ES 2

O B S E R V A T O R Y
SCIENCE AND TECHNOLOGY (ST)
ENVIRONMENTAL SCIENCE AND TECHNOLOGY (EST)
Teacher's Guide A
Second Year of Secondary Cycle Two

BLACK TIDES

STUDENT LOG

PROCEDURE: SSC1 – SCIENCE

EVALUATION: SSC1 – SCIENCE
SSC3 – SCIENCE

Observatory / Guide
11129-A

Name: _____ Group: _____ ST EST

The case study

Reports point out difficulty in cleaning Arctic oil spills in Beaufort Sea

EDMONTON – New research suggests that the energy industry's ability to clean up spills in ice-choked Arctic seas lags far behind its skill at pumping oil out of the ground.

Reports done for eight Arctic nations that comprise the Arctic Council and also for environmentalists come just as exploration rights in the Beaufort Sea are about to go on the block.

Monday is the deadline for energy companies to bid for rights to explore nearly two million hectares of continental shelf under the sea north of the Yukon and Northwest Territories.

But even though methods to clean spilled oil out of icy waters have improved, the reports say there is a long way to go. They add that even a minor spill can be disastrous in the Arctic, where large populations of mammals, fish and birds concentrate in small places.

"Oil spills under ice or in ice-covered waters are the most challenging, simply because they cannot be contained or recovered effectively with current technology," says the Arctic Council report published this month. . . .

Technology to clean up those spills is improving. At a conference on Arctic issues in Edmonton on Thursday, Russian energy consultant Aleksey Ostrovskiy described a type of bacteria that breaks down spilled oil in temperatures as low as 5ºC.

"It takes all the oil from pollution sites," he said. "It works both on land and at sea."

Ostrovskiy acknowledges that freezing temperatures are still a problem. "[The bacteria are] not a panacea." . . .

The World Wildlife Fund has asked the Harper government to hold off on the sale of leases until a management plan is in place for the Arctic. . . .

Source: Bob Weber, The Canadian Press, "Reports point out difficulty in cleaning Arctic oil spills in Beaufort Sea" [online article], May 29, 2008 (accessed October 7, 2009).

The case study *(continued)*

Internal memo

From: Executive Office
To: Head of Research and Development
Subject: New mandate

Cleaning up oil spills in the glacial waters of the Arctic is a source of concern for energy corporations. They have asked us to define the environmental characteristics of the region and analyze the effectiveness of a number of absorbent materials in Arctic waters. We must recommend the material that is the most effective, with the least environmental impact.

Burning petroleum products is one of the most common energy sources in Canada. However, the disturbances caused by oil spills result in the contamination of ecosystems. Oil slicks can spread thanks to ocean and atmospheric circulation. To prevent this from happening, energy corporations want us to recommend the best absorbent material.

You will determine which material to recommend by conducting laboratory tests on four materials. We suggest you first reproduce the climatic conditions of the Arctic. Then you will test four of the following materials, whose properties we have already studied:

– cotton fibre
– natural sponge
– cat litter
– vermiculite
– perlite
– absorbent paper
– polyester fibre

The enclosed information documents will assist you in fulfilling this mandate.

Thank you for your prompt attention to this matter.

Gail Diamond
Vice President, Sokaris
On behalf of the Executive Office

In this case study, you will play the role of the head of Research and Development, the department that must fulfill the study mandate. You will simulate oil by mixing two parts cocoa with three parts vegetable oil.

Name: _____ Group: _____ ST EST

Creating the context

I ask myself questions

Name: _____ Group: _____ ST EST

Creating the context *(continued)*

I must

I think

Reflection

	Yes	No
Do I fully understand the scientific concepts covered in this case study?	☐	☐

Name: _____ Group: _____ ST EST

Planning the case study

I plan

Materials

Procedure

Name: _____ Group: _____ ST EST

Planning the case study *(continued)*

Table of results

Reflection

	Yes	No
Have I considered other approaches?	☐	☐

Teacher's initials

Name: _____ Group: _____ ST EST

Completing the case study

I experiment

Safety rules followed

Reflection

	Yes	No
Did I record and justify each of the changes I made to my plan of action?	☐	☐

Name: _____ Group: _____ ST EST

Analyzing results and drawing conclusions

I analyze my results

Name: _____ Group: _____ ST EST

Analyzing results and drawing conclusions *(continued)*

I draw my conclusions

Name: _____ Group: _____ ST EST

My evaluation

Use the evaluation grid on page 12 to evaluate yourself. Write A, B, C, D or E in the "Me" column of the chart below.

SSC1—Seeks answers or solutions to scientific or technological problems				
Criteria*	**Observable indicators**	**Me**	**Teacher**	**Comments**
1	**Creating the context** Definition of the goal and formulation of the hypothesis		☐ With help	
2	**Planning the case study** Relevance of the elements of the plan of action: materials and procedure		☐ With help	
3	**Completing the case study** Relevance and accuracy of the recorded observations		☐ With help	
4	**Analyzing results and drawing conclusions** Relevance of the results analysis and of the conclusion		☐ With help	

*** Evaluation criteria**

1 Appropriate representation of the situation
2 Development of a suitable plan of action for the situation
3 Appropriate implementation of the plan of action
4 Development of relevant conclusions, explanations or solutions

Name: _____ Group: _____ ST EST

My evaluation

Use the evaluation grid on page 13 to evaluate yourself. Write A, B, C, D or E in the "Me" column of the chart below.

SSC3—Communicates in the languages used in science and technology				
Criteria*	**Observable indicators**	**Me**	**Teacher**	**Comments**
1	**Creating the context** **Planning the case study** Relevance of the selected concepts and of the steps in the procedure		☐ With hellp	
2	**Analyzing results and drawing conclusions** Formulation of the analysis, the conclusion and the description of the environmental characteristics		☐ With help	
3	**Creating the context** **Planning the case study** **Completing the case study** **Analyzing results and drawing conclusions** Use of scientific vocabulary		☐ With help	

*** Evaluation criteria**

1 Accurate interpretation of scientific and technological messages
2 Appropriate production or sharing of scientific and technological messages
3 Use of appropriate scientific and technological terminology, rules and conventions

Evaluation grid

Name: _____ Group: _____

SSC1 Seeks answers or solutions to scientific or technological problems

Criteria*	Observable indicators	A	B	C	D	E
1	**Creating the context** Definition of the goal and formulation of the hypothesis	The goal and hypothesis are very clearly defined and relevant to the case study.	The goal and hypothesis are clearly defined and relevant to the case study.	The goal and hypothesis are not very clearly defined OR are not very relevant to the case study.	The goal and hypothesis are not very clearly defined AND are not very relevant to the case study.	The work must be done again.
2	**Planning the case study** Relevance of the elements of the plan of action: materials and procedure	The list of materials is complete. The procedure is relevant and very clear.	The list of materials is almost complete. The procedure is relevant and clear.	Many elements are missing from the list of materials, OR the procedure is not very relevant or clear.	Many elements are missing from the list of materials, AND the procedure is irrelevant or unclear.	The work must be done again.
3	**Completing the case study** Relevance and accuracy of the recorded observations	All of the observations are relevant and accurately recorded.	Most of the observations are relevant and accurately recorded.	Some of the observations are irrelevant OR are not accurately recorded.	Most of the observations are irrelevant AND are not accurately recorded.	The work must be done again.
4	**Analyzing results and drawing conclusions** Relevance of the results analysis and of the conclusion	The results analysis and the conclusion are very clear.	The results analysis and the conclusion are clear.	The results analysis OR the conclusion is not very clear.	The results analysis AND the conclusion are not very clear.	The work must be done again.

* Evaluation criteria

1 Appropriate representation of the situation
2 Development of a suitable plan of action for the situation
3 Appropriate implementation of the plan of action
4 Development of relevant conclusions, explanations or solutions

Name: _____ Group: _____

Evaluation grid

SSC3 Communicates in the languages used in science and technology

Criteria*	Observable indicators	A	B	C	D	E
1	**Creating the context** **Planning the case study** Relevance of the selected concepts and of the steps in the procedure	All of the selected concepts and the steps in the procedure are relevant.	Most of the selected concepts and the steps in the procedure are relevant.	Some of the selected concepts OR some of the steps in the procedure are relevant.	Only a few of the selected concepts AND a few of the steps in the procedure are relevant.	The work must be done again.
2	**Analyzing results and drawing conclusions** Formulation of the analysis, the conclusion and the description of the environmental characteristics	The results analysis and the conclusion are very clear, and all the environmental characteristics are well described.	The results analysis and the conclusion are clear, and most of the environmental characteristics are well described.	The results analysis and the conclusion are not very clear, OR most of the environmental characteristics are poorly described.	The results analysis and the conclusion are not very clear, AND most of the environmental characteristics are poorly described.	The work must be done again.
3	**Creating the context** **Planning the case study** **Completing the case study** **Analyzing results and drawing conclusions** Use of scientific vocabulary	Scientific vocabulary is used throughout the student log.	Scientific vocabulary is not used in some parts of the student log.	Scientific vocabulary is not used in many parts of the student log.	Scientific vocabulary is barely used at all in the student log.	The work must be done again.

*** Evaluation criteria**

1 Accurate interpretation of scientific and technological messages

2 Appropriate production or sharing of scientific and technological messages

3 Use of appropriate scientific and technological terminology, rules and conventions

Information documents

Oil spills: cleaning up the mess

On November 21, 2004, Newfoundland's coastal waters had that sheen that comes from a crude oil spill. Up to 170 000 litres of oil were spilled at the Terra Nova oil platform off the southeast coast, creating a slick approximately nine kilometres long and one kilometre wide. This story was national news.

Canadians hear only about the biggest oil spills, but oil spills occur every day. In Canada, there are about 12 reported spills of 4000 litres or more each day (one of which occurs in navigable waters). Some spills are unintentional, like the Terra Nova production spill in November 2004, while others are deliberate illegal discharges of bilge oil—a ship's waste oil.

As long as society depends on oil and petroleum products, spills are a substantial risk. Understanding environmental impacts, along with contingency planning, is needed to mitigate the effects of oil spills.

Environmental impacts

Oil spilled at sea has numerous environmental impacts affecting everything from sea birds to sea life to life on land.

Sea birds

Birds are some of the most sensitive creatures to oil exposure. Oil is readily absorbed into birds' feathers. When that happens, it decreases insulation from the cold as well as their waterproofing and buoyancy. A drop of oil the size of a quarter on a bird's feathers is sufficient to destroy the insulation and waterproof characteristics of the plumage. Like a pinhole in a diver's dry suit, their 40-degree-Celsius bodies are rapidly cooled by the near-zero-degree water. The birds are also poisoned by the oil when they clean it off themselves. This inevitably leads to their deaths by hypothermia, poisoning or starvation. This level of sensitivity is why oil pollution from ships travelling off Canada's coasts causes the deaths of hundreds of thousands of sea birds every year.

Sea life

Sea plants and sessile (immobile) organisms are especially impacted by oil absorption. Fresh crude oil has an abundance of volatile compounds, such as benzene and toluene, which are readily absorbed through the skin or plant membrane and are toxic.

FAST FACTS

About 10 million tonnes of oil and petroleum products are used worldwide each day. However, only a small percentage of oil used is actually spilled.

More than 300 000 sea birds are killed each year off Canada's Atlantic Coast by chronic illegal marine waste oil discharge. That is equivalent to an *Exxon Valdez*-level impact every winter.

Methods of recovered oil disposal include direct reuse in refineries or heating plants, use as road cover, incineration, and disposal in landfill sites.

Information documents *(continued)*

Animal feeding behaviour can change. Seals sometimes react to oiling by not eating, which compounds the negative effects of the oil. Loss of habitat can also make it difficult for an animal to find proper shelter or food sources.

Fish and shellfish may be tainted and unsuitable for eating for a year or more. Spill areas are sometimes closed to commercial fishing as a precaution.

Life on land

All plant and animal life on oiled shorelines is harmed through direct contact with the oil, ingestion of oil, smothering, and destruction of habitat and food sources. Oil is harmful to shore birds and mammals, such as seals, sea lions and walruses. If a beach where they lay their eggs or give birth to pups is oiled, many of the young die after coming in contact with the oil.

Intertidal[1] life forms are also particularly vulnerable to oil since they consist primarily of plants and animals that move slowly or not at all. It takes from months to years for an oiled intertidal zone to be recolonized. Intertidal life may also be damaged by cleanup efforts due to movement of people and vehicles and by cleaning water that is either too hot or under high pressure.

Cleaning up the mess

When it comes to environmental emergencies, no single organization can do it all. Effective emergency response requires teamwork among governments, industry, communities and local organizations. Federally, Environment Canada, Natural Resources Canada, Fisheries and Oceans Canada, the Canadian Coast Guard, Transport Canada and Public Safety and Emergency Preparedness Canada may each have a role to play depending on the incident.

Contingency planning is an important step in ensuring effective response to oil spills. Response teams include operations, science and communications personnel. Action planning includes stopping the flow of oil, containing the oil and cleaning it up.

The fate and behaviour of oil on shorelines is influenced by many factors, some of which relate to the type of oil, some to characteristics of the shoreline, and others to conditions when the oil is deposited on the shoreline, such as weather and waves. For example, an oil slick could be carried by surface currents or winds to areas where it causes the greatest damage to wildlife habitat. On the other hand, a slick could be carried out to the deep sea, where it disperses naturally and has lesser direct effect on the environment.

1. Intertidal: referring to the area between the high- and low-tide marks.

FAST FACTS

Studies have shown that benzene, toluene and many other volatile compounds are present in samples downwind of an oil burn. These compounds are usually measured at even higher concentrations from an evaporating oil slick that is not burning.

Remote sensing instruments are used onboard aircraft, and satellites such as Canada's Radarsat are used to detect and track oil spills.

Booms—floating mechanical barriers designed to stop or divert the movement of oil on the water—are the most frequently used piece of oil spill cleanup equipment.

Information documents *(continued)*

Three major approaches to physical recovery of oil from the water surface are skimmers (used to remove oil from the surface), sorbents (that recover oil through absorption) and manual recovery. All of these approaches require relatively calm water conditions.

Alternatives for oil spill cleanup include in-situ burning and chemical treatments. In-situ burning involves controlled burning of the oil. The major advantage of this technique is its potential for removing large amounts of oil over an extensive area in less time than other techniques. The major disadvantage is the toxic emissions from the smoke produced. This technique also requires relatively calm water conditions.

Treating the oil with specially prepared chemicals is another option for dealing with oil spills. An assortment of chemical spill-treating agents, such as dispersants, is available to assist in cleaning up or removing oil. However, these agents are not always effective, and the treated oil may be toxic to aquatic and other wildlife. . . .

Source: Environment Canada, "Oil Spills: Cleaning Up the Mess," *EnviroZine* [online news magazine], January 13, 2005 (accessed October 7, 2009).

Information documents *(continued)*

EXAMPLES OF ABSORBENT MATERIALS

Cotton fibre

Cotton fibre comes from the seeds of a shrub called a cotton plant. The fibre can be harvested when the seeds are ripe. Cotton fibre is inexpensive and biodegradable. However, the many chemicals used in large-scale cotton farming may be harmful to the environment.

Cotton fibre can be used as is. For example, absorbent cotton, better know as *cotton wool,* is widely used in the fields of medicine, personal hygiene and cosmetics. Cotton fibre can also be spun into cloth, lace or other materials.

Natural sponge

Natural sponges are made from the dried and treated skeletons of aquatic animals. Sponges are found in seas and oceans but also in some lakes and rivers. There are over 5000 varieties of sponges, but only about 15 of them are collected for sale.

Cat litter

The composition of cat litter varies considerably from one manufacturer to another. However, the basic substance is usually dried and granulated clay. The clay comes from fine-grained sedimentary rock containing at least 50 percent aluminosilicate, a type of mineral.

Vermiculite

Vermiculite is a mineral with a complex chemical formula. When heated, it expands considerably. This expansion makes it porous, thus giving it absorbing and insulating properties. For these reasons, it is used in hydroponics and to improve soil texture.

Perlite

Perlite is a silica-based expansive volcanic rock. It is used principally to improve soil texture. When heated, it can expand to as many as 20 times its volume. It then forms highly porous white granules. The pores in these granules hold the moisture that plants need to grow, and they aerate the soil.

Absorbent paper

Absorbent paper is made from wood fibres. Although it is derived from natural materials, its production involves considerable processing. It can also be made from recycled paper or cardboard, which reduces its environmental impact. Absorbent paper, like wood, is biodegradable.

Polyester fibre

Polyester fibre is made from petroleum-based polymers. Its manufacture is similar to that of plastic. Also like plastic, polyester fibres are not biodegradable. However, the fibre is very strong and presents certain other advantages. It can also be recycled or manufactured from recycled products, such as plastic bottles.