.

Water Stewardship begins with educating each other about water.

Knowing about water helps us move towards protecting and conserving clean water for all species. This Water Stewardship guide outlines ways to help you start educating students, friends, and community groups about the importance of water.

How to Use This Guide

This guide is designed for your convenience. You can read it cover to cover, or turn directly to a particular section, for immediate information.

The guide is divided into chapters covering different aspects of water stewardship education. It includes:

- an introduction to water stewardship
- key concepts for water stewardship
- teaching ideas/activities
- case studies
- information on taking effective action
- information about water
- a list of resources
- appendices

Use the table of contents to find the section you need.

Who Should Use This Guide?

This guide has been written by teachers for teachers who wish to increase their students' awareness about water and water stewardship. While the handbook will be of particular use to teachers in the K-12 school system, it can also be used in community-based programmes or projects sponsored by citizens groups, clubs, or government agencies.

You will find a theme woven through the book that suggests greater collaboration among schools, government agencies, and community groups to achieve improved water stewardship at the community and regional levels.

Use this guide to design a programme that fits your students' particular needs and circumstances. You will find that the activities and examples provided are not intended to be age specific, although some activities may be more useful for students of a particular age. Feel free to adapt the materials.

This book uses specific examples to illustrate approaches to a topic or project, rather than trying to present a step-by-step manual of teaching ideas.

Chapter One

INTRODUCING WATER STEWARDSHIP

What is Water Stewardship?

Water Stewardship is a growing awareness of the importance of water to all living species. Water Stewardship means making informed decisions and taking appropriate actions to protect and conserve water for all plants and animals who share our planet. It means leaving healthy, undiminished aquatic ecosystems for future generations.

Why do we need Water Stewardship?

Available, drinkable water makes up less than 1% of our total water supply. An ever-increasing human population is totally dependent on that small volume of water.

Several international agencies have estimated that a reasonable quality of life depends on an average of about 80 litres of water per person per day for domestic, agricultural, and industrial uses. In Canada and the United States the average is about 500 litres every day, while in Madagascar it is 5.4 litres. The average in Vancouver B.C. is about 700 litres per day.

Most of the water used in the "developed world" is for waste removal, washing, cleaning, irrigation, food processing and preparation, and for industrial processes. Only a fraction of the 500 litres a North American uses each day is actually consumed directly as drinking water. However, in many other parts of the world, human life literally hangs in the balance of water supply. Available, safe, clean water in quantity is a dream.

All living things need water

Humans are not the only species which depend on water. All life forms require water. A significant portion of the planet's biological diversity depends on inland and marine aquatic habitats. In turn, humans depend on many of these aquatic and marine ecosystems for food and for revitalization of water and air.

We have often acted without thought for our impacts on aquatic life and habitats. We pollute vast areas of fresh and salt water. We drain or dump fill into marshes, fens, sloughs, ponds, tundra, bogs, and swamps without recognizing their importance for the fabric of life on which we ultimately depend. British Columbia's land base has just over 6% wetlands, most of which are in the northwest corner of the province. In other areas of the province where wetlands are a minute percentage of the land base, these diverse habitats are disappearing at an alarming rate. 80% of the wetlands in the Fraser Valley delta are gone. In the Okanagan Valley there is extreme development pressure on wetland habitats and a poor inventory of what exists. The words from the Joni Mitchell song of the 1960s, "The Big Yellow Taxi," ring true:

Don't it always seem to go
That you never know what you've got 'til it's gone
They paved paradise and put up a parking lot…

We change the courses of rivers, drain lakes, flood canyons, defoliate stream banks, and build canals, often without a real understanding or concern for the long term consequences of our acts.

Sustainable ecosystems, of which humans are only a part, are only possible with healthy aquatic habitats. We must find ways of developing a new water ethic as well as a new land ethic. We must recognize that acting in our interests as humans is only possible if we also act in the interests of the other living things with which we share the Earth.

As Aldo Leopold put it in ***A Sand County Almanac***,

> *"a land ethic changes the role of Homo sapiens from conqueror of the land-community to plain member and citizen of it. It implies respect for his fellow-members, and also respect for the community as such."*

Water in British Columbia

British Columbia is one of the richest areas of the world for aquatic habitats. Its coastline is immense. Its rivers and their watersheds are some of the most important in North America. It is the site of the largest salmon run in the world and of some of the most significant fisheries.

Our vast forests depend on rain and snow. We draw upon the power of water to produce large amounts of electrical energy. We have created large garden landscapes and farms through irrigation.

Everywhere, growth and development depend on water and demand larger and larger quantities of it. Our cities have developed along waterways, at estuaries and harbours. Water is a highway. Water is a part of our psychology, an inseparable part of our appreciation of the scenic beauty of the province.

As the population of the province grows, we will be challenged to develop our capacities as stewards of water, wetlands, aquatic habitats, and life. Effective education for Water Stewardship is essential. It is to that purpose that this handbook, and the Water Stewardship Project, are dedicated.

Who is interested in Water Stewardship?

There is an ever expanding interest in Water Stewardship. There are many different groups interested in protecting or restoring aquatic and riparian habitats. School groups, water suppliers, community groups (including the First Nations communities), municipal governments, federal agencies, and Ministry of Environment, Lands, and Parks personnel are all eager to participate. All over the province, pressures are being brought to bear on these habitats by the rapid growth in human population. We believe that an educated population is essential for effective environmental citizenship. Many water management and land use decisions are made not by professionals but by lay people serving on municipal councils, regional district boards, water districts, and irrigation boards.

Results of Effective Water Stewardship

By educating present and future decision makers regarding the value of our aquatic ecosystems we will avoid habitat destruction and the loss of biodiversity that results from uninformed decision-making and poorly planned development. Effective water stewardship will lead to an enhanced quality of human life.

The Chinese philosopher Kuhn Stu, expressed the idea three centuries before the birth of Christ:

> *"If you are thinking a year ahead sow seed, if you are thinking ten years ahead plant a tree, if you are thinking one hundred years ahead educate the people,"*

History of the Water Stewardship Project

In 1989, the Ministry of Environment, Lands, and Parks of British Columbia, under the auspices of the Fisheries Branch Hatchery Education and Information Initiative, requested proposals for a review of fish-related education initiatives that were being undertaken by public and non-profit agencies across North America. The Branch also requested a survey of its staff to determine the nature of their current activities in public education concerning fish and aquatic habitats. Educational resource material relating to freshwater ecosystems were collected from all over North America. Over 25 sources were found. Provincial fisheries staff were also interviewed and the findings were summarized.

In the fall of 1991, a group of biologists and educators met to discuss the kinds of education programmes that could be created to further develop knowledge and awareness of fresh water ecosystems in the province of British Columbia. It was decided that a pilot programme involving both schools and community groups interested in water stewardship should be developed.

Objectives of the Water Stewardship Project

- **to define stewardship**
- **to implement several stewardship projects in the Okanagan**
- **to develop a Stewardship Guide for Fisheries personnel as well as for community groups and educators.**

In June of 1992, a team based at the Simon Fraser University Tele-Learning Centre (Faculty of Education) in Kelowna was contracted to undertake the project. Letters were sent to every public school in the Penticton, Summerland, Central Okanagan

(Kelowna), Vernon, and Armstrong-Spallumcheen school districts inviting applications to participate. Twenty-two pilot schools were selected representing a wide range of teaching situations,

Chapter Three

KEY CONCEPTS FOR WATER STEWARDSHIP

Parent: **"What did you learn in school today?"**
Child: **"Nothing."**
Typical dinner table conversation

Parent: **"What did you learn in school today?"**
Child: **"We learned that water is finite and that humans are major users of water. Could we do an experiment to find out how much water we use at home each day?"**
Typical dinner table conversation after key concepts were emphasized at school.

Developing a Water Stewardship Program

Environmental Education, like many other contemporary subject fields taught in schools, is rich in resource materials. At the beginning of the Water Stewardship Project we filled a very large room with examples of curriculum materials for the project teachers to use and analyze. However, a curriculum is not simply a set of activities or learning experiences, no matter how excellent or worthwhile these may be. A curriculum is a program of learning experiences, supported and reinforced through teaching and materials, in which there is a coherent, logical purpose and a set of progressions used to reach this purpose.

The topic of Water Stewardship is so large and there is so much material available that there is a tendency to "do" many neat activities but not to tie the activities together with important concepts. One of the major goals in developing the Water Stewardship Guide was to come up with a set of key concepts about water, aquatic habitats, aquatic life, and stewardship of water.

Providing a Structure for Learning

These key concepts are meant to provide a structure to help students connect their water stewardship experience and activities into meaningful patterns. We recommend that teachers and students use these key concepts to organize and evaluate learning in their classrooms.

The following list was developed in consultation with teachers, scientists, technicians, resource managers, and conservationists.

** Note the icon or logo which accompanies each concept. These icons are designed to help your students remember the key concepts. For your convenience, these icons have been printed as a black line master in the Appendix.*

Key Concepts for Water Stewardship

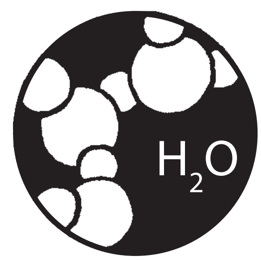
• 1. Water is essential for life.

All life on earth requires water. Without water there would likely be no life on Earth. While there may be frozen water or some water vapour on some of the other planets in the solar system, most are either too hot or too cold to have any liquid water. No traces of life as we understand it have been found on any of the other planets in our solar system.

• 2. All living things depend on water.

Different life forms have different water requirements, but all need water in some form. Different life forms may compete for water when water is scarce. Thus, water is a limiting factor in the environment.

• 3. Water is a unique material.



Water can exist as a solid, a liquid, or a gas. It dissolves many different types of materials. It is polar, that is, water molecules attract each other and tend to stick together in drops and films.

• 4. All water is part of the hydrological or water cycle.

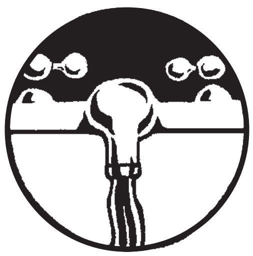
Water passes through this cycle as it changes from a liquid, to a gas (water vapour), and back to a liquid again. Water may also be found as a solid (ice and snow). Water is an integral part of the weather/climate system.

• 5. Streams, lakes, and rivers, as well as other water bodies are part of larger systems known as Watersheds.

Watersheds are characterized by the contours of the landscape, the vegetation covering the land, soil and rock formations, and prevailing patterns of climate in a region.

• 6. Watersheds are dynamic.

They change and evolve over time as a result of geological and biolo gical processes as well as human activities.



• 7. Humans are major users of water.

As animals, we humans need water for our lives, but we also use water in our technological processes to make things, generate electricity, grow food, and process food. We often compete with other life forms for water.

• 8. Water is finite.

There is only so much water available on earth at any given time. The amount of potable (drinkable) water, suitable for use by humans without advanced treatment is very limited.

• 9. Aquatic habitats are essential elements of the biosphere.

Aquatic habitats are home to a wide variety of plant and animal species and are necessary to maintain biodiversity. Many life forms exist for all or part of their life cycles in aquatic habitats. When water is used or contaminated with toxins, the habitat can be destroyed and species may be lost, resulting in a loss of overall biological diversity.

- **10. Contaminants and toxins can move within water.**

Contaminants have harmful effects on life forms, including humans, which are far removed in time and place from the sources of the toxins.

- **11. There are a number of careers and vocations working with water, aquatic habitats, and their management.**

There are jobs with private sector and government agencies as well as a variety of careers within forestry related fields.

- **12. Different human cultures have different values about water and different patterns of use.**

The concept of water stewardship should be examined from the perspectives of differing cultures and value systems.

How to Use the Key Concepts

The key concepts can be used to:

- provide guidance for the selection of resources for a Water Stewardship Program or for the evaluation of existing curriculum materials

- plan teaching units or school projects

- act as guidelines for developing a comprehensive, school-wide, cross-grade or cross-subject plan for Water Stewardship education

- serve as a template to help assess prior knowledge and learning

- help students to plan and monitor their own learning projects

- help schools and community agencies develop joint Water Stewardship Projects and assist in monitoring the results of the projects

You will find teaching and learning activities to accompany the key concepts in Chapter 5 of this guide.

It is important to remember that the key concepts have been developed for both teachers and students. Students need to be introduced to the concepts and then have them reinforced through activities and experiences.

Students can be encouraged to develop their own metaphors, examples, and illustrations for the key concepts. By doing so, students can develop a real understanding of what each one means.

Teachers of young children may have to simplify the key concepts to make them more accessible to their students.

Key Concepts Across the Curriculum

There is currently great interest in multidisciplinary approaches to school programs. Many educators feel that the traditional isolation of one subject from another in schools detracts from the development of powerful understanding and is also a poor reflection of how knowledge is actually created and applied in the real world.

Water Stewardship is a natural topic for interdisciplinary study. It presents a good opportunity to make meaningful connections among subjects like Math, Science, Social Studies, Art, Music, Language Arts, and Technology Education. It is not possible to study water without using: Mathematics to determine quantities, Biology/Ecology to study the living systems, Chemistry to analyze the composition, Language Arts to debate the issues, the Arts to express the aesthetics of water, and Social Studies to grapple with the social implications of water use decisions.

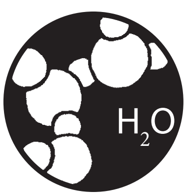
This does not mean that these individual subjects lose their identities by becoming part of a curriculum stew. Instead, the study of Water Stewardship can give students opportunities to develop an appreciation of the power and importance of the separate subjects, while seeing the connections among fields.

An Integrated Approach to Water Stewardship

The charts that follow at the end of this chapter are an example of how a class might use the key concepts in a variety of subject areas. the charts use the Cedar Creek (CC) Watershed (WS) as an example of curriculum integration.

Students and teachers might also work together to develop a plan for an integrated unit by using a "web" or "bubble diagram" of topics. See the example on page 29.

TABLE 1 – Cedar Creek (CC) & its Watershed (WS) as an Example of Curriculum Integration

	Social Studies	Science	Language Arts	Math	Fine Arts
1 Water is essential for life 	How has the availability of water shaped human settlements in this area?	How do living things use water?	Water poetry, water legends of First Nations Peoples.	How much water is there in the watershed now? How much is being used by humans and other creatures?	Create drawings/ paintings on the theme of water, humans, and the land.
2 All living things depend on water 	What climatic area(s) is this watershed in? How does the availability of water affect plant & animal life?	How does the available water define local communities of plants & animals?			
3 Water is a unique material 	How does water shape the landscape as an agent of erosion?	Exploration of states of matter through state changes of water: freezing, boiling. Is water a "universal solvent?"		Exploring relationships between volumes of liquid water vs. volumes of ice. Developing a method of measuring rainfall.	Exploring the characters of watercolours. How do the colours in watercolour work?
4 All water is part of the hydrological or water cycle 	What is the Water Cycle? How much Rainfall does the Watershed get? How much Snow? How much water is stored in lakes?	Exploration of Weather and the Water Cycle. Clouds, Rain, Snow, Ice, Solar Energy & the Water Cycle.	The weather as subject for writing and conversation. Why do people often talk about the weather?	How could you measure the amount of water used by a growing green plant in one week?	Clouds and the Weather as subjects for Graphic Arts & Music.

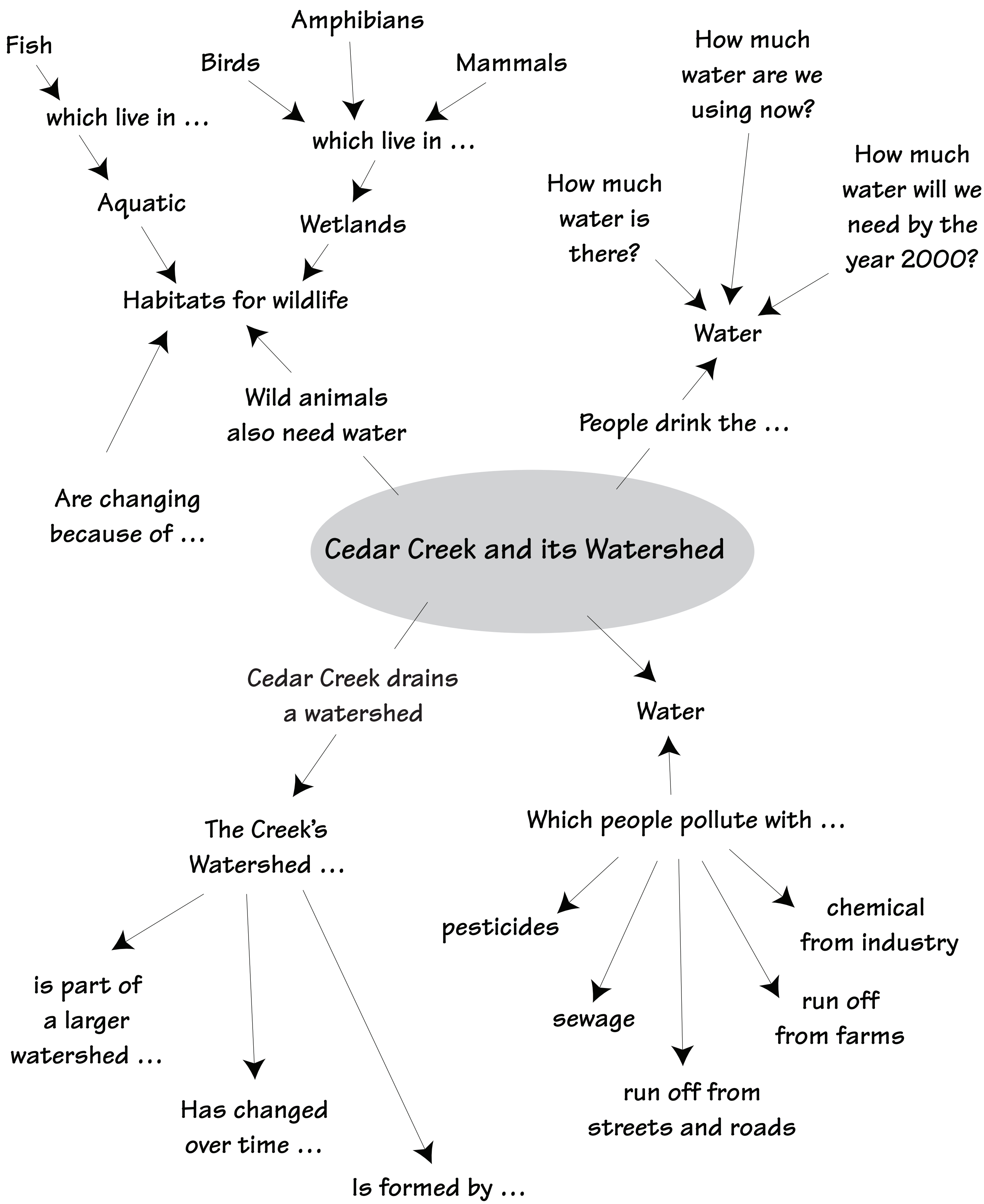
	Social Studies	Science	Language Arts	Math	Fine Arts
5 Streams, lakes, & rivers, as well as other water bodies are part of larger systems known as Watersheds 	What is the Watershed of Cedar Creek? Why does the Creek have this Watershed area?	Build a model Watershed using a Stream Table. Explore Evidence of erosion in the area.	Explore the names given to Lakes, Creeks, and Rivers. How did they get these names?	Measuring the flow rates and volumes of Cedar Creek & its major branches.	
6 Watersheds are dynamic 	What human activities are now changing the watershed?	Explore evidence of past changes in the watershed & develop a time line showing changes in the WS for the past 50-10 000 yrs.	Interview pioneers in the area of the CC Watershed to discover their experiences of WS change during their lives.	Map a section of the WS using simple survey instruments, like plans tables and Silva Compasses.	Write and stage class play based on the life of a well known local WS pioneer.
7 Humans are major users of water 	Conduct a survey of the industrial, domestic and agricultural uses of water in the CC WS.	Classify the river sources as above ground, aquifer, or ground water table.		Find out the available water volume of the CC WS. What are the predictions for its future demand?	

	Social Studies	Science	Language Arts	Math	Fine Arts
8 Water is finite 			Develop a report for the local regional district on the status of CC & the WS. Present the report as a final desktop published document & accompany the presentation with an oral report with graphics.	Develop statistics and graphs to show changes to the CC WS in the period 1900 to the present. Apply these stats and graphs to the report for the Regional District.	Design a poster to convince people to use water conservatively and to apply water saving devices in the home.
9 Aquatic habitats are essential elements of the biosphere 	What was the status of wetland habitats in the CC WS in 1900, 1950, and now? What caused these changes? Are any of the species which depend on wetlands extinct, endangered, threatened?	Develop a landscape plan based on the size of the typical single family home lot. Design the plan to avoid irrigation uses of water, to provide wild life habitats, and to promote the use and conservation of native plant species.			Build models showing the different approaches to landscaping and have the models critiqued by local developers, realtors, and landscape architects.

	Social Studies	Science	Language Arts	Math	Fine Arts
10 Contaminants and toxins can move with/in water and have harmful effects on life forms 		Do a survey of common water in the CC WS. Test the waters of CC and its branches for the presence of some of these contaminants / pollutants and attempt to identify their sources.	Use Rachel Carson's *Silent Spring* as a reading to focus on the biological effects of polutants in water. Stage a debate on the topic: "Rachel Carson: Sound Precaution or Hysterical Over-Reaction."	Develop a mathematical model to illustrate the impacts of bioconcentration in which substances such as DDT or Dioxins can move upwards in food chains. Graph the phenomenon of bioconcentration using actual research data.	
11 There are a number of careers and vocations working with water. 	Arrange for a visit to class by a professional from fisheries, water management, water quality monitoring, irrigation, forest hydrology, or other water-related professions and fields. How does his/her work relate to the overall understanding and/or development of the CC Watershed?	Contact the local college & find out what programmes they have related to water resources, fisheries, or aquatic habitats. What background would a person have to have to enter these programmes? Contact firms which sell or install irrigation equipment or plumbing fixtures. What training do employees need in water conservation technology?	Write a letter to a local agency responsible for water quality, water supply, fisheries, wetlands, or other aspects of the CC Watershed. Explain that your class is studying the watershed and that you would appreciate any information about the work of their department, and how that work might contribute to your class project.		

	Social Studies	Science	Language Arts	Math	Fine Arts
12 Different human cultures have different values about water and different patterns of use. 	Review the traditions of the First Nations Peoples regarding water and water habitats. What was the status of the cultural attitudes toward water among the First Nations peoples in the region.		Write a series of water tales or legends for the CC WS and perform these as dramatic readings.		Many native peoples had symbols such as rock paintings and carvings which marked sources of water or springs, and various water life forms. Collect examples of some of these and use them as the basis for linocuts, paintings, or graphic designs for a series of Water Awareness caeds.

A Topic Web for Planning an Integrated Study of Cedar Creek's Watershedp



Chapter Four

TEACHING AND LEARNING – A PHILOSOPHY

"The principle goal of education is to create people who are capable of doing new things, not simply repeating what other generations have done— people who are creative, inventive and discoverers. The second goal of education is to form minds that can be critical, can verify, and not accept everything they are offered.... So we need pupils who are active, who learn early to find out by themselves, who learn early to tell what is verifiable and what is simply the first idea to come to them."

Piaget

A Constructivist View of Learning

The Constructivist view of learning is quite complex, but generally it may be said to be founded on several key ideas. They are:

- **Learning is dependent on the student's prior knowledge, experience, and attitudes. Knowledge is built upon existing knowledge. The learner connects new experiences with past experiences.**

- **In order to learn anything, a student must be engaged with the tasks of learning. Although interactions with teachers, mentors, peers, and tutors can facilitate the learning process no one can learn for someone else.**

- **Human beings learn in an attempt to make meaning of the world. They relate learning experiences to themselves and to their own worlds and cultures.**

- **Learning is context sensitive. We associate what we learn with where, how, and why we learn it. Skills and knowledge gained in one setting are not automatically transferred to other settings.**

Learning Through Water Stewardship

Many of the activities and learning experiences provided in this guide are based on Constructivist concepts about learning. In particular, the following beliefs have shaped the development of the Water Stewardship Program:

1. Learning occurs as part of a learning cycle.

(See the diagram that follows)

The learning cycle can be divided into the following phases:

• Assessing prior knowledge

✦inding out what students already know about a topic or concept is a good starting point for teaching and learning. This helps in planning learning experiences, selecting appropriate resources, and monitoring new learning. Use the "Test Your Water Knowledge" survey located in Appendix B to find out what your students already know about water.

• Providing appropriate experiences for learning

✧xperiences and activities which are not connected to broad ideas or purposes, are not likely to be effective in promoting learning.

Inquiry and activity does not exist for its own sake, no matter how much fun it is, how engaging it is, or how popular we find it. When we use experiences and information as a basis for thinking, reflection, and learning, then they become valuable. We need not only "hands- on" activities, but also "minds-on" activities.

- **Debriefing and Reflecting**

Thinking and talking about an experience helps students and teachers to answer a number of questions such as: What did the experience mean? Why did we do this? What have we learned? What are we still unsure about? What else do we need to do?

- **Applying and Integrating**

Students use their learning in new ways. They put their experience into their own words, apply what has been learned to new problems, practice skills, use tools, or try things out with new materials or in new settings.

- **Assessing learning**

All through the learning cycle, the students and teachers should be keeping track of what is going on. They should identify problems, watch for uncertainties, decide which skills need refining, and determine where further work is needed.

Mistakes, errors, even disasters can be useful as long as they are used to help the learner understand or improve skills and performances. Ongoing assessment is an intrinsic part of the learning process.

2. Students are more likely to find a learning experience valuable if they can connect it to their own lives.

Learners need the opportunity to think about learning experiences in the context of their own lives and to understand why things are being taught and learned. Conceptual frameworks, curriculum guides, learning outcomes, goals, and critical indicators should be of service not only to the teacher but also to the students.

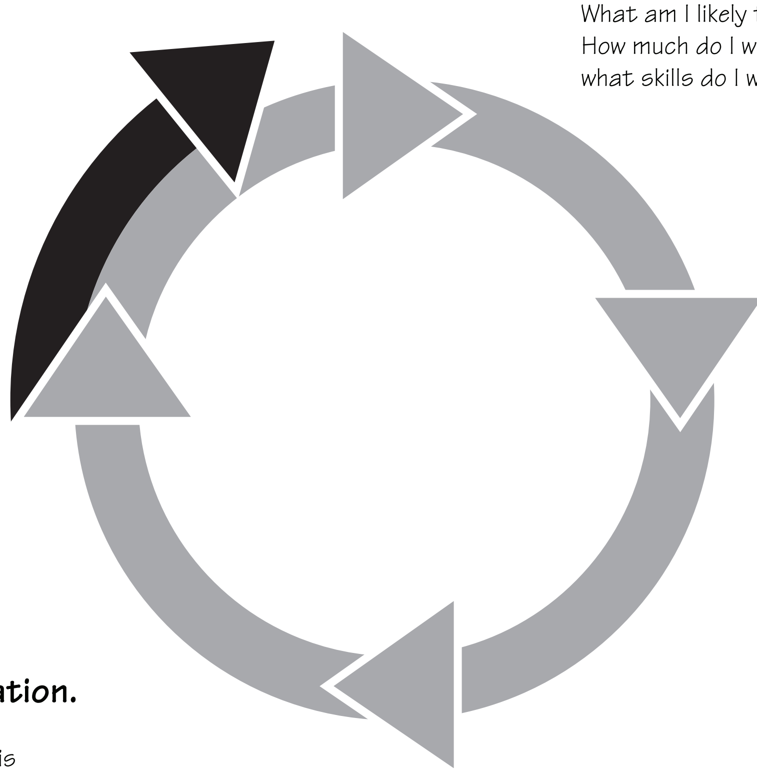
Thus, this guide can be shared with students and used in a co-operative fashion to help students keep track of their own performances.

The Learning Cycle

This is not really a circle or cycle, but a spiral. The student may leave phase 4 ready for new experiences, but he or she will have added the learnings, concepts, and experiences from the previous set to their knowledge base. Thus, learning and experience promote and extend new learnings and experiences.

Phase 1.
Assessing Prior Knowledge.
Reviewing Previous Experiences and Feelings.

Why? What is to be learned. What do I already know about this? What skills do I have? What am I likely to learn? How much do I want to know; what skills do I want to gain?



Phase 2.
Experiences for Learning

Why are we doing this? How can I connect this experience to what I already know?

Phase 3.
Debrief Experiences.
Reflections. Interpretation.
Assessment. Personal Integration.

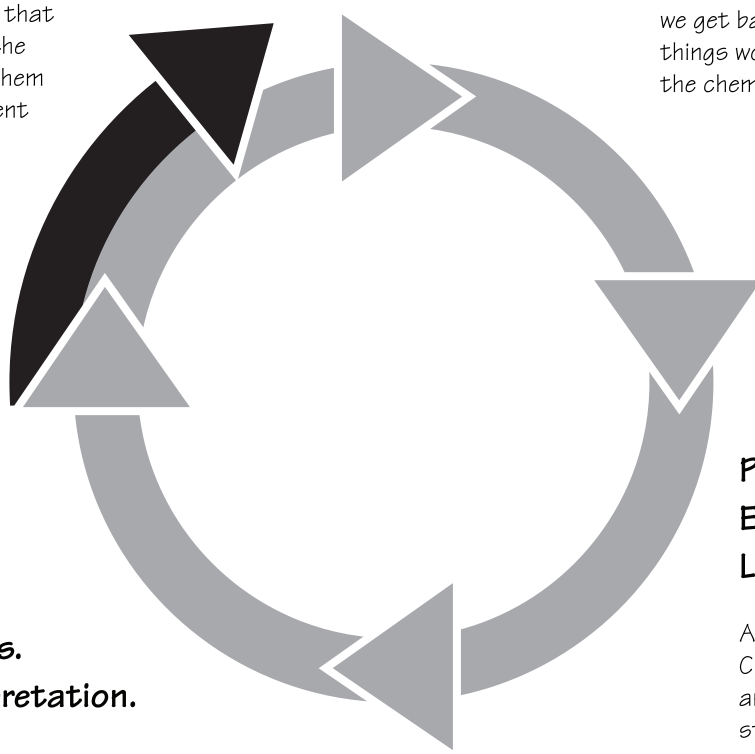
What have I learned from the experience? How does the new knowledge or experience change what I thought I knew/could/do/felt before the experience? How good is my knowledge? How firm are my skills? What do I still want/need to learn about this?

Phase 4.
Application.
Practice.
Further Integration.

What can I do with this knowledge & experience? What could I make with it? Should I apply it to my current situation? How does it change what I knew/felt before? Who could help me learn more or accomplish my goals? What tools or experiences do I still need?

An Example of the Learning Cycle

Applied to a Field Experience Testing Water Quality



Phase 1.
Assessing Prior Knowledge.
Reviewing Previous Experiences & Feelings.

Have you ever done any chemical tests on water or other liquids? Can you remember what they were for, or what information you got from them? We are going to use some simple chemical tests to find some basic facts about the water of Cedar Creek. Why do you think we might want to gather this information? We are going to learn how to do these tests and how to record the information so we can use it when we get back to school. What sorts of things would you like to learn about the chemistry of the creek's water?

Phase 2.
Experiences for Learning.

A field trip to Cedar Creek. Class is divided into teams and each team works at a station to make measurements of the water temperature, pH, dissolved oxygen, and nitrates. Each team also collects a water sample for Coliform testing back at school. At each station the team discusses the importance of the test with an aide or mentor who operates the test station.

Phase 3.
Debrief Experiences.
Reflections. Interpretation.
Assessment.
Personal Integration.

Each team summarises its data and presents the information to the other teams. Results are compared. One team's results for the nitrate test is very different from the others. The class reviews the test and the team with the differing results compares its procedures with those of the other teams to see if they might have made a mistake. The class decides to send one class member to gather some more creek water so they can all repeat the test. The class then decides what sort of "press release" they could issue on the "health" of the water in the creek. Some members decide that they haven't tested for things like phosphates, which might get into the creek from fertilizers and soaps. While they think the Creek is relatively unpolluted, they still would like to know more about its water quality.

Phase 4.
Application.
Practice.
Further Integration.

One group decides to become experts on other water quality tests and to try to continue further water testing. The class also decides that because they did the tests in the winter, they might want to do them again in the spring, when different conditions might give different results. The class also decides to repeat the tests on another creek which is slower running and which passes near a cattle feed lot.

3. Data, information, knowledge, and understanding are different from each other.

Information or data collected without interpretation, questioning, criticism, review, and application are not likely to lead to an increase in student knowledge or understanding.

Students need to collect information and structure it around a framework such as the key concepts outlined in Chapter Three. These key concepts can be learned in a variety of ways and will help students develop an understanding of water, whether they live in Vancouver, Vernon, Courtenay, Coquitlam, or Dawson Creek.

4. Student learning can be helped through interactions with other people.

Students can work co-operatively with team members, mentors, teachers, resource people, and guides. Student learning is often enhanced by membership in teams, work groups, partnerships, classes, and communities.

Many projects and activities in this guide encourage co-operation. The Water Stewardship Program attempts to balance individual and group activities.

5. Students need to be taught more than new information and skills — they also need to develop positive attitudes about themselves as learners.

The challenges which face us in developing a new, more sustainable, more appropriate relationship to the environment, are difficult and sometimes daunting.

In order to help students face these challenges, we must encourage them to be creative and inquiring, think clearly and critically, make effective decisions, and learn how to resolve conflicts. To accomplish this, we must begin to transfer some responsibility for learning from the teacher to the student.

6. Teachers should introduce students to the rich history of human knowledge and encourage them to add to their cultural heritage.

Humans have developed many rich and powerful ways of thinking about the world around them and about their own lives. The natural sciences, the arts, the humanities, the practical arts, and mathematics all represent important fields of human knowledge. Introducing this knowledge to students is important.

Using real questions, issues, and problems provides an ideal starting point. Given the importance of water for life, Water Stewardship provides a good focus and a vehicle for moving across these areas of knowledge. See the chart in Chapter Three for examples of activities from different fields or subject areas.

7. It is important to provide students with ways to help them remember and make sense of what they learn.

The icons or logos which accompany the key concepts for water stewardship (see Chapter 3) can be used to help students remember what they learn. These symbols can also be used to help the student organize data and information.

Chapter Five

ACTIVITIES FOR WATER STEWARDSHIP

"Every child should have mudpies, grasshoppers, waterbugs, tadpoles, frogs, mud turtles, elderberries, wild strawberries, acorns, chestnuts, trees to climb, brooks to wade in, water lilies, woodchucks, bats, bees, butterflies, various animals to pet, hayfields, pinecones, rocks to roll, sand, snakes, huckleberries, and hornets, and any child who has been deprived of these has been deprived of the best part of his/her education."

Luther Burbank

A common adage associated with environmental education is: Awareness, Knowledge, Action. We believe that to become a steward of the environment and to take effective action, awareness and knowledge must be addressed also. The activities in this chapter will help increase your students' awareness and knowledge and lead to action. Stewardship is an evolutionary process and these activities will help foster that evolution.

A major flaw often found in many existing water resource and activity books is the lack of connection between activities and key concepts.

The intent of this chapter is to offer activities which are clearly linked to the key concepts for water stewardship. The activities are designed to illustrate how teachers can use key concepts to select, refine, and adapt activities from existing sources, or how they can develop new approaches on their own.

We have not tried to link the activities to particular age groups. We know that teachers will present the materials to their students in ways they deem appropriate.

How the Activities are Organized

Every activity in this chapter is organized around one of the key concepts. For every key concept, a learning activity (or set of activities) is outlined in detail. The activities are presented in the following way:

- **Activity**—a learning activity which clearly illustrates a key concept of water stewardship

- **Background information**—helpful information about water

- **Materials**—a list of materials needed (Sometimes it may seem difficult to find the equipment needed for the activities. One good way to acquire the equipment is to send home a list of materials that you need and ask the students to do a "Scavenger Hunt.")

- **Procedure**—step by step instructions

- **Extensions**—follow-up ideas for a particular concept

- ***Assessment Ideas**—suggestions for ways to observe what your students are learning

- **Connections to the Curriculum**—an explanation of how the water activity fits into various subject areas

**Assessment in this program is designed to be informal rather than formal. The ideas given in this section are simply suggestions of ways that your students can demonstrate what they have been learning. More formal evaluation of your students will be left up to* *you and will depend on the age of your students, course requirements, and your particular teaching style.*

We recommend that you begin your study of water by checking what your students already know. Try using the "Test Your Water Knowledge" survey found in Appendix C of this guide. Watch your students as they carry out the various activities in this chapter and observe how their understanding grows. At the end of the water study, use the survey again and find out how much your students have learned.

Pick and choose which key concepts suit you and your students. Look over the list of activities which follows. These activities are designed to foster the key concepts. You can also use activities from the Ministry of Environment, Lands, and Parks Project Wild to build the key concepts. See the table in Appendix D which matches key concepts to Project Wild Activities.

List of Activities

Concept 2: All living things depend on water.

Different life forms have different water requirements, but all need water in some form. Different life forms may compete for water when water is scarce. Thus, water is a limiting factor in the environment.

Background Information

- **With Canada's abundance of fresh water, it is easy to forget the great dependence life has upon a supply of clean water. Lack of water directly translates into a lack of variety of life forms. As Canada's population continues to grow, and pollutants continue to enter the water cycle, the availability of fresh water is rapidly becoming an important issue.**

- **There are many major water diversion schemes on the "drawing board" which advocate diverting major rivers to help meet the water needs in the U.S.A.**

- **Sixty per cent of Canada's fresh water drains northward to Hudson's Bay and the Arctic Ocean, while ninety per cent of the population is located along the country's southern border. This places greater demand upon the water resources in the southern reaches of the country. In this southern part of Canada, industrial pollution, agricultural chemicals, poorly treated sewage, and other forms of pollution are affecting the quality of fresh water.**

- **Many wetland areas have been drained for agriculture and human habitation, devastating the freshwater ecosystems. The reduction of these wetland areas and the deterioration of water quality, results in a dramatic reduction of the number of species in a region. This, in turn, makes ecosystems much less stable. The preservation of freshwater quality and ecosystems is one of the most pressing environmental problems facing us today.**

Activity: Comparing Habitat Life

Differences exist between plants and animals depending on whether they live in water, near water, or on dry land. Students can observe and compare the different life forms found in these areas.

Discuss the following list of Habitat Life Questions with your students before the activity. You will be investigating life in three places: in the water, at the edge of the water, and on dry land. Use the questions again after the activity, for further discussion.

Habitat Life Questions

- Are some species found only in one place? How do they differ from plants or animals found in other places? What features do they have which make it possible for them to live where they were found?

- Are any species found in all three sites? What features do they have which make it possible for them to survive in all three places?

- Are some species very restricted in their distribution—found only in very specific conditions? What role does water play in determining the occurrence of these species? Are they water living, water requiring, or water avoiding?

- Does any species spend part of its life in water and part of its life somewhere else? How do the different stages of its life cycle differ?

- If the pond was drained or the creek dried up, what do you think would happen to the plants and animals you found? Which would survive? Which might thrive and increase? Which would die?

- Where is there the greatest number of different species of life? Where is there the lowest number of different species? Why do you think this is so?

- In which environment would it be most difficult to survive?

- Which life forms would be most affected by change in temperature, humidity, light, available water, or food supply as the day progressed or the seasons changed? Why?

Materials:

camera or video camera
micro-boxes
measuring tapes
paper and pencils
string or twine
clip boards
collecting nets
hand lenses
binocular microscopes
monocular microscopes
field guides

Procedure:

Select a field site near a body of water (a shallow lake, pond, or slow flowing, shallow stream). Divide students into groups of 3 or 4. Ask them to:

- **Observe plants and animals found in three places: in the water, at the edge of the water, and on dry land (above high water).**

- **Make a record of what you see. Draw, write, take photographs, or videotapes. Use field guides to help you identify what you see.**

Notes:
The biggest obstacle to this sort of field survey is identifying what is found. You might prefer to organize three separate trips instead: one to examine aquatic life, a second to look at life at the edges, and a third to look at dry land critters. This will avoid the rush to find things and enable students to make more careful notes.

Students should be encouraged to make good notes, measurements, and sketches so they can then make good use of reference books back in the classroom.

Make checklists ahead of time to help students look for particular plants or animals at the field site. Use an illustrated field guide to help you make up a list.

Don't worry about the names of everything. Encourage students to make up their own names if they can't find the correct one—the important thing is to observe, record, and think.

Assessment Ideas:

- Compare what you found, in each of the three places, by making a graph, chart or large mural.

- Show the differences in the type of life forms found in the three habitats. Possibilities include: making an illustration, chart, tape recording, or even a play with students dressed up as the major life forms from each habitat.

- Write a paragraph describing what happens to plant and animal life when a pond dries up over a period of time.

- Become an expert on one or two species of life forms found during the study. Give a report.

- Take part in a school fair. Create a display to show what you know about your chosen species and the role water plays in its life.

Extensions:

- Find out more about the species you observe. Work with field guides and reference books to collect further information. It is not essential to correctly name all species—in fact this is even difficult for experts to do. You may, however, wish to introduce senior students to taxonomy.

- Decide how many different species there are in the three locations and estimate their relative abundance. Use a five point scale to record abundance: 1 = very rare (only one or two seen) up to 5 = very large numbers (so abundant they can't be counted).

Connections to Curriculum:

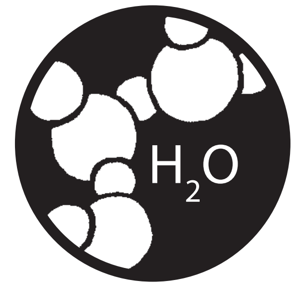
Science: observing, identifying cause and effect relationships, record keeping, making inferences, classifying, using field guides

Social Studies: understanding habitat requirements of living things, examining relationships between environmental conditions and life forms

Math: graphing, estimating, measuring

Fine Arts: drawing and sketching

Concept 3: Water is a unique material.

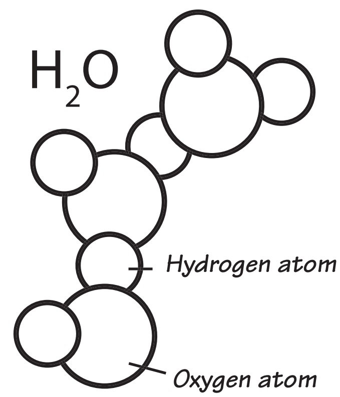


Water can exist as a solid, a liquid, or a gas. It dissolves many different types of materials. It is polar—water molecules attract each other and tend to stick together in drops.

Background Information

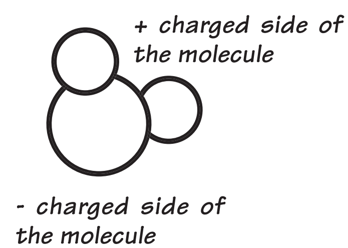
- **Pure water is a colourless, tasteless liquid. It freezes to form solid ice at 0° C and boils to form a gas, water vapour, at 100° C. (at sea level). Liquid water has a density of 1 g/cm3 (at 4°C. at sea level).**

- **The chemical formula for water is H2O. Water molecules are formed from two atoms of hydrogen (the smallest and lightest of all the known atoms) which combine with one atom of oxygen.**



- **The hydrogen atoms are on one side of the molecule, while the oxygen atom is on the other side. This shape is important for explaining the properties of water. (Imagine that the water molecule is a Mickey Mouse head, with the oxygen atom forming the head and the hydrogen atoms forming the ears.)**

- **Because the hydrogen atoms are more electrically positive than the oxygen atom, the hydrogen side of the molecule is more positive and the oxygen side tends to be more negative. This difference between one side and the other means that water molecules are polar.**



- **In nature, likes repel and unlikes attract. The North Pole of one magnet will attract the South Pole of another.**

- **When we have a container filled with water, it is really filled with water molecules. The hydrogen, or positive side of a molecule will tend to attract the negative, oxygen side of another molecule.**

- **This mass of weak attractions, when combined for millions and millions of molecules, means that water tends to stick together. Water forms beads or droplets and has a surface tension. This is why water will rise in a fine tube through capillary action.**

  It is also why Redwood and Douglas Fir trees can pull water, over 100 meters upward, from the roots to the crown of the tree far above the forest floor, through capillary action.

- **Because of the electrical charges and shape of the water molecule, it also tends to form a definite structure when it freezes.**

■ Solid water, or ice, floats on top of liquid water. People might think that solid ice would sink in liquid water, but ice is actually less dense—there is less actual matter in a litre of ice, than in a litre of water. You can see this when you freeze water in a container and observe that the ice expands, perhaps causing the lid to pop off, or the container to crack.

■ The electrical charges of water also explain why we need to use soap for washing. The soap molecules get between the water molecules and break up the clumps of water, making water wetter!

If you've tried to wash without soap, you may have noticed that the water tends to form beads or blobs on your skin, and it is difficult to get really wet and to remove the dirt. Soap acts as a wetting agent and breaks up the attraction between water molecules.

Activities: Properties of Water

Here are a set of activities designed to help students explore and understand the properties of water. Read through the activity titles and decide which ones you will work on.

Materials:

This is the complete materials list for all the activities which follow. Depending on which activities you choose, you may only need a few of these items.

freezer, ice cubes, or crushed ice
plastic ice cube trays or small plastic or paper cups
water
salt
thermometers
glass jars or plastic yogurt tubs
an electric kettle or a hot plate
sauce pan
liquid detergent
eye droppers
sewing needles
flexible plastic tubing (.5 or 1 cm in diameter, cut into short pieces each about 10 cm long)
fine diameter tubing (.2 cm or less)
plastic jugs or pouring containers

Activity: Freezing Water

Procedure:

Divide the students into teams of 3. Ask each team to:

1. Fill a plastic ice cube tray or paper cups with water.

2. Record the water temperature with a thermometer, then place the trays in the freezer.

3. Take the temperature of the water every 10 minutes until the water starts to freeze. Keep a record of the time and the temperature for each measurement.

4. Watch what happens to the water as it freezes. Some things to look for include:

• Does the water freeze suddenly or slowly?

• How long does it take for all the water to freeze?

• Does the water freeze from the top of the container down or from the bottom up?

Assessment Ideas:

 Make a graph showing how the water changed temperature until it reached the freezing point. Show when the water froze solid.

Extensions:

■ Design an experiment to find out which would freeze first—a cup of water at room temperature (20° C) or a cup of water at the boiling point (100° C). Write the steps of your experiment and list all the equipment you would need.

■ Mix salt into water (at room temperature) and stir until the salt dissolves. Place the salt water into the freezer and take measurements and observations over time. How does the behaviour of salt water compare to that of fresh water?

■ Gather up a tub of crushed ice, some salt, a thermometer, and a partner. Have one person add several tablespoons of salt to the ice and mix together. The other person will place a thermometer in the salt and ice mixture and take the temperature—without letting his or her partner see the results.

Have the first person predict the temperature of the ice-salt mix. Is it accurate? Discuss why the temperature is what it is.

Try adding more salt and making observations over longer time periods. Think about why we put salt on icy roads in the winter? Why do people put salt in crushed ice to make homemade ice cream?

■ Repeat the above using sugar instead of salt.

Activity: Observing Density of Ice

Procedure:

1. Pour some water into a paper cup.

2. Mark the level of the water with a wax crayon or felt pen on the outside of the cup.

3. Place the cup in the freezer and let the water freeze solid.

4. Take the container out of the freezer and compare the level of the ice with your original mark.

Assessment Ideas:

- Discuss any changes you observed in the water level. What happens when water turns to ice? What does this tell you about the weight or density of ice? Can you explain why solid water (ice) floats on top of liquid water? Suppose ice didn't float, but sank to the bottom when the water temperature reached 0°. Would this make any difference to life on earth?

Activity: Boiling Water

Procedure:

Divide your class into teams of 3. Ask each team to:

1. Pour water into a sauce pan or kettle.

2. Record the water temperature with a thermometer then begin to heat the water.

3. Every five minutes, carefully measure its temperature. Record the results.

4. Measure the temperature when the water begins to boil and record the results.

Be very careful around boiling water. Boiling water, or the steam above, it can burn your skin. Ask for an adult for help if you are unsure about what to do.

5. Continue boiling the water for another 5 minutes. Take the temperature.

6. Turn off the heat and take the temperature again.

Assessment Ideas:

- Describe the temperature changes you saw. Once the water began to boil, did it continue to get hotter? What do you think would happen if you continued to boil the water and didn't turn off the heat?

- Make a graph or a set of drawings to explain what you observed.

Activity: Observing Capillary Action

Procedure:

1. Take various diameter plastic tubes and dip them into a container of water. (Add a few drops of food colouring so you can see the water.) Observe the level of water outside the tubes and inside the tubes. Is there any difference?

2. Place your finger or thumb over the upper end of the tube and hold it there. Now lift the tube out of the water, keeping your finger or thumb sealed across the upper end. What happens?

3. Take your finger off the tubing. What happens now? Can you explain what is going on here? Repeat this, lifting the tubing from the water without holding your finger across the upper end. What happens?

Assessment Ideas:

- Discuss what you observed. What does this tell you about water? Why would this be important for trees?

Extension Ideas:

If you have a really small diameter piece of tubing, place one end of the tubing in an open container of water. Leave the other end open and hold the tube so that the upper, open end is straight up above the water container. Watch what happens to the level of water in the tubing.

Place a stalk of celery into coloured water and leave over night. Explain what is happening.

Activity: Observing Surface Tension

Procedure:

1. Wash and dry your hands thoroughly.

2. Pour some water into a clean shallow dish or plastic yogurt tub.

3. Try to place a sewing needle so that it floats on the surface "skin" of the water. (It may take a few tries to do this or you may want to try setting it on with tweezers.) Think about why the metal needle floats—shouldn't it sink?

4. Once the needle is floating, use an eye dropper to add one drop of dish detergent to the water. Be careful not to create a splash or to disturb the water and needle. What happens to the needle?

Assessment ideas:

- Discuss why you think the needle floats. What changed when you added the soap? Why?

- Write your ideas explaining why you think we use soap to wash things.

Extension:

- Pour a small amount of water into a shallow dish so that it covers the bottom. Add one or two drops of food colouring. Swirl the plate gently so the food colour mixes uniformly with the water. Now add one or two drops of alcohol to the water in the plate. Note what happens. Can you explain the behaviour of the coloured water?

Connections to Curriculum:

Math: measuring length, volume, and temperature, and graphing

Fine Arts: drawing and sketching

Science: observing properties and changing states of matter, predicting, hypothesis testing, record keeping, using thermometers, becoming aware of safe procedures when heating and handling equipment and materials

Language Arts: report writing, oral reporting.

Concept 4: All water is part of the hydrologic or water cycle.

Water passes through the cycle as it changes from a liquid, to a gas (water vapour), and back to a liquid again. Water may also be found as a solid (ice and snow). Water is an integral part of the weather/climate system.

Background Information

- **Water is a very unique material because it can exist in all three states of matter- solid, liquid, and gas within a 100° C temperature range. Thus, water freezes and becomes a solid at 0° C, yet boils and changes into a vapour at 100°C. (at sea level).**

- **Liquid water is always evaporating unless the air around it is already holding all the water vapour it can, at that temperature and pressure.**

- **Water will evaporate into dry air even when the temperature is very low—as people discover when drying clothes outside in the winter. Water will even boil at room temperature if the air pressure above the liquid is reduced enough.**

- **Under normal temperature and pressure ranges, the energy which drives the water cycle is solar energy. The sun's energy evaporates water.**

- **The sun's energy creates the differences in air pressure, which cause high and low pressure weather systems and which carry water vapour, containing air, up into the higher atmosphere where it condenses to form clouds, snow, ice, hail, and rain.**

- **These same differences in pressure create the winds which carry water-containing air from place to place and shift water from the oceans to the land, from wet regions to dry ones. The water cycle is a solar powered system.**

Activities: Observing Water in Different Forms

Materials:

This is the complete materials list for all the activities which follow. Depending on which activities you choose, you may only need a few of these items.

shallow bowls
kettle
small hand mirrors

one or two potted plants such as coleus, geranium, or chrysanthemum
plastic sheeting
medium sized aquarium or terrarium tank
electric fan
gauze from a first aid kit
elastic bands
three or four thermometers
rubbing alcohol
kitchen scale

Activity: Missing Water

Find out what happens when water is heated. Observe steam and discover what happens to water that continues to boil.

Procedure:

l. Place a measured amount of water in a kettle or pyrex beaker and bring it to a boil. Keep boiling for several minutes—don't let the kettle boil dry.

2. Let the kettle cool and measure the remaining water. Find out how much water is left.

3. Think about where the missing water went.

Assessment Ideas:

■ Discuss ways to recover the water which escaped from the kettle. If the water from the kettle is still in the room, where is it? How could we get it back?

Note: The key point here, is that water is matter. Matter cannot be created or destroyed under normal circumstances. Therefore, the water that was no longer in the kettle cannot have been lost. It must have changed form or state.

Activity: Observing Water in Our Breath

Procedure:

1. Blow gently on a hand mirror. What do you observe?

2. Place the mirror in a fridge for 15-20 minutes. Take it out and blow onto the chilled mirror surface. What do you observe now?

Assessment Ideas:

- Discuss the results of the experiments. What is the mist you see? Where does the mist come from?

Activity: Changing Ice into Water

1. Place several cold, dry chunks of ice into a bowl.

2. Put a thermometer in the bowl so that it is near, but not actually touching the ice.

3. Observe and record the thermometer readings as the ice melts. Take a temperature reading every 5 minutes.

4. When all the ice has completely melted, wait ten minutes and take a final temperature reading.

Assessment Ideas:

- Make a graph showing how the temperature changed during the melting process.

- Make a report describing what you thought would happen to the temperatures. Compare your initial ideas with what actually happened.

Activity: Observing Water on Your Body

Procedure:

1. Run up and down a flight of steps until you begin to sweat. Observe the sweat. Where on your body is it?

Assessment Ideas:

- Think or talk about what perspiration is made of. Where does the water come from, and what purpose does it serve?

Activity: Observing Water in Plants

Procedure:

1. Set a potted plant inside an empty aquarium tank.

2. Cover the tank with a piece of plastic sheeting held in place with tape.

3. Leave the plant for a day or so. Observe the aquarium tank and plant. What do you notice about the walls of the aquarium?

Assessment Ideas:

■ Discuss what you observed. If you noticed moisture or fogginess on the aquarium wall, where did this water come from?

■ Offer an explanation as to why a large tree in a yard can provide cooling on a hot day, not only by creating shade, but also by evaporation.

Activity: Weighing Water

Procedure:

1. Weigh a potted plant, including the plant, the pot, the soil.

2. Fit a piece of plastic sheet over the top of the plant so that it covers the soil surface, but allows the stem of the plant to pass through an opening.

3. Use tape or an elastic to seal the plastic against the rim of the pot and against the plant stem.

4. Place the pot with its covered soil on a window ledge or counter top. Weigh the plant and pot again every day.
Do not water the plant or remove the plastic seal which covers the soil.
Observe what happens to the weight of the potted plant.

Assessment Ideas:

■ Describe your results. Compare your observations with those made in the activity, Observing Water in Plants.

Activity: Watching the Weather

Procedure:

1. Keep a log of the weather. Observe changes in cloud cover, type of cloud, precipitation, wind (strength and direction), temperature, and air pressure (if you have a barometer).

2. Make careful observations and notes for several weeks. Things to observe include:
• Which sorts of conditions seem to precede rain or snow?
• Which sorts of winds bring bad weather?
• What is the average daytime temperature?
• What is the range of air pressure change over the time period?
• Does low or high pressure indicate improved weather?

3. During the same time period, try to post the daily weather map from the local newspaper on the class bulletin board. Make comparisons for the following:
• Do your observations agree with the weather predictions?
• Does the wind in your area blow toward or away from high pressure systems as indicated on the local weather map?

Note: Check to see if your school has a connection to an on-line computer service, such as the Community Learning Network (CLN) in B.C., or to other Internet services. If so, you may be able to download daily weather satellite maps and other weather information to your school computer.

You will need a computer with a telephone modem, a phone line connection, and an account for an on-line service. You will also need the appropriate software for making the connection and searching for the weather information. In some school districts, local computer co-ordinators can provide assistance, while in other districts, school librarians can help you make the connections.

Assessment Ideas:

- **Write or give a report explaining what you observed and learned about weather conditions and predicting weather.**

Activity: Reading Weather Maps

Procedure:

1. Obtain a map from the weather office showing average annual rainfall patterns in your area.

2. Locate the following:
• Where are the wettest places?
• Where are the driest or sunniest ones?
• How do these places of greatest wetness or dryness correspond to the local terrain? Are the dry places near the mountains, in valleys, on open plains, or up-wind from the prevailing wind direction?

3. Act as class meteorologist for a day. Use the map to make a prediction about the weather for the next day. Compare your results with those of the official forecasters.

Note: Maps showing the different bio-geoclimatic zones or biotic regions of B.C. can also be compared with the weather and climate zone maps to explore the connections between climate and life forms in an area.

Assessment Ideas:

- Use a newspaper weather map, without the written forecast, to predict the weather conditions in the area of the map and for the period covered by the map.

- Describe why it rains more on the windward sides of hills and mountains, than on the leeward or protected sides?

Activity: Measuring Relative Humidity

Meteorologists use wet and dry bulb thermometers to determine the relative humidity of the air. The relative humidity is a measurement of how much water vapour is present in the air at a given temperature.

Procedure 1:

1. Use a thermometer to measure the temperature of rubbing alcohol. Record it.

2. Tie a piece of gauze bandage around the bulb of a thermometer with a piece of string or an elastic.

3. Dip the bulb and gauze into the rubbing alcohol and record the temperature while the bulb is immersed.

4. Remove the bulb from the alcohol and record the temperature over the next several minutes. Observe what happens.

Procedure 2:

1. Wrap a thermometer bulb with a piece of wet gauze. Leave another thermometer unwrapped.

2. Place the two thermometers close together in the classroom. Record the temperature of the wet bulb thermometer while a partner records the temperature of the one with the dry bulb.

3. Record the temperatures at the same time intervals over a period of several hours. Observe what happens.

Procedure 3:

1. Place a thermometer with a dry bulb near a small electric fan, or use a hand fan to create a draft near the thermometer. Record the temperature while the fan is being used.

2. Repeat the above process using a thermometer with a wet bulb.

3. Record the temperature of the wet bulb thermometer without using a fan. Then begin to fan the bulb. What happens to the temperature reading?

Assessment Ideas:

- Keep a careful record of your observations. Explain the results of your experiments and what you think these results mean.

- Explain which would give scientists a better indication of the amount of water vapour in the air—a wet bulb thermometer reading or a dry bulb thermometer reading. Why?

Extensions:

It has been said that every bit of water that there ever was is still in circulation today. We might be drinking water that was once part of the body of a dinosaur!

Organize a class debate on the theme: No new water, so we'd better look after what we've got. Set up two teams—one for water conservation, the other against it. Have remaining students act as a jury. Have the jury decide which side wins the debate and submit a written report giving reasons for their decision.

Curriculum Connections:

Science: observing weather, cloud formations, wind, air pressure, changing states of matter, conservation of matter, conservation of energy, experimenting, making inferences, measuring, predicting, developing an understanding of human physiology and plants

Social Studies: identifying weather patterns and landforms, map reading

Language Arts: oral reporting, log and record keeping

Mathematics: measuring temperature, mass, and pressure

Fine Arts: role playing

Concept 6: Watersheds are dynamic.

Watersheds change and evolve over time as a result of geological processes, biological processes, and human activities.

Background Information:

- **The action of wind, rain, flowing water, glaciers, snow, ice, earthquakes, and volcanoes is continually changing the surface of the planet. This change may be an almost imperceptible process of weathering, or a very obvious event such as a landslide, earthquake, or volcanic eruption.**

  One needs only to observe the gravy-like consistency of many streams during the spring run off, to understand how much silt is moving from the upper watershed to the lower watershed each year.

- **Biological processes are at work in the watershed too. The natural succession of plant communities changes our watersheds as young forests mature, and lakes gradually become bogs or marshes.**

- **Perhaps the most dramatic impact on watersheds, comes from human activity. Logging, mining, agriculture, hydro-electric projects, and ever-expanding population growth are all having an impact.**

  Even global climate changes (resulting from human activities), can have significant impacts on watersheds, particularly when patterns and amounts of rain and snowfall change.

- **Geological processes, biological processes, and human activities do not work in isolation—they are interrelated. Human activities such as agriculture, logging, and strip mining may alter the processes of succession and erosion.**

Activity: Exploring How a Watershed Changes

Use a Stream Table to explore how watersheds change and what causes these changes. *See the instructions for making a Stream Table in the previous set of activities.* Or make one of the following models:

Build a Stream Table Outside

This stream table can be built on the school grounds. The directions are as follows:

1. Build a frame with 2 x 4 or 4 x 4's on a part of the school grounds where there is a natural slope.

2. Place a plastic drop sheet inside the frame.

3. Build a model watershed using sand, gravel, clay, and other materials.

Design an Outdoor Watershed Model

1. Find a spot where there is open, sloping ground, uncovered by grass or other vegetation. A loose sand and gravel bank is ideal.

2. Use a garden hose or buckets of water to simulate running water and a spade to create a landscape, letting water flow downstream across the bank. Be careful to keep the water flow quite low and gentle—you are modelling a river on a small scale.

Exploring the Changes

Use your model to find out how glaciers change a watershed.

Procedure:

1. Make model glaciers. Stir sand, gravel, and water together to make a fairly thick, but still fluid paste. Freeze the mix inside milk cartons.

2. When the mixture is solidly frozen, peel the milk cartons away from the ice and place the glaciers at various spots on your model.

3. Predict what will happen when the ice melts in the mountains. What landforms will be created or destroyed? What changes will occur? Record your predictions.

4. Observe what happens. Do you need to change your predictions?

Extensions:

Here are some other activities for developing the concept that watersheds are dynamic:

- Change some of the variables in the stream table by: changing the slope of the box, flow rate or volume of water, adding vegetation, or altering the landscape.

- Relate what students observe to real life situations in the area—point out evidence of stream erosion, delta formations, and glacial erosion.

- Interview pioneers and First Nations elders about their memories of the watershed from when they were youngsters. Ask them about what changes they've seen and what caused the changes.

■ Use museum and newspaper archives to find photographs and references to historic waterways. Find out about the changes that occurred in the watershed over time.

■ Investigate city maps to discover culverted creeks.

■ Make an illustrated glossary of the geological terms for various land forms and geological structures. Create a classroom display of these terms, using examples.

■ Visit a local watershed where logging is underway (the trip will need to be arranged with the local Forest Service or logging company). Invite representatives of the company to describe the operation and to explain what steps are being taken to avoid damage to streams through logging and road building.

Assessment Ideas:

■ Draw or write your ideas about how the watershed was, ten thousand, one thousand, one hundred, or twenty-five years ago.
✤escribe what the watershed is like today, and how it will be in the future if current trends continue.

■ Use the previous idea and create a timeline mural to display in the classroom or school. Work alone or with a partner.

■ Create an illustrated glossary of watershed terms and publish them on a computer.

■ Interpret unfamiliar maps of watersheds. Use the maps to create a three dimensional sketch or model. Or write a report describing what the map tells you about the watershed.

■ Using air photos or satellite based maps of watersheds, try to interpret the photos and answer the following questions:
• How are current human activities changing the watershed?
• How have geological or biological processes shaped the watershed that we see today?

Note: This is a good time to use air photos or satellite photos of areas near your school. Call Maps B.C. (387 -1441).

Air photos are especially interesting to students. If you can borrow a set of stereoscopic pair air photos and a viewer, the students can use these to get a 3D view of the landscape. The local Forest Service office is often a good source of these materials.

The regional district offices or planning departments of the city are also good sources of large scale, detailed maps of the area.

Connections to Curriculum:

Science: observing, measuring, exploring cause and effect relationships, record keeping, predicting, and hypotheses testing

Social Studies: doing historical research, interviewing pioneers, using archival sources, interpreting modern landforms

Mathematics: measuring and calculating, exploring scale and proportion

Practical Arts: constructing, designing, using tools, making prototypes, selecting and using materials, model making

Fine Arts: sketching, map making, model building

Language Arts: report writing, oral reporting, designing an interview, interviewing and listening skills

Concept 7: Humans are major users of water.

As animals we need water for our lives, but we also use water in our technological processes to make things, generate electricity, grow and process food. We often compete with other life forms for water.

Background Information:

- **Urban Canada uses large amounts of water. Canadians have the second highest per capita water consumption in the world, second only to the United States.**

- **Water is used to fulfill a wide array of needs, from food production and processing to generating hydro-electric power. Human activities often leave contaminants in the water cycle in the form of acid rain, agricultural run-off, and municipal effluents.**

- **The ability to turn on a tap and receive clean, running water is taken for granted by many children. Children don't always know where their water comes from and where it goes after it runs down the drain.**

- **With rapid population growth in many parts of Canada, an increasing demand is being placed upon supplies for domestic and industrial water. An understanding of the issues surrounding sources of drinking water and the disposal of waste water, are essential for the development of informed, rational decision-making about water-related issues.**

Activity: Mapping Your Water Supply

This activity is designed to help you find out what students know about the sources, uses, and disposal of water in their homes. It can be repeated at the end of your water study as an evaluation tool.

Materials:

notebook
pencil

Procedure:

1. Draw a map or diagram to show the following:
- where water in your taps comes from
- how water is used in your home
- where water goes after leaving your home
- what goes with the water that leaves your home

2. Label your map so that other people can understand it. Don't put your name on it.

3. Join a group with three other people.

4. In your group, look at another group's maps. Look over the maps and compare the similarities and differences.

5. With your group, make up a new, common water system diagram that everyone agrees on.

Afterwards, compare your map with an actual diagram or flow chart of the town's water supply and liquid waste disposal systems. How is your map different? Is anything missing?

Find out how many students have visited the town's water intake or reservoir, or the town's sewage treatment plant. Ask them about what they saw.

Extensions:

■ Go on a field trip which begins at the source of the community's drinking water. Visit any other components of the community's water and waste water system, such as sewage treatment plants.

■ Have the students keep track of water consumption in their homes for an average week. Graph the results, comparing them to consumption in other countries.

■ Compare the water system of an urban community with that used in a rural setting. Have groups research some of the following topics:
- septic fields and tanks
- fluoridation
- chlorination
- primary vs secondary sewage treatments
- coliform tests
- aquifers and wells

■ Use books on ancient Rome to find out how the Romans built elaborate water supply systems—aqueducts, fountains, drains, in order to supply their cities with water. Other ancient civilizations also built waterworks: canals, dams, pumps, dikes, irrigation systems. Students can report on a number of these.

Note: *City: A Story of Roman Planning and Construction*, by David A. Macaulay, is an excellent reference. *Underground*, also by Macaulay, describes the structures below ground needed to support life in a modern large city.

Assessment Ideas:

- Design a new water system map or diagram. Compare it to the map designed before your study of water. Observe any changes. Has the diagram become more accurate or more detailed? Does it show cause and effect relationships which weren't present in the first map?

Connections to Curriculum:

Social Studies: map drawing, diagram drawing, investigating civic government services, exploring health and environmental regulations, studying regional water features and watersheds, developing an awareness of historical practices and life in ancient times

Math: graphing, estimating, measuring

Science: investigating water treatment methods, public health, and water supply

Practical Arts: exploring civil engineering (water systems and treatment plants)

Language Arts: developing library skills, making book reports, and oral presentations

Fine Arts: drawing, drafting

Concept 8: Water is finite.

There is only so much water available on earth at any given time. The amount of potable water, suitable for use by humans without advanced treatment is very limited.

Background Information

- **Water is finite. The earth is essentially a closed system in which the water cycle operates with no deletions or additions. With our abundance of freshwater rivers, streams, and lakes, one may easily forget the very small proportion of this limited resource which is actually accessible and usable to us. By examining the statistics on location and the state of water resources on earth, students may see how small and limited our usable water resources actually are.**

- **Students can also examine the potential effects of climate change on the state of the planet's water. If global temperatures rise even a few degrees through the greenhouse effect, the impact on the polar ice caps will be tremendous. Large areas of heavily populated coastline could be flooded and significant areas of agricultural land could be lost.**

Activity: Analyzing the World's Water Supply

Students can analyze water statistics to find out about the availability and condition of the world's water supplies.

Materials:

statistics on the earth's water supply
(See Appendix A- A Compendium of Water Facts and Figures)
chart paper
graph paper

Procedure:

1. Read the following information:
- 95% of the world's water is ocean water
- 3.4 % is ground water
- 1.6 % is frozen
- .005 % is surface water
(Source: The State of the Environment Report For British Columbia, 1993, p. 18.) Note: These figures are estimates and vary slightly with different sources.

2. Construct a graph to show the relationship between ocean water, fresh water, and accessible fresh water.

Note: An example of such a graph is shown in A Compendium of Water Facts and Figures, Appendix A. This is only one way to graph this information however, and students should be encouraged to try other approaches. See the extension ideas that follow.

Extensions:

■ Cut an apple to demonstrate the amount of fresh drinkable water on earth. Leave the peel on, so that each piece of apple you cut is still covered by some peel.

Take an apple and cut it into four equal pieces. Take one piece and cut it into five equal parts. Take one of the 5 small sections—this represents the amount of fresh water on earth, in all forms. The rest of the apple pieces combined represents the amount of salt water on earth.

Take the small piece (which represents the world's fresh water) and cut it into three equal sections. One section represents the total amount of fresh water which is frozen. The two remaining sections represent all of the world's underground water.

Finally, take one of the three tiny sections and carefully peel it. Cut the peel into three pieces. One of these pieces of peel represents all the surface, non-frozen, available fresh water on earth!

■ Another way to dramatically demonstrate the amount of surface water available on earth is to:

- start with 1000 ml. of water in a beaker
- pour out 28 ml. to represent the fresh water on earth
- from the 28 ml. pour out 23 ml. to represent the frozen water tied up in glaciers and icecaps
- that leaves 5 ml.
- from the 5 ml. pour out 4 ml. to represent the ground water in aquafers and underground streams
- from the 1 ml. remaining, pour out .8 ml. to represent water in the air and in the soil
- you will have approximately two drops left which represents all the surface water in lakes, rivers, streams, marshes and wetlands.

■ Hold a classroom debate. One group can represent a city or regional government who wants to install water meters to measure how much water is used in each home. They also want to charge a fee based on how many litres of water each home uses in a month (just like the bills we get for electrical power, gas, and telephone).

The other group can represent homeowners who would argue that there should either be no fee for water use at all, or that there should be a very low charge for water use as part of the overall city or regional taxes. This fee would be the same for every home, no matter how much water was used. (This is currently the situation in many B.C. cities and towns).

Using their knowledge of water resources, students representing the government side can prepare arguments to support their opinions.

■ Stage a debate about using technology to distil salt water in order to produce drinking water for humans. Students can be divided into three groups: one group who is for the idea, one group who is against it, with the remaining group acting as a jury to decide which of the sides in the debate wins.

■ Keep a personal log of how much water is used in your homes over a period of one week. The data might be organized as:

Use	**Amount of water**
cooking food	__ litres
flushing toilets	__ litres
washing clothes	__ litres
____________	__ litres
____________	__ litres
____________	__ litres

Write a report or make a graph to show what you find out. Make a personal plan for conserving water in your home.

Assessment Ideas:

■ Make a poster or draw a picture to show what you discovered about the world's drinkable water supply.

■ Write a report or letter to the local city or regional government. The report should explain why all new homes should be required to install low volume flush toilets and shower flow- restrictors. The report should also state why all existing homes should have to install them by the Year 2000.

Use actual data to support your point of view. Describe the amount of domestic water use in your region, and the potential water savings attained by using these two conservation approaches.

■ Make a sketch chart outlining your city's water supply system. Where does the water come from and what is done to it before it gets to your home? How much water is used every day, week, month, year in your city?

■ Develop a written argument for or against the use of meters on private wells.

In some regions, people who have wells on their own property must install water meters on the wells. These meters measure how much water is drawn from the well and the owner of the well is charged a tax or fee by the regional government for the use of the water.

■ Write a report or prepare an oral presentation outlining your ideas for ways to conserve the world's fresh-water supply.

Connections to Curriculum:

Math: analyzing data, graphing, calculating per cent, scale and proportions

Social Studies: investigating government roles in resource conservation, exploring taxes and government services

Language Arts: oral speaking, debating, creative writing

Fine Arts: designing graphs, using page layout, line and colour

Concept 9: Aquatic habitats are essential elements of the biosphere.

Aquatic habitats are home to a wide variety of plant and animal species and are necessary to maintain biodiversity. Many life forms exist for all or part of their life cycles in aquatic habitats. When water is used or contaminated with toxins, the habitat can be destroyed and species may be lost, resulting in a loss of overall biological diversity.

Background Information:

■ **Water is habitat for many forms of life.**

■ **Biological diversity refers to the variety of living organisms within an ecosystem. Organisms within an ecosystem not only include the obvious variety of wild animals, birds, and fish, but also include other important organisms such as bacteria, fungi, and algae.**

■ **All of these organisms play a vital role in the functioning of a healthy ecosystem. Biological diversity reflects the health of an ecosystem. Biological diversity influences the stability of an ecosystem, while lack of diversity often results in a less stable ecosystem.**

One way to illustrate this concept is to reflect on the typical urban lawn. The lawn is an artificial ecosystem in which the homeowner has replaced the native flora and fauna with one species of plant—the lawn grass. The system will be stable as long as the homeowner maintains it. To do this he or she will be required to spend considerable time and money weeding, spraying, and irrigating.

If the homeowner neglects the lawn, it will quickly be invaded by other plants and animals and begin to become less homogeneous. When the homeowner planted the lawn, a monoculture was created— an ecosystem with only one major species.

This makes the lawn system unstable—it can only be maintained by spending energy and doing work. Native ecosystems, on the other hand, will only change slowly and will tend to be stable unless there are outside interventions, or climate and soil conditions change.

■• **In aquatic communities, the diversity of organisms found, directly reflects the quality of the water. Within uncontaminated water, a wider variety of organisms is often found than in polluted waters.**

■ **In polluted water, the variety of organisms is reduced, leaving fewer pollution-tolerant organisms which will thrive in larger numbers. Thus, polluted waters often have large numbers of very few species, while water in its native state supports a wider array of species in more balanced numbers.**

Activity: *Going on a Pond or Stream Study*

This lesson is a field study of life in water habitats. Use the term field study rather than field trip. Using this terminology helps students and parents realize that field experiences are an important part of learning and not frills or a day off. Students will visit a stream or pond, and collect and observe the organisms who live there. This lesson is designed to help students see the relationship between biodiversity and water quality. It will also help students move toward an examination of biodiversity and environmental conditions on a larger global scale.

This activity has three parts: collecting of a sample of invertebrates from a small stream or pond, determining types and numbers of species found, and creating an index to calculate the biological diversity of the stream.

The method used in the activity is borrowed from *Field Manual for Water Quality Monitoring* by Mark K. Mitchell and William B. Stapp, 1991.

Materials:

dip nets
kick screens (preferred for stream work)
ice cream buckets
hand lenses
aluminum baking pan or pie plates
wide mouth jars and bottles
tweezers
turkey basters
sugar
styrofoam egg cartons or ice cube trays
microscope slides

Wear rubber boots or old running shoes, shorts or old jeans, and bring a change of clothing and footwear.

Procedure:

Before the Field Study teachers should:

1. Discuss how water quality affects the numbers and variety of organisms that live in the water.

2. Make and show overhead transparencies of the more common fresh water bottom-dwelling invertebrates, so that the students know what to look for on

the field trip. (Use a simple field guide to find common species of fresh water life.)

3. Clearly explain the purpose of the field trip—to take a survey of the types of organisms found living in the stream or pond you are visiting. Pay particular attention to the organisms who live in the bottom materials of the stream or creek.

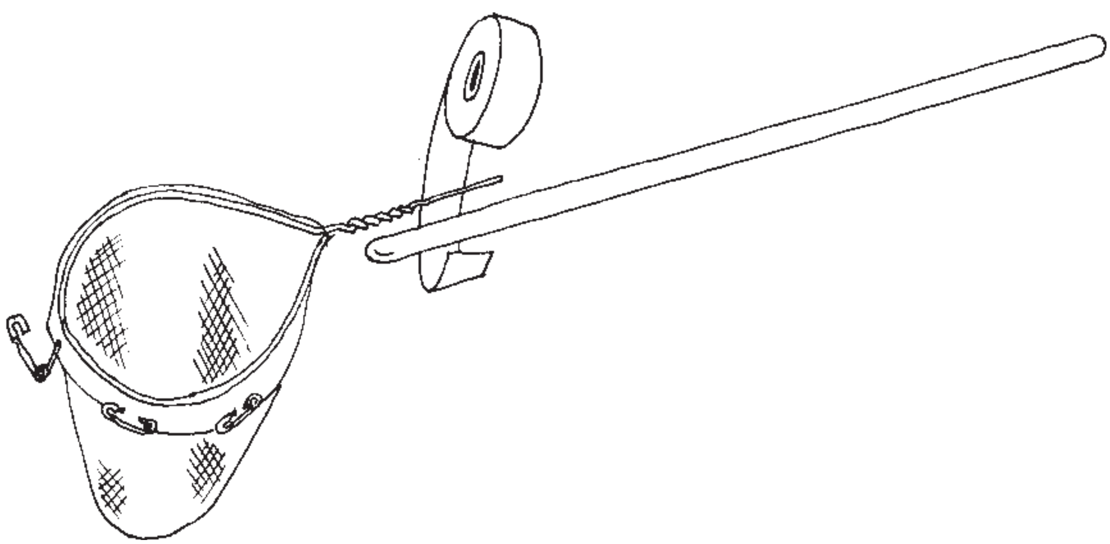
4. If you are going to a stream, check with The Ministry of Environment, Lands, and Parks Fisheries Personnel to determine the timing of your trip so you won't disturb spawning fish.

How to make dip nets

The easiest type of net to make is called a D-Frame Net. Gather up an old pole, broom handle, or stick, a coat hanger, and some netting (an old nylon stocking leg with attached foot is ideal).

Bend the coat hanger so that it forms an oval or circular frame. Attach the handle to the coat hanger at the hook of the coat hanger with duct tape or string.

Stretch the stocking opening across the coat hanger frame and fold the nylon over the wire rim. Use small safety pins to hold the nylon to the wire frame.



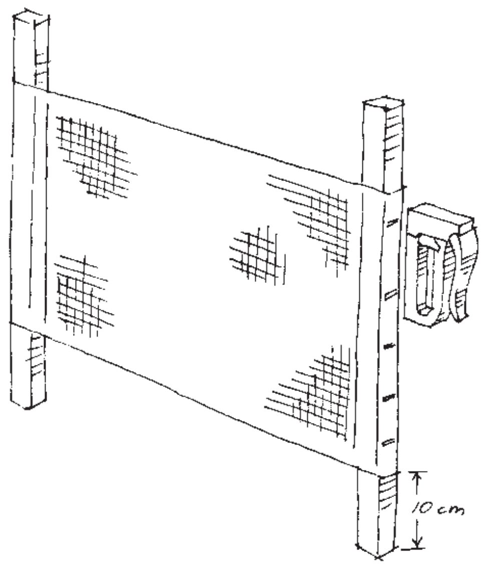
How to make kick screens

purchase fine-mesh screen door screening (1.1 meter per kick screen)

find 2 hockey sticks or broom handles

wrap the screening around the stick 10 cm. from the bottom leaving 10 cm. of stick protruding to bury in the stream bottom

staple the screening to the stick.



During the Field Study

Note: Before any sampling begins, the class should be reminded about their impact on the area. Students must return all specimens to the pond or stream at the end of the study, restore rocks to their normal positions, and avoid doing damage to the organisms or the area.

1. Look for the common invertebrate life forms (insects, worms, crustaceans) found in water. You don't need to identify the organisms you find—only decide whether one organism is different from another in some obvious way.

2. Use the dip nets or kick screens to collect your samples. Try to:
- **work in groups of two or three**
- **choose a sampling area in the stream or pond bottom, about 1 m in length**
- **have one person hold the net on the downstream side of the area you are sampling**
- **have another person go upstream and lift up any rocks 5 cm or more in diameter. Rub the rocks in the water to free them of organisms clinging to the surface. Do this above the net.**
- **when all of the larger rocks have been moved, have one person gently**

shuffle his or her feet on the stream bed (above the net) for two or three minutes. This will stir up any organisms which are living in the bottom mud and debris.
- return rocks to their normal positions

3. Pull the net upstream and remove it from the water. Empty the contents of the net into an ice cream bucket or large jar. Come away from the water.

4. Pour the contents of your bucket or jar into a shallow aluminum tray. Look at the organisms you have collected. Use the tweezers and/or the turkey baster to separate organisms from any grit or mud.

5. Make sketches of what you find. Use your field books and hand lenses or magnifiers.

6. Calculate the diversity of the organisms you've found. (See the instructions which follow this section.)

7. Carefully return the organisms to the place where you found them.

8. Select two other parts of the stream or pond to sample. Choose different habitats—perhaps an area where the current is slower or faster, where there is overhanging brush, or where the stream undercuts a bank. Make notes, sketches, and calculations at each part of the stream you sample.

How to calculate the diversity of bottom-dwelling organisms

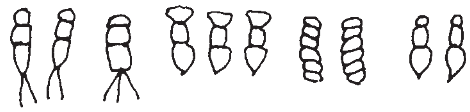
1. Choose one organism in the tray. Look at it carefully and note its major features: shape, number and types of legs or other appendages, colour, how it moves and so on. Place this organism in a small amount of water on the surface of a glass slide,egg carton or ice cube tray. This is your counting tray.

2. Choose another organism from the tray and place it beside the first organism, making sure both are covered with a small amount of water.

3. Repeat this process of selecting and moving the organisms to the counting tray until you have a row of 10-20 organisms there.

4. Group the organisms according to type. (Similar ones are placed beside each other.) Each type can be called a "run". How many runs (different types) do you have?

See the following example of how to group your organisms.



If a letter is given for each different organism in this group of 10, the letters could be: A, A, B, C, C, C, D, D, E, E.

5. Calculate a Diversity Index (DI), using this formula:

$$DI = \frac{\text{number of runs}}{\text{number of organisms}}$$

In the illustration, the Diversity Index would be:

$$DI = \frac{\text{5 runs}}{\text{10 organisms}} \quad DI = .5.$$

If every organism had been different, the DI would have been:

$$DI = \frac{10}{10} \qquad DI = 1$$

If all the organisms had been the same, the DI would have been:

$$DI = \frac{1}{10} \qquad DI = .1$$

After the Field Study

1. Use your Diversity Index calculation to make conclusions about the water quality in the stream or pond you sampled. A higher Diversity Index represents more biological diversity. More diversity means a better quality of water. A notable exception to this might be in high elevation rivers draining glaciers. They often have low biodiversity but are not polluted.

2. Examine the relationship between the location of each stream sample and any factors which may be having an impact on the water quality.

3. Make note of any major differences in the Biodiversity Indexes from site to site.

Extensions:

■ Select a stream which has significant locations which may show drastic changes in water quality. For example, look for locations before and after sewage treatment plants, industrial areas, or agricultural areas. Draw a map which shows the locations of the test sites and the results. Monitor the water quality over time.

■ Do some further testing of the sites for such factors as dissolved oxygen, pH, temperature, nitrates, or conductivity. Attempt to make connections between the chemical test results and the Diversity Indexes of invertebrates at the different sites.

■ Use common field guides to determine the identity of the different species of invertebrates collected. Find out as much as you can about their habitat requirements. Try to connect this information with the relative abundance or scarcity of the different organisms.

■ Create a large wall map of the section of creek sampled. Attach drawings of the various organisms found and Biodiversity Indexes from the different sampling sites.

■ Discuss the accuracy and validity of the Biodiversity Index method as a means of estimating water quality. Are there any possible false assumptions? Might the sampling approach have missed any species which might nevertheless be important in the stream ecology? Might the method have favoured the collection of some organisms over others, making some organisms appear more abundant or common than they actually are?

■ Explore the problems of sampling by using a "How many jelly beans are in the jar?" puzzle as a class challenge. Get a large glass jar and fill it with coloured objects in different proportions—jelly beans, perhaps. Mix the objects well.

Have students come up with different ways to figure out how many jelly beans are in the jar, without counting them one by one.

Invite students to try out their sampling designs and estimate the number of beans in the jar. You might want to stage a contest with a prize for the closest estimate.

Assessment Ideas:

1. Give students a set of data which shows the Diversity Indexes of invertebrate populations from a number of test sites on an imaginary stream. Have them use the data, interpret the results, and draw some conclusions regarding the health of the stream.

2. Take the students on one more field study, to a different stream or locale. Have students work in teams to: design their study of stream life, select and use equipment, gather data, calculate the DI's for the stream, and present a final report on the health of the stream using all the information gathered from the field study.

This is an ideal summing up activity. Since the students will work in groups, the students should be asked to review how well their group members worked together, and to self-assess their team work.

Connections to Curriculum:

Science: studying biology, observing, comparing, classifying, examining cause-effect relationships, making inferences

Fine Arts: drawing, sketching, map-making

Mathematics: calculating percentages, using scale and proportion

Language Arts: recording field data, keeping field records

Concept 10: Contaminants and toxins can move within water.

Toxins can have harmful effects on other life forms, including humans, which are far removed in time and place from the sources of the toxins.

Background Information

- **In moving through the hydrologic cycle, water carries nutrients which are essential to the environment. However, water may also carry contaminants which are harmful.**

- **Because the hydrologic cycle works on a global scale, vast regions of the planet are linked by this process. For example, the flow of rivers and precipitation moves contaminants from southern regions in Canada, the United States, Europe, Russia, and Asia into the Arctic where mammals and fish are contaminated by southern pollution.**

- **An understanding of the water or hydrologic cycle is essential for understanding global ecology and the worldwide implications of environmental contamination.**

Activity: Reducing Toxic Dumping

Although most people have seen storm drains, many do not have a clear idea about where the drains (and their contents) actually go.

In this activity, students can study the path that water-borne toxins take from a storm drain near their school. Based on their findings, they will develop an action plan to help reduce toxic dumping.

Materials:

map of the local community

Procedure:

1. Draw a map of where you think water goes when it is passed down a storm drain.

2. Compare your map with a community map which shows where the storm drains actually run.

3. Find out if the run-off, collected by storm drains, is treated in any way before being discharged. Where does the run-off go? Are sanitary sewers joined to the storm sewers in case of overload in the sanitary sewers?

4. Review the hydrologic (water) cycle. Discuss the following questions: What would happen to toxins poured down a storm drain in your area? How might toxins be transported by surface waters or by ground waters? Could a toxic material which went down a storm drain in one place end up in well water in another?

5. Brainstorm with others and think of ways to inform the public not to pour toxins down storm drains (or household drains, either).

6. In a group, choose one or two practical solutions and develop an action plan to help reduce toxins moving through storm drains.

Criteria for choosing a solution could include:
- cost
- time involved to implement it
- number of people required to make it work
- special training
- special equipment

7. Present your plan.

Extensions:

■ Implement other suggestions from the brainstorming session.

Note: In many communities Storm Drain Marking is an activity which students have undertaken. Pictures of a fish are stenciled onto the curb beside the storm drain to remind people that storm drains are connected directly to streams. Pamphlets explaining about storm drains and how to dispose of toxins properly are delivered to residences. This activity is usually sponsored by the Department of Fisheries and Oceans and is written up in the Stream Keepers Guide. Contact the Department of Fisheries and Oceans Community Advisor in your area for more information

■ Write a newspaper article informing the public of the problems which result from dumping toxins down storm sewers. A map and diagram of the water system could accompany the article. A team of students might approach the editor of a local newspaper for help in developing and publishing the article.

■ Design a brochure. One of the reasons there is a problem with the disposal of household toxic chemicals is that many homes have cupboards and shelves with a number of potentially harmful substances. Often these chemicals are old, out of date, and may even be decomposing their containers.

The class might develop a design for a brochure to be distributed to all parents in the school concerning the hazards of such materials, examples of them, and recommendations for safe disposal. The class could desktop publish the brochure and a group of students might seek support from local printers to produce it.

Note: In a number of communities, the local fire departments sponsor special days on which people can bring any sort of unused or old chemicals to the fire halls for disposal. A number of oil companies now have special programs to recover waste oil.

■ On a rainy day students might collect run-off water from the school parking lot, a local mall or other large paved area. Use the water to irrigate growing bean seedlings and observe any effects.

■ Investigate the toxicity of run-off water using the following method:

■. Make a series of dilutions of the run-off water by adding one drop of the run-off to 500 ml of distilled water. Add one drop of the first dilution to a second lot of 500 ml of distilled water.

■. Use the original run-off, the first dilution, and the second dilution, and add 2-3 ml of each to a culture jar containing live yeast cells in a sugar solution. (Add about 1/2 tsp. of dry yeast to a solution of 10-15% sugar.)

■. Cover each yeast culture with a rubber glove stretched over the mouth of the jar. Observe the results over 1-2 days, keeping the yeast culture jars in a warm place. If there are toxins in the run-off water, they may kill the yeast cells or depress their growth. See if the diluted run-off water still has any effect.

Note: This method is known as a Bioassay, in which the growth of one organism is used to measure the effects of toxins, or other materials which might be present in very small quantities. Cultures of other organisms such as bacteria, or even small aquatic animals such as brine shrimp could be used, but yeast cultures are easy to establish and killing a few yeast cells seems to have less serious ethical dimensions than does the destruction of a happy group of brine shrimp, even though these organisms are grown in aquarium shops as food for fish and amphibians.

■ Use the above method to investigate the potential toxicity of many household chemicals, even in low concentrations. We daily pour large amounts of soap, cleansing fluids, tea, coffee, cooking oils, cosmetics, and other items down the drain. We also often discard unused or out of date drugs, such as aspirin and other common medicines, down the toilet or in the garbage, where they can enter the groundwater unless the solid waste disposal area is very well maintained.

Assessment Ideas:

■ Provide the students with the following scenario:

You are the county medical health officer. A family using well water complains of having headaches, rashes, and itching, and sometimes dizzy spells. They think the problem might be coming from their well, but they live away from industry and in a rural area. The farm is on the shore of a large lake.

About 15 km upstream on the lake is a city of about 20,000 people. Your analysis of the well water from the farm shows trace amounts of a common additive used in car gasoline. The family claims that their car, farm machinery, and trucks are not operated near the wellhead and they never discard oil or gas on the farm lands. Where will you look next for possible sources of the contamination in this water? Develop a story to continue the scenario and write it up as if it was a report from you, the Medical Health Officer, to the regional water board.

■ Ask students to write a report on the chemical toxin potential of his or her home. Begin by having students conduct an inventory of the chemicals found in their homes. Chemicals include medicines, soaps and cleaning products (for people and the home), pesticides, solvents, used oil and gas.

For each chemical the students should decide:

- what would happen if the chemical was dumped down the storm drain
- how the chemical should be disposed of in a safe manner

■ Students might examine reports of famous chemical toxin spills or problems. For example: Minimata, Japan; Love Canal, USA; Prince William Sound (The *Exxon Valdes*); Union Carbide, India.

Students can select one famous spill and write a report or give an oral presentation to the class outlining:

- what happened
- why it happened
- what was required to clean up the spill
- who paid for the clean up
- who suffered as a result of the spill
- what was learned as a result of the accident
- what changes were made to laws or procedures

Connections to Curriculum:

Social Studies: mapping, studying rainfall, water movement on the land, lake and river system geography.

Science: developing a definition of toxic chemicals, examining how toxins work in the environment through bioconcentration, developing household chemical safety, examining cause and effect relationships, making inferences, replicating experiments

Language Arts: persuasive writing, desktop publishing

Graphic Arts: desktop publishing and design, map making

Concept 11: There are a number of careers working with water, aquatic habitats, and their management.

There are jobs with private sector and government agencies as well as a variety of careers within forestry related fields.

Background Information

- **A great number of people in many jurisdictions are employed to look after water resources. These jurisdictions overlap somewhat and the structures of their organizations change periodically, so we can only provide a general description of their areas of responsibility.**

- **There are jobs with the Federal Government, which oversees the waters of anadromous fish—fish that use both the ocean and inland waters during their life cycle. The federal Department of Fisheries and Oceans (DFO) is concerned with enforcement, enhancement, public involvement, habitat, inspection, and fish culture (hatcheries). The activities of DFO are supported by the Fisheries Act, a federal law.**

- **There are also careers with the Provincial Government, which has interest and jurisdiction on all waters (surface and ground) in British Columbia. The Ministry of Environment, Lands, and Parks (MOELP) is concerned with enforcement, water management, water rights, water quality, habitat, fisheries, and wildlife. These activities are governed by the Water Act (which is currently undergoing major revisions) and the Wildlife Act. The Ministry of Forests is concerned with the management of the forests and range land in a watershed. There are many careers preserving, protecting, and restoring these ecosystems which are interrelated to all the systems in the watershed.**

- **Regional and Municipal Governments have interests in waters in their areas. The supply of water for drinking and irrigation is of prime concern, as is the treatment of sewage and the handling of storm drain water. There are jobs in many of these areas as well.**

- **First Nations governments also have interests and concerns in streams, lakes, and rivers in British Columbia. Land claims, including traditional fishing rights, are currently before the courts to determine how the resources should be allocated and used. People in a variety of roles and jobs are working together to decide these issues.**

Activity: Investigating Careers in Water Stewardship

Students can make phone calls to set up interviews with people who have careers in Water Management and Stewardship.

Note: Before students begin to make phone calls, teach them how to use the Blue Pages of the phone book. The Blue Pages are divided into 3 main government sections: Canada, British Columbia, and Municipalities and Regional Districts.

- Check out the availability of people before your students start to make calls. Many agencies have educational or public relations personnel who will come to the classroom as guest speakers. Students should only call people who have agreed to be contacted and at a convenient time.

- Make up " Investigation Cards" which list questions that students can ask. Or have students make up their own questions. See sample Investigation Cards below.

- Have students role play phone calls with partners before they actually make calls to government agencies. Help the students learn to be polite and well-prepared with questions.

- Wherever possible, have student callers ask the person being interviewed to describe what his or her job entails.

Materials:

phone book
telephone
permission for students to make long distance calls (use 1-800 numbers, where possible)
Investigation Cards

Procedure:

1. Look through the blue pages of the phone book and decide who you would like to call.

2. Develop a list of questions to ask the people you phone. Or use questions that your teacher gives you. See sample investigation cards and questions which follow.

3. Make your call and ask your questions. If the person is willing, ask for a description of his or her job. Remember to thank the person at the end of the call.

4. Keep notes of who you call, their phone number and what they said.

Sample Investigation Cards

Make up some of these cards ahead of time and have your students use them when making phone calls. Present different challenges on each card.

Investigation Card

You are the investigator and it is your challenge to:

Find out who has water licences on a particular creek.

Investigator (your name) ________________________

Name of agency to phone ________________________

Agency telephone number ________________________

Contact person's name ________________________

Their telephone number ________________________

Is this person willing to come to class as a guest speaker?

Yes ____ **No** ____

What date and time would be convenient? Date ____ Time ____

(Write your notes on the back of this card.)

* Develop challenging questions on other cards. For example: **Find out what to do if you see someone throwing rocks at spawning fish.** Have students develop their own challenges or use some of the sample questions from below.

Sample Questions

Try to develop investigative ideas using real questions and concerns of your students. Or use some of these sample questions:

Where does the water in our community come from?
How is the water treated before it enters the system?

How is the water treated after it has been used? Where does it go?

What is the quality of water in a specific stream? Who has jurisdiction on the stream?

From whom do we need permission to start a storm drain marking project?

Where should toxic waste be disposed?

Are trout in a stream all right to eat?

We would like to plant trees on the side of a stream. From whom do we need to get permission?

We would like to investigate the aquatic life in the stream, what are the best times of year to do that?

We would like to do a clean up of a stream. When is the best time to do that? Where can we put the litter and from whom do we need permission?

When can we fish in the local stream? What is the limit of fish we can catch? Do we need a fishing license?

How many registered water licences are there on the creek and what volumes of water do they allow the licence holders to take?

How many salmon spawn in a creek?

We want to build a spawning channel. Whom do we need to contact for permission?

We want to raise salmon in the classroom. Whom should we contact?

Our creek is drying up and we would like to save some of the fish by moving them. From whom do we need permission?

Where can we get a map of the creek showing the land owners along it?

How much water flows down this creek in a year?

We are concerned about flooding around our creek. Whom do we call?

We are concerned that logging is occurring too close to the creek. Whom do we call?

We are concerned that cattle are watering and defecating in our creek, and breaking down the banks. Whom do we call?

What are the First Nations claims on this creek?

What is the traditional native and present native food fishery on the creek?

Extensions

■ Take a field trip to a government agency and have students try to find answers to certain questions. Of course, you will want to alert the agency ahead of time.

■ Get information on the "Scientists and Innovators in the Schools Programme." Arrange for a guest scientist to come and speak to the class. Phone 604-687-8414

■ Arrange for a day of "job shadowing" in which students are paired with people who work in water-related jobs. Students can prepare questions about the job ahead of time. Possible questions include:
- What do you do in a typical day?
- What do you like and dislike about your job?
- What kind of training did you need?
- What new things are you learning now?
- Do you have any other career goals?

Assessment Ideas

■ Make a presentation to the rest of the class showing what happened during the job shadow or interview. This could be in the form of a skit or role-play.

■ Make a large class chart showing the structure and functions of all the agencies concerned with water use and management.

■ Write a journal entry describing a "Day in the Life" for your chosen profession in a water related field.

Connections to Curriculum

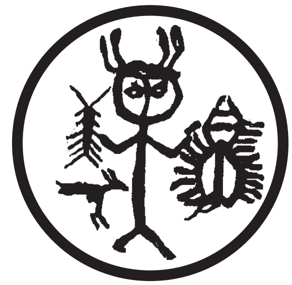
Language Arts: speaking, listening, note taking, report writing

Practical Arts: investigative training and work requirements

Social Studies: taking personal histories, investigating the roles of government agencies, researching careers and work

Fine Arts: role playing

Concept 12: Different human cultures have different values about water and different patterns of use.



The concept of water stewardship should be examined from the perspectives of differing cultures and value systems.

Background Information

- **Canadians are the second highest per capita water consumers in the world. For domestic (household) use in Canada we use an average of 340 litres of water per day. USA uses 425 litres per day, United Kingdom, 200 litres per day, Sweden, 200 litres per day, France, 150 litres per day, and Israel, 135 litres per day. (Environment Canada - Fresh Water Series - Water Works)**

- **In Canadian homes 45% of daily water use is for flushing the toilet, 30% for baths and showers, 20 % for laundry, and 5% for cooking/drinking.**

- **Such high use of water is the result of a number of factors:**
  - **Water is regarded as abundant, therefore little has been done to encourage conservation (although this is beginning to change).**
  - **Over one-third of Canadians pay a flat fee for their water, no matter how much they use.**
  - **Over one-third of Canadians pay less per litre when their consumption actually rises.**

- **In countries where water is in shorter supply, or where larger populations are competing for limited water resources, consumption is much less.**

- **The public is beginning to become aware of the issue of water consumption. Increases in populations and shortages of precipitation in certain regions have raised the profile of this issue.**

- **In addition, proposals to sell Canadian water resources to the United States have created a great deal of controversy. Certain proposals even plan to divert waterways to feed USA markets. Clearly, the issue of how our water resources are used is becoming one of the more prominent issues of our times.**

- **Different cultures have different religious ceremonies involving water – for example, the practice of bathing in the Ganges River or Christian baptism.**

- **Different cultures have different norms for bathing and showering activity. North Americans often bathe or shower once a day. Other cultures where water is scarce may bathe once or twice a year.**

Activity: How Much Water Do I Use?

This activity is intended to make students more aware of how much water they actually consume in day-to-day living, and to compare this to the consumption in other countries.

Begin by having students discuss and determine how to estimate the amount of water they use in a day. Make up a chart which shows the average amount of water used to flush the toilet, brush teeth, take a bath or shower, cook dinner, wash dishes and clothes, take a drink, and so on.

Materials:

graph paper
record sheets

Procedures:

1. Keep track of how much water you use in a week and what you use it for.

2. At the end of the week, calculate how much water you've used. Divide this amount by the number of days you used the water. This figure tells you how much water you use a day.

3. Compare the amount of water you used per day, with the amounts people in other countries use per day. Use water statistics to find your information. See examples of water statistics which follow.

4. Make a graph to show the rates of water consumption in different countries.

5. Discuss why differences in water consumption might exist among countries.

Water Statistics

These statistics show the amount of water used per capita in different countries.

Country	Litres of Water Used
USA	425 litres
Canada	340 litres
Sweden	200 litres
UK	200 litres
France	150 litres
Israel	135 litres

Note: These figures are created by dividing total daily household water used by the population of the country to produce the per person result. These figures do not include water used for industry, mining, and agriculture.

Extensions:

Some activities to further develop the concept are:

- Find out which human activities use the most water. Industry and agriculture may use a much larger percentage of water than the average household. Compare the percentage of water which is used for various activities (home use, industry, agriculture, and so on) in Canada. Find out how these percentages compare to water used in other countries.

- Locate a penpal in a foreign country. (This may be a "keypal" if you have access to the Internet through a computer and modem). Ask your pen pal to complete the same water use survey you did in your class. Find out how much water your penpal uses in a typical day. Think about the lifestyle of your penpal. Can you explain why she or he might use a different amount of water than you do?

- Write a story in which a town runs very short of water. Only a few members of the community have access to active wells. What happens in the town?

- Develop a model of a landscaped yard, built to the scale of the average city lot in your area, and come up with some ideas about using native plants which do not require extra irrigation.

- Investigate different sorts of agricultural irrigation methods used in your area and present a report to the class on which ones use the most and least water.

- Compare the prices of these products in a one litre size:
  - tap water
  - soda pop
  - bottled mineral or spring water
  - milk

  Find out which is most expensive. Which is least expensive? Do you think price makes a difference to how people use a product? What do you think would happen if tap water cost more?

- Interview elders or spokespeople from the local First Nations community. Find out their ideas and concerns about water, aquatic life, and water habitats. Possible questions include: What role does water play in the life of your community? What role did it play in the past? Is anything different now? Do you have any water legends, stories, or ceremonies you can tell me about?

- Take a survey of water rituals from a variety of religions and traditions within your community or from around the world. Baptism with water is an important

Christian ceremony, for example. Create a display showing what you find out about the ceremonial importance of water.

■ Explore the aesthetics of water. Water is often the subject of poems, songs, paintings, stories, films and so on. Ask students to find out how water is used as a subject in a variety of contexts. Possible contexts include:
- songs and music
- tales and legends
- poetry
- graphic arts
- movies and films
- advertising

Encourage students to explore cross-cultural art forms, too.

Assessment Ideas:

■ Design a plan of action to reduce the amount of water you consume in your home. Try out your plan and record your daily water use once again. Afterwards, compare the results to see if your plan helped you use less water. Write a report on what you found out. Make a graph to illustrate your findings.

■ Use water as the subject of creative art or music projects. Set up a class display or presentation of student work.

■ Design a presentation or write an essay to show how water is an important subject in the arts or religions of many cultures.

Connections to Curriculum:

Math: graphing, performing number operations, calculating averages, comparing unit costs

Language Arts: letter writing, creative writing.

Social Studies: creative problem solving, investigating lifestyles of other cultures and countries, researching patterns of resource use

Practical Arts: exploring landscape design, model building, investigating agricultural practices

Fine Arts: painting, sketching, drawing, musical composition

Chapter Seven

DEVELOPING SCHOOL ACTION PROGRAMS

"Always act in such a way that the principles underlying your actions could become the principles of humanity."
Immanuel Kant

The following material is based on the **Action Handbook***, by William Hammond, Natural Context, 1993. It is reprinted here in an adapted version with permission of the author.*

Why do we need Action in Education?

Since the earliest days in the 1960's, when environmental education was being redefined from its predecessors—nature education, conservation education, and outdoor education—environmental education has been defined to include three critical components:

- a developing awareness of the environment and one's connections to it
- a developing understanding of environmental concepts and knowledge of ecological, scientific, social, political, and economic systems
- a capacity to act responsibly upon what one feels and knows within the processes of the democratic system, in order to implement the best solutions to environmental problems

Many environmental education programs built their philosophical foundations, curriculum frameworks, and program activities upon the premise that awareness leads to knowledge, which in turn creates the potential and capacity for appropriate actions. This premise may be questioned.

It is often evident that people who have considerable knowledge may not be particularly effective as action takers. It is also evident that people can be overwhelmed by the sheer volume of information, sometimes conflicting or contradictory, about a given topic. Many people would like to wait until all the scientific and technical questions have been definitively answered before taking action.

But science is always tentative, it is always in process and there may always be new discoveries and inventions which will profoundly alter today's situation. Nevertheless, we need to act responsibly, recognizing the limits of current knowledge and technology. If we were to wait for total percent certainty, we would likely never act. As has been noted by other environmental writers, a decision not to act is also a decision.

Beginnings of Action in Schools

Many young people appear to have no feeling of connection or sense of personal control over the "system". Instead they feel rejected by the democratic system or feel that it has failed them. However, many very successful instructional programs have been designed and implemented since the early 1960's to engage students in action work, within the context of schooling.

These programs have clearly demonstrated that if students are taught basic "action skills" and are actively involved in trying to solve local, provincial, national, or international problems, they will act within the democratic system as responsible citizens—not only while in school but after graduation.

However, schools are not usually seen as venues for action. Many people continue to see schools as places for learning about things, rather than places for learning how to do things—especially when learning how means taking action on significant or controversial problems.

Issues in Implementing a School Action Project

Implementing an action project within the context of schools is different from implementing one within community organizations, businesses, or special interest groups. Schools have special obligations to the spirit of ethics and fair play, in a world of diverse values and viewpoints. Schools are obligated not to use their privileged positions to propagandize and must not make self-serving advocates of students who are required to attend.

It is critically important that every school board, principal, and teacher makes an uncompromising commitment to provide students with a wide range of viewpoints on any values-based issue. It is important for students to recognize that knowledgeable people may differ widely in how they see a problem and what they see as a solution.

It is up to the student to make an informed choice about what position to take on any issue. If a student does not feel allowed to take a reasoned position which varies from his or her teacher or classmates, we will know that education has been replaced by propaganda or indoctrination.

Role of the Teacher in an Action Project

Introducing action into the curriculum requires a change in the teacher's role. He or she must move from being the primary conveyor of information, to being the facilitator of action-skill development and coach or mentor in student decision-making and implementation of proposed solutions.

A set of goals for developing action in schools may be described in the following way. Teachers must develop programs that:

- help students develop the capacity and skills to effectively anticipate the consequences of their actions.

- enhance student self-concept by helping students to be independent thinkers and instilling them with confidence for leadership. Leadership comes from acquired knowledge, understanding, skills, and experience which is built upon previous successes.

- develop student spirit and skills, and inspire, motivate and prepare students to be full participants, working for positive change within the democratic system.

Why Action Projects are an Important Part of Education

There are other good reasons why action projects play an important role in the basic education of all learners. These reasons are:

1. It has long been an accepted principle of education that one of the most powerful ways to teach something is by modeling the thing to be learned.

2. Constructivist views of teaching and learning point out the importance of students applying information in order to build a personal body of knowledge. If we expect students to truly understand new knowledge, we must provide them with real life situations where they can transfer and apply their knowledge to new situations or circumstances.

3. Critical and creative thinking strategies are enhanced when people are given real, life-wrenching things to think about—things which affect their neighbors and themselves.

4. Students don't always get an opportunity to do something of benefit for others. The power of the altruistic feeling which comes from doing something for someone else is missed. Many students truly enjoy the feelings of accomplishment and satisfaction when they complete a service project for the first time.

5. Many business and education authorities believe that students should have opportunities to develop skills in leadership, conflict resolution, and teamwork or collaboration. Young people need to experience new co-operative, collaborative leadership alternatives as opposed to the highly competitive, win-lose, leader-follower models with which they are generally provided.

6. The practices that characterize effective schools such as: time management, co-operative learning, a safe and orderly setting and interdisciplinary studies, are enhanced when students have an opportunity to take on a meaningful role in school leadership and service responsibilities.

7. When students develop more community perspective and commitment they feel attached to their communities and enhance their sense of belonging to something larger than themselves. Such attitudes replace the notion of "us versus them".

8. Improved life skills, data collection skills, communication skills, co-operation, time management, and priority setting are critical outgrowths of any student participation in an action program. The best way to learn many skills is in the context of meaningful, real applications of them.

9. Political effectiveness is learned through experience. Action programs provide students with an opportunity to develop skills in the political process and to apply them in a variety of contexts.

10. Students have the opportunity to become peer teachers, as well as learners. They can build relationships with many different people in the school and community as they work on their action goals. Students gain experience and support of mentors who assist them as they strive to attain their goals.

The three important outcomes that are likely to be acquired by every student participating in an effective school-based action program are that students become committed to natural systems, to democracy, and to their community.

Types of Action Projects

Over the past thirty years, experience has affirmed that action work within schools, can be effective with students from preschool through high school and beyond. It is just the level of sophistication and magnitude of the problems addressed that varies with age levels. A successful "Action Project" may be an individual effort or a small or large group endeavor within the context of school programs.

In Canada, many schools have become involved in environmental action. The various projects have included:

- SEEDS (Society, Energy, Education and Development)
- Salmonid Enhancement Program (SEP) of the Department of Fisheries and Oceans of Environment Canada
- Environmental Youth Corps, Local Initiative Projects and Opportunities for Youth
- Ducks Unlimited
- Canadian Wildlife Federation's Habitat 2000 program
- Watershed Restoration Projects
- other joint efforts between schools and community interest groups

In the USA, the Monday Group (environmental seminar classes) of the Lee District Schools in Florida, has possibly the longest running school-based action program in the nation.

The Monday Program has been featured in the Project Wild Teacher's Guide as a model for school-based action projects. It was established by Bill Hammond and Environmental Education teaching staff, some of whom began school-based action work in 1962.

Other approaches to action programs may be found in the effective programs developed at Southern Illinois University by Harold Hungerford and his graduate students. These programs are called Investigating and Evaluating Environmental Issues and Action Skill Development Modules.

Other programs to mention include: Global Rivers Environmental Education Network (GREEN) Program, established by William Stapp and his graduate students at the University of Michigan, and the Audubon Expeditions Program established by Michael Cohen and implemented through the National Audubon Society of the United States.

There are literally hundreds of other documented, successful environmental action programs which have been conducted in schools and developed by classroom teachers throughout North America and the world.

Implementing Action Programs in Classrooms

Key Elements of an Action Program Component in Schools

The action element of a sound educational program requires that a student have mastery of basic skills in reading, writing, math, science, social studies, the arts, ecological systems, and technology applications. In turn, the action element provides a very effective context for the direct application of these academic subjects in the real world.

Action projects bring life to learning, because the ultimate outcomes are unknown as learners take part in the action. The experience becomes a real problem-solving process which allows students to synthesize what has been learned in school and apply it directly to the selected problem or issue.

An action program enhances the development of character skills for students of all ages. Honesty, integrity, work ethic, trust, positive risk-taking, collaborative participation, and empathy for others are a few of the character skills that are emphasized through action work.

Learner-Teacher Guidelines

A critical teacher role in implementing action programs is coaching students to plan their broad visions or goals into a set of key steps, milestones, or critical sub-goal accomplishments. In this way, if the time constraints of the school setting or the political process (which always seems to take longer than most of us estimate) delay the attainment of the ultimate goal, students will still have a positive sense of accomplishment, of partial closure, and a feeling that they indeed made a difference and can continue to make a difference if they persist.

There are other important guidelines that have evolved over years of studying successful practices for carrying out action projects or programs in schools.

Simply stated they are:

1. Learners should be free to decide upon and select the problem they feel is important to research and address with action. Teachers and other adults may serve as advisors in this process. However, it is important for the students to develop personal ownership of the project.

2. A basic set of "action skills" can be learned and must be taught, practiced, and applied. These include:
   - how to identify, research, and investigate the problem or issue
   - developing leadership and group organization skills
   - developing communication and lobbying skills (letter writing, phone calling, public speaking)
   - developing presentation skills
   - developing conflict resolution skills
   - "force field" analysis—determining support and opposition to the solution and selecting appropriate methods, strategies, and tactics for implementing action
   - understanding alternative strategies, learning how to sustain and continue projects

In addition to mastering these individual skills, it is equally important to master collaborative team skills, particularly if a project is a group project. Often, we do not distinguish between individual skills and the equally complex but different set of skills required to be an effective, contributing group member.

3. The Monday Group in the Lee County Schools program has developed a set of guidelines for interactions and communication with those involved in any action project. They are:

- **Express positions in positive terms.**
  If you are opposed to something, you must be for something. It is your responsibility to express what you stand for and what your proposed solution is, in positive, concrete terms.

- **Avoid stereotyping others.**
  Treat everyone as a person of high moral worth whether they are in support or opposition to your project. Stereotypes : (developer, environmentalist, liberal, conservative, politician, bureaucrat, tree hugger) get in the way of establishing positive relationships and communications, because they lump individuals into categories.
- **Do your homework—become an expert on your topic.**
  Read specific articles about your topic, interview experts, do field investigations, and get first hand information where possible. Don't rely on rumours or hearsay. Identify the core problem or issue(s) and formulate your research questions and hypothesis based on the best way to address the problem.

- **Follow the "force field".**
  Investigate the viewpoints of all people who have a stake in the problem. Keep an open mind to the views of others. Try to consider the impact that proposed actions will have on the lives of the various stakeholders, both in

the short and long term. Formulate an action plan selecting the strategies and tactics you believe are most appropriate to the situation.

- **Avoid scapegoating.**

If you fail to attain your goal for any reason, avoid the temptation to blame your lack of success on someone else or on some other set of circumstances. If you failed to attain your desired goal, it may be because you did not do something as well as you needed to. You may have not done your homework, lobbied, or communicated to all the concerned people effectively enough.

- **Recycle your efforts.**

If you do not reach your intended goal, recycle your efforts or start the process all over again. You know far more the second or third time through the process than you did the first time. You know key resource people and what worked and didn't work in your initial approach. Do it again! Try again and again until you succeed.

- **Be persistent—stick with it!**

People don't always recognize the potential students have to accomplish community changes, particularly on environmental problems and issues. Long term planning, commitment, and a tenacious approach are most important to the success of significant environmental action projects. The action process tends to be a spiraling pattern of action-research-action-research-action. This is why recycling your efforts is critical to success.

Three Levels of Action

There are typically three types or levels of action work. Succeeding levels require a greater degree of sophistication and skills for successful action.

Level 1: Actions which result in a distinct end-product within a fairly short time period.

This type of project involves generating products or producing results such as: wildlife habitat improvements, marked watershed storm-water drainages, developing informational publications and multimedia programs, planting trees, recycling trash, or building and placing bird or bat boxes in critical locations. Other activities might be: writing letters, making phone calls to decision makers, or buying a piece of tropical rainforest. The goal is to achieve action within a fairly short period of time.

Level 2: Actions which result in ongoing or sustained environmental processes.

This category includes Level 1 type projects, but it goes farther. Level 2 projects involve the development and design of long term, on-going endeavours that continue even after the project designers have moved on to other grade levels, schools or projects.

People involved in Level 2 action projects have to develop strategies to train their successors and to maintain political, institutional, or financial support for the long term.

Level 3: Actions which result in some level of policy change.

A Level 3 project is directed at changing or creating new public policy at the school, school district, city, county, state, or federal level. Students in this type of project need sophisticated skills in lobbying, working with mass media, dealing with governmental processes, and knowing how to work within the democratic system. Projects of this type require the most complex set of skills in order to succeed.

Although the three levels of action require different qualities and sets of skills, one level of action work is no more important than another. Elementary, middle, and high school students have successfully carried out projects at all levels. A typical pattern for a teacher and students is to evolve through the levels as skills are acquired and students mature. However, students and teachers sometimes directly enter a higher level and accomplish a Level 3 project without ever completing a Level 1 or 2 project. In any action project, motivation, commitment, and skill development are the keys to success.

Mentors in Action Programs

Mentor: a wise, loyal advisor; a teacher or coach

Students rarely succeed in their first attempts at action without developing a special supportive relationship with someone outside their group. This specialized form of intervention and teaching or coaching may be defined as mentorship.

A mentor provides support in many ways. He or she may advise, counsel, encourage, suggest, and provide critical information or materials. A mentor gives support at the right time—perhaps by making critical phone calls when the way seems blocked.

A mentor may be a friend, another student, a caring teacher or school staff member, a business person, or an outside government or public agency member. Whoever it is, a mentor can make you feel positive and willing to risk the next step in your action plan.

In the Monday Groups, the team of teachers tries to make sure that every student feels positive affirmation of his or her efforts every day. This affirmation helps students recognize the progress that she or he is making.

When speakers or resource people from business, government agencies, or community groups meet with students, they are encouraged to get to know one or two of them. They are urged to make follow-up calls or write brief notes of encouragement to the students. Often, these encounters become a rewarding and collaborative relationship for both the mentor and the student.

The mentor relationship must be actively cultivated and supported for all students engaged in action work. While this is especially true for students new to action work, even experienced project workers find mentors to be an important element in helping them to pursue their goals.

Leadership

Leadership, within this context of this guide and these action projects, is defined as existing when a person takes actions which help a group move toward attaining its goal. This definition of leadership is much more inclusive than many. By using it, anyone can see his or her potential for leadership.

Conflict Resolution

The "art of the possible"—even when things seem impossible!

For centuries, the primary ways to solve conflict have used force, cunning, trickery, or skillful negotiation. In this type of conflict resolution, there is usually a winner and a loser. Recent conflict resolution strategies focus on both sides working to get mutual satisfaction—a "win-win" approach.

"The only good deal is one where all parties to the deal feel they got a good deal." Frank Hammond, President S.S. White Dental Company

Two different strategies for this type of negotiation are summarized in Getting To Yes by Roger Fisher and William Ury. Their process may be summarized as having the following attributes:

Attributes:

- ***People***—separate the people from the problem.
- ***Interests***—focus on interests, not positions.
- ***Options***—generate a variety of possibilities before deciding what to do.
- ***Criteria***—insist that the result be based on some objective standard.

These attributes are the basis for a negotiating process that has four steps:

Step 1. Define the Problem. (In the real world)
Identify what is wrong. What are the current symptoms? What is disliked? What is the preferred situation?

Step 2. Analyze the Situation. (In theory)
Diagnose the problem. Sort symptoms into categories. Suggest causes. Observe what is lacking. Note barriers to resolving the problem.

Step 3. Consider Possible Approaches. (In theory)
What are the possible strategies or prescriptions for addressing the problem? What are some of the theoretical cures or solutions? Generate broad ideas about what might be done.

Step 4. Develop Action Ideas (In the real world)
What might be done? By whom? When? How? What specific steps might be taken to deal with the problem?

This process is powerful if the participants are skilled in problem analysis or have a facilitator to guide them through the process. Too often, participants have not developed enough skill to objectively separate the problem from the personalities or to distinguish the underlying problem from the symptoms which surround it. In either case, training can provide a real bridge to getting past these obstacles.

Developing Student Confidence: Simulations and Role plays

Simulations, role plays, and debates are effective ways of helping students develop an understanding of environmental issues. Each of these strategies allows students to look at issues from many points of view.

It is often effective to assign roles to students that they would not typically choose. This "force fit" helps participants to develop empathy—an understanding of what it feels like to be in someone else's shoes. Here are some examples of how to train students for political lobbying, using simulations and scenarios.

Definition of Lobbying

To many people, the word "lobby" as a form of political influence has connotations of corruption or political sleaze. In the development of the Monday Group Environmental Action program, the staff have defined the term as: "To lobby is to communicate with and persuade a person(s), agency or organization that represents a "power influence" on an objective you wish to achieve." A lobbyist is the person(s) doing the lobbying.

With this definition in mind the Monday Morning staff have created a way to teach students the process of lobbying. It is as follows:

Instructional Goal: To develop skills in effective lobbying in all students.

Guidelines for Action: Set up a lobbying team that is made up of three team members. Each person on the lobbying team should have a very specific responsibility and role to play in the lobbying effort. The three assignments are as follow:

Lobbyist Role 1: The Recorder
This person plans the lobbying session with two other team members and observes and records all that occurs. He or she usually leads the debriefing session for the rest of the team members immediately after the lobbying session.

Lobbyist Role 2: The Listener/Support Speaker
This person co-plans the lobbying session and listens carefully to everything people say. He or she should be ready to assist the Presenter by adding key points which have been missed and providing additional information, as needed, during the lobbying session.

This member of the team must know the objectives for the lobbying session and be sure the Presenter covers them all. He or she must participate in the debriefing session when lobbying is complete.

Lobbyist 3: The Presenter
This person co-plans the lobbying session and is prepared to be the primary communicator for the lobbying team. He or she must also take part in the debriefing session.

Steps for Classroom Simulations of Lobbying Action

1. Do your homework and plan.

2. Make appointments for the lobbying session.

3. Make an effective entrance with introductions and set the stage.

4. Communicate your purpose and plan to the person(s) being lobbied.

5. Clarify understandings and commitments.

6. Summarize the key points of understanding and define follow-up actions and their timing.

7. Thank the person(s) being lobbied and remind them of follow-ups or commitments to be acted on (by both parties).

8. Debrief the session with the lobbying team to verify what each person observed and to review commitments and follow-up promises.

9. Send a note thanking the person(s) who was lobbied, include any pertinent information and affirm commitments.

Note: Written scenarios based on actual community issues, may be used in the lobbying practice sessions. Other students or teachers can act as the "targets" of the lobbying effort and can evaluate the success of the team's approach.

Try role playing the lobbying of a mock county commissioner or other elected official. Have the class critique each team's lobbying effectiveness. A variation might be to ask the recorder/observer to publicly debrief the lobbying team in front of the remainder of the class and invite class feedback.

An Example of a School Action Project

Here's an example of an action project that you can use to involve students and community members.

Riparian Zones

A riparian zone refers to an area situated on the banks of a river or other body of water. Riparian planting means re-planting indigenous vegetation on the banks of a creek, river, or other body of water.

Background Information

Riparian areas are an important part of aquatic ecosystems. By restoring vegetation in these areas, the health of these systems will improve dramatically and quickly. The benefits of riparian planting include improvement of the habitat and strengthening the food chain not only for aquatic organisms, but for terrestrial organisms and birds as well. Riparian planting helps: stabilize stream banks, traps sediments and pollutants, slows and dissipates flood waters, provides thermal cover, and improves water quality and wildlife habitat.

Urbanization, logging, and agriculture, in some areas, have had a profound negative impact on the riparian zones of our waterways. In urban areas, streams have been dredged, channelized, culverted, and development has occurred right up to the banks. Past logging practices have seen harvesting right up to the edges of lakes and streams. Livestock have been allowed to browse riparian vegetation, denuding the banks of major waterways.

Remediation of these problems through riparian planting is inexpensive and rewarding for groups interested in protecting aquatic environments.

Activity: Riparian Planting

This type of project can be taken on by clubs or school groups. It involves planting indigenous trees and shrubs in the riparian area of lakes, streams, and rivers where the vegetation has been removed by grazing or human activities.

Ask a naturalist or landscaper for help on choosing the right type of trees and shrubs for planting. Use ones that are indigenous to your area and can be planted fairly easily. Spring is a good time for planting.

There are several ways to get trees and shrubs to use for planting:

- grow your own from cuttings
  (Note: only Cottonwoods (Populus) and Willows (Salix) are easily propagated this way. These are usually the natives and are a good choice for your first year.)
- start your own from seed
- purchase plants from a commercial nursery

- get plants donated by forest tree nurseries
- use a combination of the above

Materials:

trees
shrubs
hoe or shovel
well-rotted manure
straw for mulching
mouse guards

Procedure:

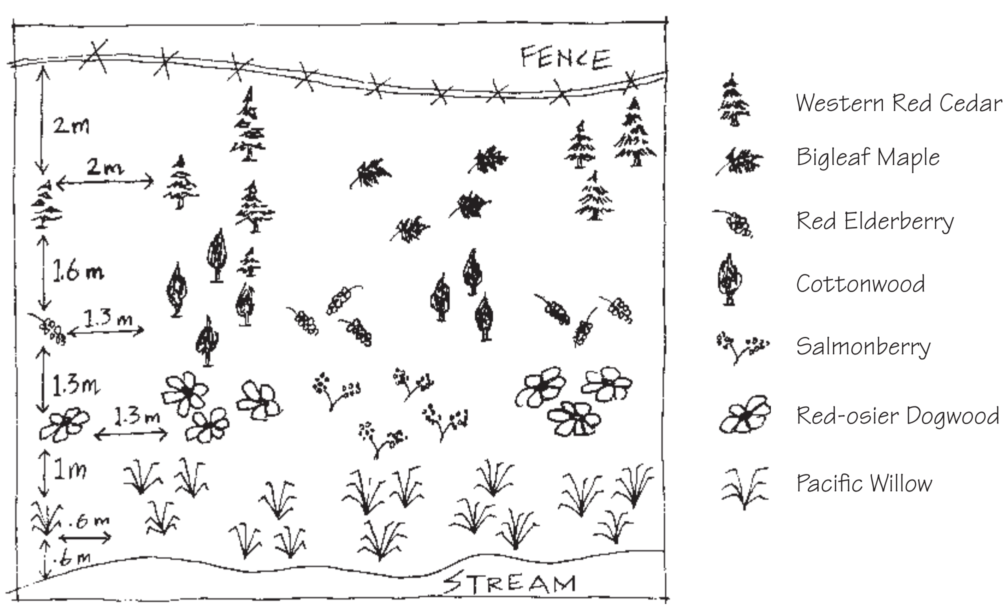
Before Planting

1. Get approvals from the owners of the land where planting will take place.

2. Find a source of trees and shrubs for planting.

3. Plan your planting. Find out which plant species suit the area and map out how you will plant them. Make the layout look as natural as possible. (Ask a naturalist or landscaper for help.)

Note: if you are planting only one or two species, the planning is easier. Generally, you will want willows in the wetter sites, close to the stream bank and the cottonwoods further back. Shrubs and conifers can be interspersed as shown in the diagram. To emulate natural succession, you may want to plant deciduous trees the first year and coniferous trees in subsequent years.



During Planting

Begin by explaining and demonstrating the following steps to your group. (See the diagram showing a properly planted tree.)

The steps are:

1. "Think" like a tree and choose a planting site accordingly. Think about high and low water conditions. The site needs to be "digable". On rip rap (rocky) sites, soil should be brought in to allow the plants a foothold.

2. Clear the micro-site. You need a circle of about 1 meter (3 feet) around the planting spot that is clear of weeds and grass.

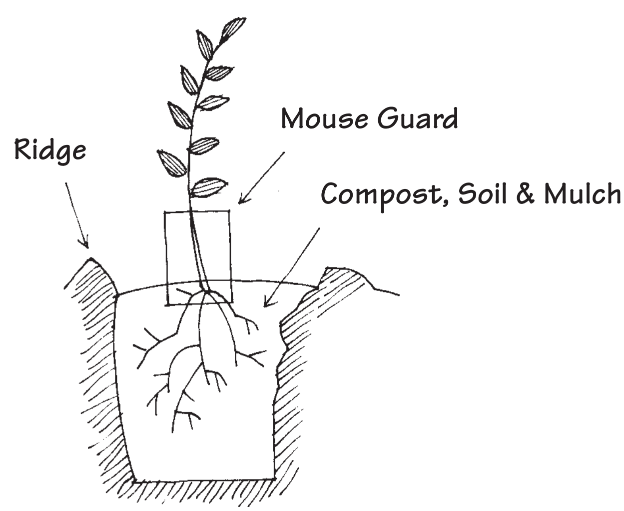
3. Dig a hole. Make it about 15 cm. (6 inches) bigger than the root ball of the plant.

4. Place the plant in the hole so that the top of the roots is slightly below ground level. Pack the soil firmly around the plant so that no roots are exposed to the air.

5. Build a crater about .3 m. (1 foot) around the plant to hold the water. Put the mouse guard around the stem of the plant with the bottom end 3-5 cm. (1-2 inches) below the ground level.

6. Place a scoop of well-rotted manure inside the crater, around the plant. Cover it with a mulch of straw.

7. Water the plant by filling the crater with 8-12 litres (2 or 3 gallons) of water. Place a stake next to the plant so that it doesn't get trampled or mowed and is easily found for follow-up care.



After Planting

1. **Water the plants once a week over the summer.**

2. **Remove competing weeds.**

3. **Remove the stakes once the plants are well established.**

Publicity

Invite the media to your planting. Put up signs at the planting site to explain what you are doing and why. Education of the public can begin by publicizing the work you do in riparian planting.

Summing Up

Awareness and knowledge without the capacity for effective, appropriate action is sterile and lacks engaging power or relevance for students.

The above concepts, guidelines, and approaches, can be used to train students for effective action. The fact that many classes have had great successes protecting , restoring, and sustaining the environment speaks for the success of action projects. Less evident, but equally important, are the personal success stories of students who discovered their capacities for leadership and increased their sense of self-worth and competence.

Directions for specific action and monitoring projects such as: Stream Mapping, Water Quality/Quantity Surveys, Stream Invertebrate Survey, Storm Drain Marking, Stream Clean-Up, and Streamside Planting are available through the Fisheries and Oceans Streamkeepers Handbook. Contact the Community Advisor or Water Stewardship Co-ordinator in your area for information.

APPENDICES

APPENDIX A

A Compendium of Water Facts and Figures.

We have assembled some key items of information in an accessible format to meet the need for a compendium of information about water, aquatic life, and aquatic habitats. We hope the compendium will be useful to busy teachers. You may also want students to "dig" for information in other sources and to compare information critically. The numbers from different sources will be slightly different.

Students often like collections of interesting, perhaps novel, and unfamiliar facts. For many years the column, Ripley's Believe it or Not, provided interesting, bizarre, and obscure items of information entertaining newspaper readers all over North America.

Today, the Guiness Book of Records and Harpers Index serve the same general purpose. While bits of information don't constitute an education they can be the bricks from which foundations of knowledge and concepts are built. They can provoke thought. During any unit of water studies it can be useful to invite students to create class displays, clip files, give daily reports, or provide other quick capsules of information about water. As much as anything else, the search for interesting items can lead students to browse information sources which they might otherwise ignore.

Water Facts

The first several of the following facts are taken from: *State Of The Environment Report For B.c.. Ministry Of Environment, Lands, And Parks*. 1993. The sources for facts from other sources are cited with each fact.

"British Columbia has the highest incidence of water-borne illness in Canada." (p. iv.)

The Largest and most important river drainage system in B.C. is the Fraser River. It drains almost 1/4 of the land area of the province. (p.19.)

The average annual flow of the Fraser R. is 3,972 cu. m/sec. This is enough to fill three Olympic size swimming pools every second.

Sixty per cent of the water withdrawn for use in Canada was used in thermal power generation (conventional and nuclear power stations.) (p.20.)

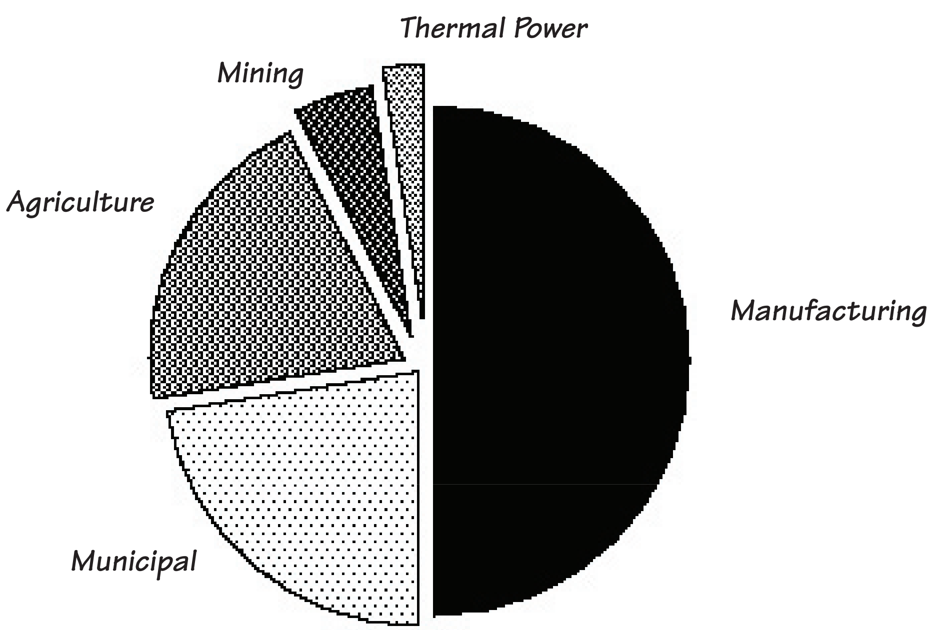
In B.C., nearly 78% of the municipalities have water rates that do not promote water conservation. In most municipalities people pay the same flat rate no

mater how much water they use. B.C. has the second lowest water-use charges in Canada. (p.21.)

Pollution Control Permits are required where human activities, such as industries or farms, discharge wastes into water. They specify what sort of wastes may be discharged, the amount of waste permitted, and the type of treatment required prior to discharge. The idea of the permits is to stop any waste discharge which will seriously degrade water quality below the point of discharge.

In October, 1992, there were 3,596 active waste discharge permits in B.C. Since July 1990, 259 operations have been listed as "not in compliance" with their permits.

"Over 1.5 million people in B.C. live in communities which lack, or have minimal sewage treatment." (p. iv.)



Water Use in B.C., by type of use

In B.C., there are 64 secondary and 9 tertiary treatment plants discharging into fresh water serving 550,000 people.

Six primary treatment facilities still discharge into fresh water: unfortunately, the two largest primary treatment plants in B.C., at Annacis Island and Lulu Islands in the lower mainland, on the Fraser River, serve more than 700 000 people. (p.24.)

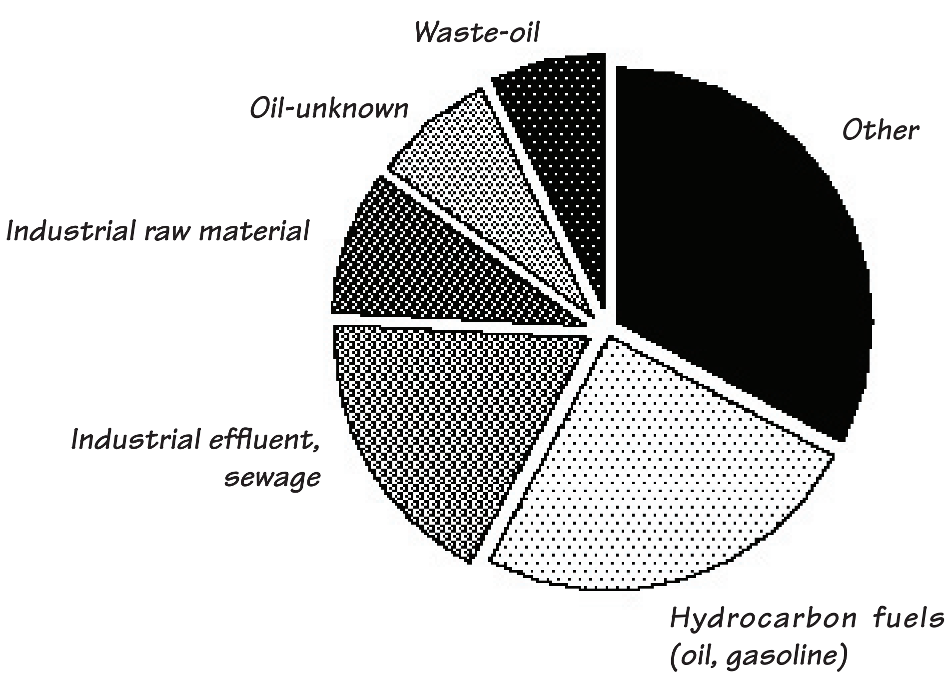
There are nine municipalities serving a total of 240,000 people, which discharge untreated sewage into marine waters. They include the cities of Victoria, and Prince Rupert. (p. 33.)

Another seven municipalities serving 660,000 people, discharge primary treated sewage into marine waters.

Between April 1991 and March 1992, there were 506 spills of hazardous materials into freshwater in B.C. Of these, the largest number were oil and gasoline spills. (p.26.)

In 1991, over 4,300 commercial vessels harvested over 80,000 tonnes of salmon from or in B.C. waters. The value of the catch was nearly $170,000, 000. This was about 9% of the total world supply of salmon. About 15% of the salmon catch is produced from enhancement activities such as stream enhancement, artificial hatcheries and spawning channels, fishways, and side channels. (p.45.)

B.C. supports the 3rd largest freshwater sport fishery in Canada. In 1990, 390,000 people spent 4.5 million days angling. They caught 9.6 million fish, an average of 2 fish per day per fisher. They spent $457 million on their sport. This level of expenditure has been estimated to create or maintain 5300 person years of employment. (p.48.)

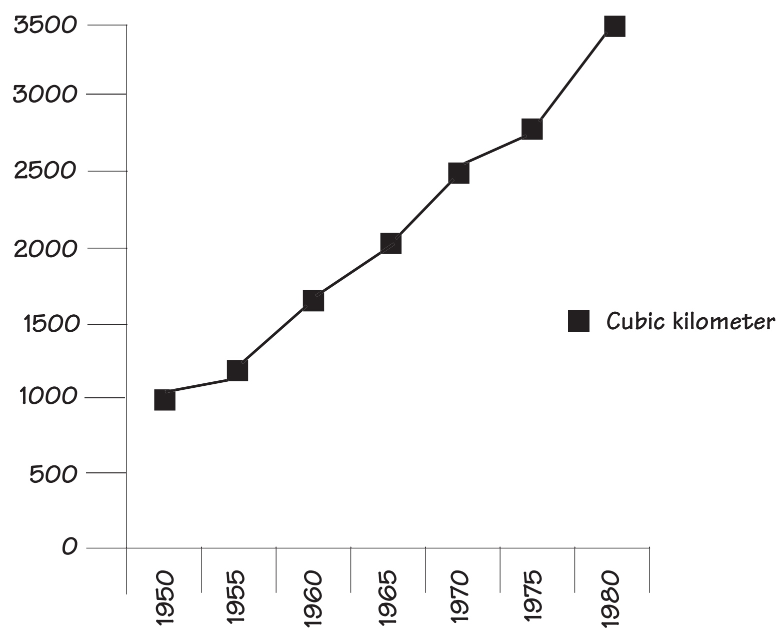


B.C. Hazardous Material Spills, by Type, percentage.
April 1991- March 1992

Just over 6% of B.C. is covered by wetlands. The highest percentage of the wetlands in B.C are in the NE corner (27%). Wetlands are rapidly being converted to provide space for agriculture and rapidly growing human populations. (p.43.)

Over thirteen million (44%) of Canadians swim for recreation.

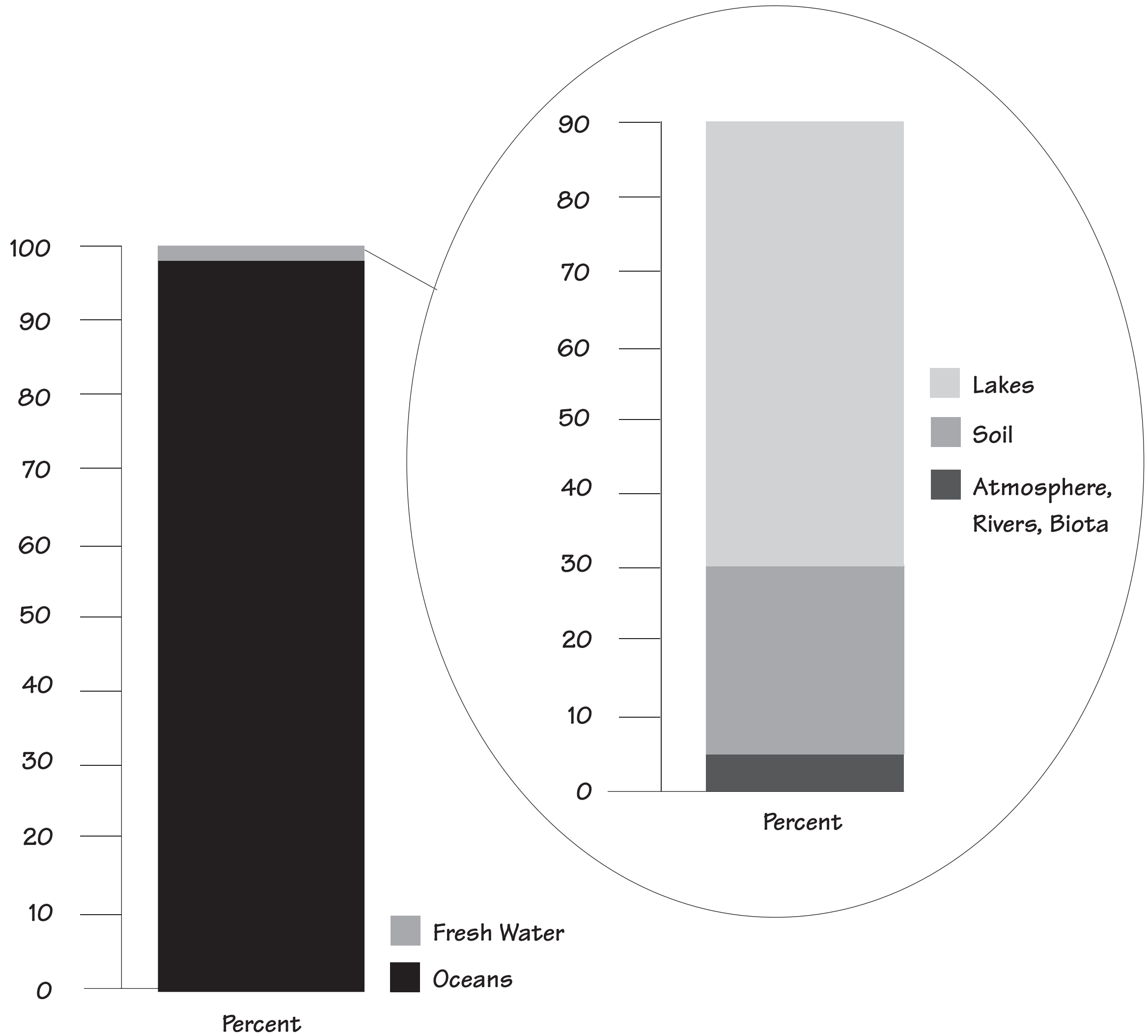
About six million Canadians (20 %) purchase fishing licenses annually.
(p. 44) *Currents of Change, Inquiry on Federal Water Policy. 1985.*



Global Water Consumption: 1950-1980
(Cubic kilometers)

Eight per cent of Canada is covered by lakes: more lake area than any other country on Earth. Canada shares, with the U.S., seven of the world's largest lakes, the Great Lakes system. The average annual precipitation in Canada is about 600 mm/year (6 meters). However, on the Pacific Coast, rainfall can reach 3500 mm, or 35 meters/year! (p.25) *Currents of Change, Inquiry on Federal Water Policy. 1985.*

Canadian rivers discharge close to 9% of the world's water supply.
(p. 34) *A Primer on Water*, Environment Canada. 1991.



Salt v Fresh Water, and distribution of Fresh Water, compared

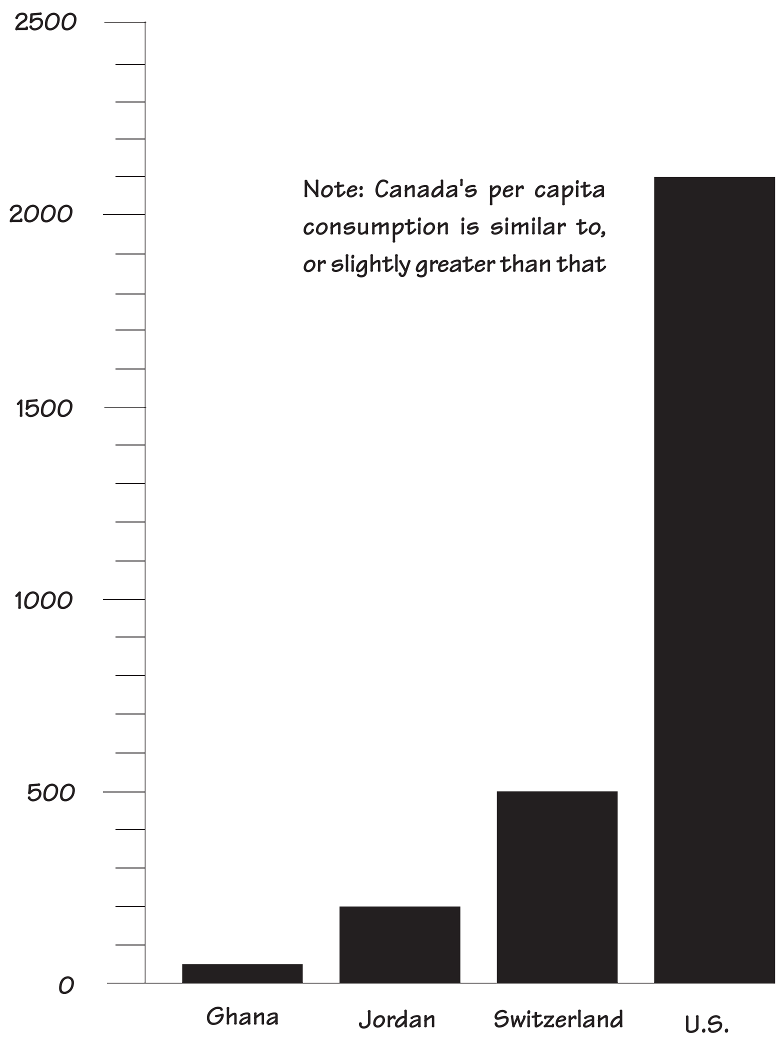
In 1987 Canadians spent $110,000,000 on bottled water. This figure is expected to double by 1995. In a 1990 study by the Consumers Association of Canada 12 of the 16 domestic or imported bottled waters contained potentially harmful contaminants at levels above those considered acceptable in the Canadian guidelines for drinking water quality.
(p. 21) *A Primer on Water*, Environment Canada. 1991.

One litre of tap water in Canada costs about .00047 cents. The same amount of bottled water would cost 50 cents; cola, 79 cents; milk, 95 cents; table wine, $8.00. (p.18) *A Primer on Water*, Environment Canada. 1991.

In Canada about 36% of the annual precipitation is in the form of snow.
(p. 9) *A Primer on Water*, Environment Canada. 1991.

The same water molecules that are now circulating on Earth were circulating more than 1 billion years ago. Virtually no new water has been created since water was first formed on the planet, more than one billion years ago. The water we drink today might have been in a plant, other animals, the ocean, or other people before.

About 83% of our blood is water. (p. 7) *A Primer on Water*, Environment Canada. 1991.



Water Withdrawn per person per year (in gallons per year)

To support a reasonable quality of life requires about 80 litres of water / person/day. World average water consumption varies from 5.4 litres/person/ day (Madagascar) to more than 500 litres /person/day (U.S.) More than 70 percent of the population of the U.S. drinks water that has passed through waste water treatment plants elsewhere (upstream).
(pp.102–3) *State of the Earth Atlas*. Seager, Joni. (ed.) N.Y.:Simon & Schuster. 1990.

APPENDIX B

Test Your Water Knowledge Survey

Assessing Prior Knowledge.

Because prior knowledge is important in the formation of new knowledge, it can be useful for teachers and students to assess what students already know about Water Stewardship before beginning any unit of learning experiences. This assessment can take many forms in addition to the typical "paper and pencil" pre-test. Interviews, developing goals for learning contracts, class discussions, creating maps and diagrams—are all useful assessments of prior knowledge. The following questions are written as if they were test items but they could be used as an agenda for class discussion or student interviews.

It is important that students understand the purpose of finding out about what they already know before beginning a set of learning experiences. They should be invited to develop the questions, and to interpret the results of any paper and pencil tests, diagrams, or mapping exercises. Students can be quite good at recognizing what knowledge they don't have, and what skills they lack.

The assessment of prior knowledge must be seen as the basis for developing learning goals, for planning learning experiences, and for measuring future progress toward goals, rather than as a basis for assigning scores or for ranking and sorting. The items provided here are examples only, although they do connect to the framework of key concepts about Water Stewardship which has previously been described .

Most of these questions do not have one single correct answer. Many of the "facts" and figures are estimates and vary from source to source. Many of the answers will depend on where you live.

Test Your Water Knowledge.

1. What percentage of the world is covered by water?

2. How much water is contained in the human body?

3. How much water does the human body lose in a typical day?

4. What percentage of water used inside the home is used for: flushing the toilet, bathing and showering, doing laundry, and for cooking and drinking?
Note: this could be a good starting point for having students monitor their water use at home and in the school

5. In many parts of the world, marshes, bogs, and other wetlands are often drained and filled in or destroyed for farming, housing, or recreation. Why should we be concerned about the loss of these wetlands?

6. We use water in our homes, in industry, in mining, in thermal power generation, and in agriculture. In British Columbia, which of these activities do you think uses the most water? Which uses the least?

7. Where does the water which comes out of your water faucet at home or school come from? Draw a simple diagram showing all the steps you think the water takes from its source to your faucet or sink.

8. Where does the water from your home go when it goes down the sink drain or toilet? Draw a simple diagram showing the steps you think the water from your home takes after it leaves your house.

9. What is the largest lake in your area? What is the largest river? Can you draw a sketch map showing your town, and some of the bigger lakes and rivers in your area. If you can, try to expand your map to show how the river(s) connect(s) to the ocean, or what lakes they flow into.

10. Think of all the things you use water for each day. Start with getting up in the morning and make a list of "water using activities" as you go through your day, finishing at bed time. Opposite each activity, try to make a rough estimate of how much water (litres) you think each activity uses.

11. If you put some water into a saucer or small bowl, and leave the bowl or saucer uncovered on an open counter top or sink for several days or weeks, what will happen? Explain what you will observe.

12. What are clouds?

13. Why does it rain sometimes? Where does the rain come from?

14. If you had a can of poisonous chemicals in your home, why should you never dump it down the sink, or flush it down the toilet? What should you do with it in order to dispose of this poisonous stuff?

15. Your home is supplied with water. Where does the water come from? What sorts of work do people have to do in order to make water available in your home whenever you need it? Who do these people work for?

16. Is water free? You use water every day, but do you have to pay for it? What do you think it costs your family for water every year?

17. How many centimetres of rain falls in your area each year? Which is the driest place in B.C.? Which is the wettest place?

18. What is snow?

19. Can you think of some animals that live in water and cannot live on dry land or outside of water? Make a list of as many as you can.

20. Can you think of some animals which live on water, or near water, but which have to breathe air? Make a list of as many of these animals as you can.

21. What is the freezing point of water? What is the boiling point of water at sea level? Why is it important to specify at sea level?

Answers......

Note: The answers to some of these questions vary from source to source and you should accept a range of answers. This is a good starting point for discussing the critical analysis of "facts and figures" so that students learn to look skeptically at statistics.

1. About 75% of the earth is covered by water.

2. The human body is about 70% water. Water is about 83% of our blood fluid.

3. This question is more difficult to answer. It has been estimated that people need to consume the equivalent of 8 glasses of water/day to be healthy, but at least half of this amount can come from foods which are high in water content such as fruits and vegetables. People lose water from perspiration (sweating), from their exhaled breath as water vapour (the breath we see on cold days), and from urine and so-called solid wastes. The amount lost depends on how much water we are consuming, how much work our bodies are doing, the temperature (we perspire as a means of cooling down), and other internal factors.

4. Inside the average Canadian home water use is estimated as follows: toilet flushing 45%; bath and shower 30%; laundry 20%; cooking and drinking 5%.

5. Wetlands are very significant habitats for many species of birds, insects, small mammals, reptiles, amphibians, and plants. Small pothole ponds and lakes are important breeding areas not only for migratory water fowl but also for small song birds which nest in the surrounding rushes, sedges, and grasses. As these so-called "swamps" are filled in for development, or sometimes simply as dump sites, the habitat is destroyed. As more and more habitat disappears, the risk of species extinction becomes greater and greater. Each time a species is lost, the overall biological diversity of the planet is reduced, and part of an ecosystem on which other organisms may depend may be lost also. It has been estimated that at least 80% of the wetland habitat in the Okanagan Valley has already been lost to development. In the lower mainland, wetlands are also threatened or have been lost in many areas of the Fraser River delta and flood plain.

6. In British Columbia, water use has be estimated as follows: manufacturing 51%, agriculture 22%, municipal 22%, mining 3%, and thermal power 2%.

7. This question's answer depends on where you live. Can you draw this diagram for your area?

8. As for number 7, above.

9. This question also depends on where you live. The answers can be quite surprising. People often don't think of little, local creeks as part of much larger river systems, but they are.

10. This can also be quite a surprise. For example, about 75% of the indoor home water use occurs in the bathroom for toilet flushing and showering. Using an insert to reduce toilet flush volume can save 45 000 litres of water in a year for a family of 4.

11. The water will evaporate, or literally, become a vapour, or gas. Water vapour is the gaseous form of water. Within a range of 100 degrees on the Celsius scale water can change from a solid (ice) to a liquid, and then to a gas, as it boils. However, even at temperatures below boiling point, water will evaporate into the surrounding air, if the air contains less water, and if it is moving. You may have noticed that ice cubes "disappear" if they are left in the freezer for many months.

12. Clouds are formed as masses of ice crystals in the upper, colder atmosphere. The high Cirrus clouds are of this type. Clouds can also be formed as water vapour condenses around small particles of dust, pollen, or other larger molecules in the air, under the right temperature conditions. Light reflecting from and passing through the water droplets gives clouds their colours. As more and more vapour condenses, the cloud will become so water-logged that it will begin to rain, hail, or snow.

13. It rains when the water vapour in clouds condenses to form droplets, which combine to form drops, which are so large and heavy that air currents can't hold them in suspension any longer, and the droplet falls to earth. Rain makers try to "seed" clouds with particles on which the water vapour will condense to form large enough droplets to fall to the ground as rain.

14. If you flush poisonous materials down the drain or toilet at home, it will end up in either your septic tank or in the sewer system. The septic tank depends on bacterial activity in the tank to treat the wastes from the home system. Toxins can poison the tank's bacteria and destroy the operation of the system. The toxins may also move from the tank into the septic field where they can then enter the ground water table and eventually enter run off, or even be pumped into domestic wells. Even when the house is connected to a central sewage treatment plant, toxic materials may not be degraded by the treatment and

may eventually enter lakes, rivers, or the ocean. Very small amounts of some household insecticides, drugs, and cleaning chemicals can be very dangerous to other organisms or humans.

15. Again, the answer to this question will depend on where you live and how your water is supplied.

16. Many people think that their water is "free". Water taxes are often hidden in the total home tax bill and are based on a flat rate charge which doesn't vary no matter how much or how little water is used. However, many towns and cities are now requiring homes to install water meters which actually measure what each user consumes. Under this system the user pays for the water on the basis of the volume used in a year. This gives people an incentive not to waste water. Most large industrial and business users must install water meters and pay for the amount actually used.

17. The answer will depend on where you live. B.C. is highly variable in climate and rainfall. The wet coastal areas are among some of the wettest places on earth (although not the wettest; that honour is reserved for the top of a mountain on the Hawaiian Island of K'Auai). The southern Okanagan, on the other hand, is among the driest areas of Canada, having a true desert climate and being home to plants and animals which are found in no other part of the country.

18. Snow is frozen water, or ice. Snow forms when water vapour in clouds in cold air freezes forming crystals of ice. Depending on air temperatures and currents the ice crystals may form slowly and take on very elaborate and beautiful forms (the true snow flake) or they may form very rapidly and fall quickly to earth once the weight of the crystal can no longer be supported in the air. It was once thought that snow flakes began to form around "seeds" of dust or other solid material but this is no longer thought to be true. Once the snow flakes reach the earth they pile up as snow. The weight of snow can compress the lower layer of crystals into more dense layers. Warming and cooling between night and day can also change the form of snow crystals providing different conditions for skiing and creating avalanche hazards in the mountains.

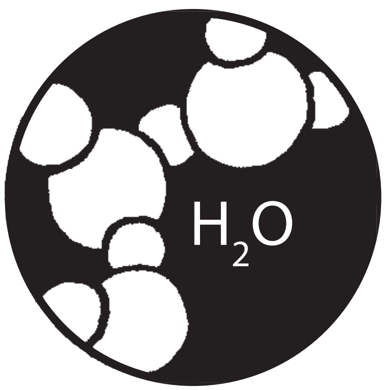
19. & 20. Some animals can only live when their bodies are actually immersed in liquid water. Fish and many invertebrates are examples. These water dwelling animals have gills, or a similar organ to exchange oxygen and carbon dioxide with the surrounding water in the way that our lung linings exchange these gases with the air. Large mammals like whales, breathe air, but depend on the buoyant support of water in order to support their large masses. Reptiles, like snakes, alligators, crocodiles, and turtles may all live mainly in water, but still require air in order to breath, and can emerge on to land to lay eggs or to find food. Amphibians, like frogs, toads and salamanders can live in water and exchange gases with the water through their skin, mouth linings, or through gills under some conditions, and can breathe air using lungs under other conditions. Many animals have life cycles in which one part of the cycle occurs in water

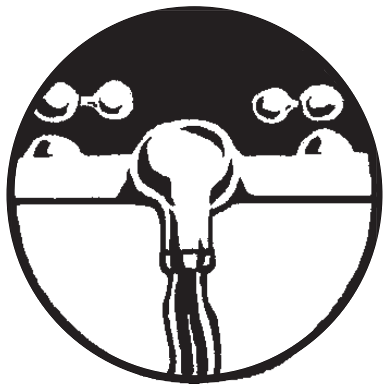
while the other part occurs in the air. Mosquitoes and dragon flies are examples of insects with this sort of life cycle. The larval stages of these insects is found in water, but the adult stage is a flying insect which lives in air.

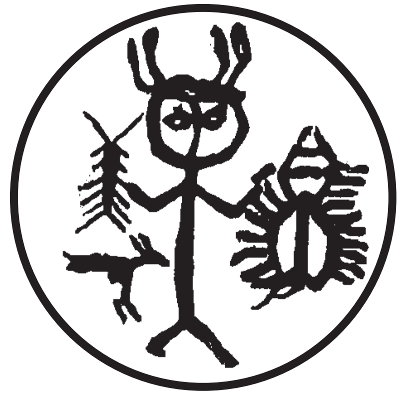
21. Water freezes at 0 degrees Celsius. Water boils at 100 degrees Celsius. It is important to specify that this is a sea level because water boils at lower temperatures when the pressure on it is less and at higher temperatures when the pressure on it is more.

APPENDIX C

Blackline Masters for Key Concept Logos.





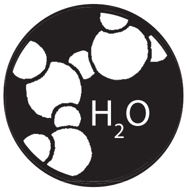
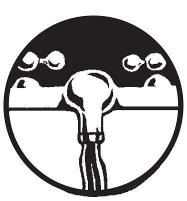


APPENDIX D

Project Wild Cross Reference

Many Project Wild Activities help foster the Water Stewardship Key Concepts. This Project Wild Cross References section gives you a guide to selecting appropriate activities for each of the key concepts.

Water Stewardship Key Concept	Project Wild Aquatic Activities Fostering Key Concept	Page
1. Water is essential for life	How Wet Is Our Planet	50
	Aqua Words	55
	Water Wings	57
	Are You Me?	62
	Designing a Habitat	70
	Puddle Wonders!	72
	Riparian Retreat	105
	Water Canaries	109
	Micro Odyssey	165
	Wetland Metaphors	168
	Marsh Munchers	172
	Migration Headache	237
	The Glass Menageris	283
	Aquatic Times	310
	Turtle Hurdles	363
	Plastic Jellyfish	368
	Something's Fishy Here!	371
	Watershed	376
	Alice in Waterland	381
2. All Living Things Depend on Water	Aqua Words	55
	Water Wings	57
	Water Plant Art	62
	Puddle Wonders!	72
	Whale of a Tail	77
	Riparian Retreat	105
	Micro Odyssey	165
	Wetland Metaphors	168
	Blue Ribbon Niche	180
	Fishy Who's Who	195
	Migration Headache	237
	Aquatic Times	310
	Watershed	376
	Alice in Waterland	381

3. Water is a Unique Material 	Stormy Weather Aqua Words Water Canaries Wetland Metaphors No Water Off a Duck's Back Deadly Skies Alice in Waterland	22 55 109 168 230 319 381
4. All Water is Part of the Hydrological or Water Cycle 	Stormy Weather How Wet is Our Planet Aqua Words Water Wings Puddle Wonders Where Does Water Go After School? Deadly Skies Alice in Waterland	22 50 55 57 72 191 319 381
5. Streams, Lakes, and Rivers, as Well as Other Water Bodies are Pa rt of Larger Systems Known as Watersheds 	Aqua Words Water Wings Riparian Retreat Pond Succession Marsh Munchers The Edge of Home Where Does Water Go After School? To Dam or Not to Dam Watershed	55 57 105 135 172 177 191 312 376
6. Watersheds are Dynamic 	Water Wings Riparian Retreat Pond Succession Marsh Munchers Watered Down History To Dam or Not to Dam Watershed	57 105 135 172 262 312 376
7. Humans are Major Users of Water 	*Water Wings* *Marsh Munchers* *Hooks and Ladders* *Water We Eating?* *To Dam or Not to Dam* *Plastic Jellyfish* *Something's Fishy Here!* *Watershed* *Alice in Waterland*	57 172 184 276 312 368 371 376 381

8. Water is Finite 	Water Wings	57
	Where DoesWater Go After School?	191
	Plastic Jellyfish	368
	Something's Fishy Here!	371
	Watershed	376
	Alice in Waterland	381
9. Aquatic Habitats are Essential Elements of the Biosphere 	How Wet is Our Planet	50
	Aqua Words	55
	Water Wings	57
	Water Plant Art	62
	Wetland Metaphors	168
	The Edge of Home	177
	Kelp Help	118
	Fishy Who's Who	195
	Migration Headache	237
	Aquatic Roots	242
	Water We Eating?	276
	Deadly Skies	319
	Watershed	376
	Alice in Waterland	381
10. Contaminants and Toxins can Move Within Water 	Water Wings	57
	Riparian Retreat	105
	Wetland Metaphors	168
	Where Does Water Go After School?	191
	No Water Off a Duck's Back	230
	Watered Down History	262
	Aquatic Times	310
	Deadly Skies	319
	Plastic Jellyfish	368
	Something's Fishy Here!	371
	Watershed	376
	Alice in Waterland	381
11. There are a Number of Careers and Vocations Working with Water, Aquatic Habitats, and their Management 	Riparian Retreat	105
	No Water Off a Duck's Back	230
	Net Gain, Net Effect	232
	Where Have All the Salmon Gone?	245
	To Dam or Not to Dam	312
	Plastic Jellyfish	368
	Something's Fishy Here!	371
	Alice in Waterland	381

12. Different Human Cultures have Different Values about Water and Different Patterns of Use 	Water Wings	57
	Riparian Retreat	105
	Mythical Mystical Monsters	115
	No Water Off a Duck's Back	232
	Net Gain, Net Effect	245
	Where Have All the Salmon Gone?	312
	Water We Eating	276
	Something's Fishy Here!	371
	Alice in Waterland	381

Developed by the participants of the "Project Wild Advanced Leader Workshop," Nov. 5,6,7, 1993 McQueen Lake, Environmental Education Centre in Kamloops, B.C.

APPENDIX E

Water Stewardship Curriculum Development Model.

This handbook is the result of a collaboration among teachers, community members, experts in water resources management, experts in water quality, experts in wetland ecology, fisheries professionals and instructional designers.

The project team is committed to the belief that when the expertise of teachers is combined with that of technical experts, better curriculum results. Teachers bring to the collaboration their experience with students, school programs, parental and community expectations, and knowledge of instructional strategies. The content experts bring their experience with the subject matter and their knowledge of the technical resources and procedures of the field. Curriculum developers and instructional designers bring their knowledge of curriculum materials and their experience with the process of curriculum design and implementation.

At the core of curriculum development is the desire to improve the education of students. The students are the real focus of any curriculum. No matter how elegant a curriculum may be in its design, no matter how sophisticated and technically accurate its content, unless the students are engaged and develop their knowledge, little benefit will have been gained. An effective curriculum not only helps students to learn the skills and knowledge of a field of study, it must also contribute to the over all education of the students.

Education implies the capacity to reflect on what is being taught and learned, to consider other points of view, and to analyze the qualities of information being presented. When students are truly educated, they may see possibilities and ask questions which were not considered by the teachers, technical experts, or curriculum developers. An effective curriculum is similar to the old proverb that when one gives a person a fish, one feeds that person for a day; but when one teaches another to fish, one is helping that person to have food for life. Thus, an effective curriculum helps the student to become a life-long learner, a person who will be committed to learning more about the subject, committed to developing further and deeper skill. We have attempted to reflect these goals in the design of the materials in this handbook.

The actual curriculum process to develop the Water Stewardship Handbook consisted of several phases.

In Phase 1, the project team consulted with technical experts in the water resources and aquatic habitat/fisheries fields to develop a working set of major concepts concerning water, aquatic habitats, and aquatic life connected broadly around the theme of Water Stewardship. The goal of this phase was to identify the big ideas which technical experts considered to be essential to an understanding of their fields.

In Phase 2, Project Teachers were asked to define their ideas about the things which they considered essential learnings in the domain of Water Stewardship. The ideas of the teachers and those of the technical experts were then compared and synthesized. The resulting list of key concepts was presented to both the experts and to the project teachers for clarification and further definition. This process resulted in a working set of key concepts about water, aquatic habitats and aquatic life which formed the framework for resource selection and assessment, field testing, assessment of student understanding, and materials development. Throughout the 1992-93 school year the key concepts were used as a compass to guide the curriculum development process.

In Phase 3, existing resource materials, including curriculum materials developed by other agencies and groups, were assembled by the project co-ordinator. Project teachers then met to review these materials and to determine which key concepts appeared to be best supported by the materials. The review also attempted to identify any other important areas of knowledge or skill which might have been omitted from the working set of key concepts. Groups of project teachers at the Primary, Intermediate, and Senior Secondary school levels then selected materials for field testing in their own classrooms.

In Phase 4, the Coordinator of the project visited classrooms of participating teachers to assist them with field-testing, and to help with special class projects and activities related to Water Stewardship. The purpose of this phase was to field-test and assess the existing materials and to develop ideas for needed teacher-developed curriculum activities or resources. During this phase project teachers met with the co-ordinator and members of the project team to review progress and to critique materials and the key concepts. The Steering Committee also met with the Project Team to review progress and to make suggestions for field-testing.

In Phase 5, project teachers met with the Co-ordinator and members of the Project Team to synthesize the results of field-testing, to present their experiences in the classroom to their colleagues and to the Team, and to suggest materials, resources, and other ideas for the draft Water Stewardship Handbook. In this phase the Project Team presented a proposed handbook outline to the project teachers and to the Steering Committee for review and comment, as well as for suggestions for change. Using suggestions and reviews from project teachers and Steering Committee members the final handbook outline was prepared.

In Phase 6, the Water Stewardship Handbook was prepared in draft form by the Project Team.

In Phase 7, the draft handbook was reviewed by members of the Steering Committee. Their recommendations for changes and additions were then incorporated into the draft and a field-test version was prepared for distribution to the original project teachers.

In Phase 8, the manual was field tested in workshops around the province. Over 150 people took part in workshops in 11 communities. Also manuals were mailed out to many aquatic experts and aquatic educators around the province. Feedback in the form of questionnaires was received on both the workshop and the manual. We are very appreciative of the thought, time, and effort that went into reviewing the handbook and completing these questionnaires. The information received was collated and incorporated. An independent editor made major revisions to shape the current edition of the handbook.

Phase 9, will involve ongoing inservice, classroom support, and networking through out the province. A newsletter will be developed along with computer conferences using telecommunications. Plans are underway to develop a Simon Fraser University Comet Course for credit and a diploma course in Water Stewardship.

Planting indigenous trees and shrubs is a wonderful activity. Willow and cottonwood cuttings can be started in styro blocks in a greenhouse or stuck directly into damp ground when all danger of frost is past. Other species are best started from seed or transplanting seedlings.

Mulching plants to hold the moisture in is a good idea on dryer sites. Stewardship activities are excellent for developing teamwork and social skills.

Inviting First Nations people to share their perspectives on the value of water provides students with incredible insights regarding our connections to the natural world.

Inviting students to speak at student planned conferences can help young people realize that they have power and purpose in their lives. Student planned conferences can be a starting point for students taking on effective action projects of their own.

Being involved in a curriculum development project provides a great opportunity for professional growth. Working with other teachers, testing out ideas, and trying new lessons are powerful learning activities for teachers.

GLOSSARY OF SELECTED TERMS

anadromous fish that migrate from the ocean to inland waters to spawn.

biodiversity a term referring to the variety of life in an area, ranging from a drop of pond water to the whole biosphere. Biodiversity includes four main considerations: landscape diversity, ecosystem diversity, species diversity, and genetic diversity.

capillary action water's ability to creep uphill when placed in a narrow tube. This phenomenon helps trees lift water to great heights.

chanellization when a stream or river has been straightened.

cirrus clouds high, thin, fleecy clouds.

fresh water this usually applies to inland waters. They may in fact be quite salty (alkaline).

indigenous originating in the region where found; native to an area.

oxbow water contained in a U shaped bend in a river. Sometimes these bends become a separate body of water if the river straightens its course.

petri dish a shallow dish with a cover, used in laboratories to grow bacterial cultures. Named for the French bacteriologist, Richard Petri, 1852-1921.

potable water water that is safe for drinking. (Pronounced with a long "o" sound)

rip rap rock covering used to protect stream banks from erosion.

riparian zone soil areas, adjacent to waterways, directly influenced by the water of a stream, lake, or wetland.

run off excessive rain or snow melt which produces overland flow to creeks and ditches.

sewage primary treatment - involves the removal of large solids and floating substances through settling and screening.
secondary treatment- after primary treatment, involves using bacteria, air, and sunlight to remove organic matter from sewage . This process also removes about 30% of the phosphorous and 50% of the nitrate.
tertiary treatment - after primary and secondary treatment is used to further reduce the phosphates, nitrates, and toxic materials from the sewage.

sustainability the preservation of biodiversity: the protection of pure water, clean air, and uncontaminated terrestrial, wetland, coastal and sea-bottom systems; the stabilization of global climactic conditions; the protection of natural beauty that we value aesthetically and spiritually and a commitment to a new economic ethic based on making better use of what we have.

stereoscopic pair a photographic technique using a pair of photographs of the same area and viewed through special glasses. It produces an image that has depth to it.

stewardship the concept of responsible care-taking; based on the premise that humans do not own the environment but are part of it. It is our responsibility to leave the environment undiminished for future generations of all living things not just people.

turbidity refers to the muddiness or cloudiness of water. It is caused by sediments suspended in the water.

watershed all the land area that drains into a particular body of water.

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