

Task 1. Urban Sprawl and the Environmental Impact of Transportation Choices

Background: The Greater Toronto Area (GTA) has gone through rapid growth, with urban areas growing into areas that had been rural. People that move to these new suburban areas tend to rely on cars for travel. The increase in car traffic requires more roadways and other support structures, such as gas stations. Rapid public transit could reduce the volume of car traffic, but people require reliable service.

Long-time residents of these small towns and rural areas are concerned that various ecosystems are at risk with increased car traffic and building projects. Others focus on how more cars in the area mean more greenhouse gas emissions. They believe that better town planning and transportation planning will mean that fewer cars are needed. Some people want all future development stopped. The provincial government at Queen's Park is reviewing these concerns.

Resources:

Several student worksheets/ resources support the task:

- ▶ Appendix 1.1 *Checklist of Preparation - Urban Sprawl and the Environmental Impact of Transportation Choices* helps the student keep track of the information and skills they need to prepare for the assignment.
- ▶ Appendix 1.2 *Summary of the Kyoto Protocol* provides an overview of the Protocol and its goals.
- ▶ Appendix 1.3 *Student Task and Expectations: Urban Sprawl and the Environmental Impact of Transportation Choices* outlines the task and identifies the expectations covered.
- ▶ Appendix 1.4 *Environmental Assessment* and Appendix 1.5 *Cost-Benefit Analysis Form* organize the students' work to help ensure that they have all the information necessary to complete the task.

Scenario: Plans for a new suburb to be built next to the town of Mediumville are awaiting final government approvals. It is located 100 kilometres outside of Toronto, and will provide housing for people who work in the city but cannot afford homes there. This new suburb will be built on land that is currently a large farm. It has a wetland and a small forest between the planned subdivision and Toronto. No thought has been given to any kind of organized public transit strategy, either within the suburb, or between it and Toronto. Students are asked to identify a public transit strategy for this planned new suburb, in the hopes of addressing some of the current residents' concerns about its impact on the surrounding environment.

Student Task: Students will prepare two reports that outline their findings about the environmental impacts, and write a letter to their local MPP. In this letter, they will suggest a plan of action that helps to meet the goal of the Kyoto Protocol to reduce greenhouse gas emissions.

Teacher resources have been developed:

- ▶ Strand-by-strand Focus Questions are supplied to help organize ideas and lessons to support the task.
- ▶ Appendix 1.6 *Environmental Impact—sample answers* has been included to provide a sample of completed worksheets.
- ▶ Appendix 1.7 *Cost-Benefit Analysis Report—sample answers*
- ▶ Appendix 1.8 *Sample Letter to MPP*
- ▶ Appendix 1.9 *Evaluation Rubric for Environmental Assessment*
- ▶ Appendix 1.10 *Evaluation Rubric for Cost-Benefit Analysis*
- ▶ Appendix 1.11 *Evaluation Rubric for Letter to MPP*

Expectations

[Note: examples in square brackets are additions tailored for this resource.]

		CH1.08P	name and write the formulae for common ionic and molecular compounds
BY1.06P	describe how different ecosystems respond differently to short-term stresses and long-term changes	CH3.01P	use scientific nomenclature to identify common consumer products
BY2.01P	through investigations and applications of basic concepts, identify a current local concern or issue involving an ecosystem [e.g. the impact of building roads and houses in areas that were fields and forests]	CH3.03P	relate chemical reactions (including rates of reactions) to familiar processes encountered in everyday life [e.g., greenhouse gases]
BY2.04P	through investigations and applications of basic concepts select and integrate information from various sources, including electronic, print, and community resources, to answer the question chosen	ES3.01P	identify the impact of climate change on economic, social, and environmental conditions
BY3.01P	assess the impact of technological change on an ecosystem	PH3.01P	perform a cost-benefit analysis, including environmental and safety factors, of technologies which have enabled us to attain ever-faster speeds on land and water and in the air, and of alternative modes of transportation
BY3.03P	identify and evaluate Canadian initiatives in protecting Canada's ecosystems [e.g. the Kyoto Protocol]	PH3.02P	investigate the benefits and risks to the community and the individual of alternatives to motor-vehicle transportation

Prior Learning Required for this Task

The task requires that the student have a basic understanding of one of the main goals of the Kyoto Protocol which Canada has ratified – to reduce greenhouse gas emissions (to 6% below 1990 levels by the 2008-2012 period). This is the context within which the research, analysis and application is pursued. See Appendix 1.2 for a one-page student summary of the Kyoto Protocol.

The Ontario EcoSchools multimedia presentation The Science of Climate Change has been designed specifically for Grade 10 Science (see back cover for ordering information).

Fundamental Skills

▶ *Read and Analyse*

Students need to be able to read material and identify/classify key ideas:

Problem

Processes

Factors

Effects

Costs

Benefits

Concept mapping activities or using other graphic organizers that help students find and classify information would provide practice.

▶ *Research*

Students need to be able to find information on changing ecosystems. This may include comparing biodiversity at different locations of the school grounds or neighbourhood. Activities that support this require students to find and interpret data. *As students learn about ecosystems in the Biology strand, they should work with the same text and electronic resources that will be available for the summative task.*

▶ *Risk Analysis*

Students need to be able to identify and assess the costs and benefits of various activities or choices. What is the environmental impact of drinks packaged in recyclable containers compared to non-recyclable containers? In particular, students need to assess the environmental impact of various transportation choices, such as public transit vs. bicycles as a way to get to school.

Science Background

See “How Approved Textbooks Link to Learning about Climate Change” (pages 45-48) for a strand-by-strand list of climate change topics in Science textbooks.

▶ ***Biology: Ecosystems and Human Activity***

Textbooks often present a generic ecosystem for describing the parts and processes of such a system. Students need to consider how specific elements in a specific ecosystem respond to short-term and long-term stress. For example, how does a two-lane road affect organisms on either side? How does a divided highway affect those organisms?

▶ ***Chemistry: Chemical Reactions and their Practical Applications***

Vehicular exhaust is a source of greenhouse gases (GHGs). A number of these gases (but not CO₂) are measured as part of the Drive Clean Program. You may want to have students compare how different gases act differently in the atmosphere.

▶ ***Earth and Space Science: Weather Systems***

This strand gives students ample opportunity to learn and explain how the atmosphere is linked to the flow of energy on Earth. Looking at Canadian climate change sites, students can explore the current state of change and predictions for the future. Special consideration of Ontario would help prepare them for the summative task.

▶ ***Physics: Motion and Its Applications***

Students must have some experience analyzing data for different modes of transportation. Many factors can be considered, such as price, personal choice, existing infrastructures and environmental impact. Ideally, students will have begun to think in terms of the cost and benefits of different transportation systems such as bikes, cars, diesel trucks and trains.

Focus Questions – Connections to Climate Change

These strand-by-strand questions are provided to suggest ways to organize ideas as you plan your lessons with the culminating task in mind.

Biology: EcoSystems and Human Activity

Focus Questions

How is the carbon cycle related to climate change?

What are the consequences of changing the carbon balance?

How does the production of CO₂ affect the carbon cycle?

How does CO₂ change the amount of heat in the atmosphere?

How much CO₂ makes a difference?

What are the consequences of CO₂ changes on ecosystems?

How can production of CO₂ be measured?

What new technologies can monitor and reduce carbon production?

What kinds of transportation would help meet the targets of the Kyoto Protocol?

How do governments in Canada support sustainable practices?

Climate Change Connections

- ▶ Any model of the carbon cycle for an ecosystem can act as a model for a *carbon budget* for the planet. This accounting framework measures carbon stocks and fluxes (inputs and outputs) by identifying *sources* that emit carbon into the atmosphere and *sinks* that remove carbon from the atmosphere. A balance of sources and sinks means that global levels remain the same. Activity that disturbs this balance can then be identified.
- ▶ Heat is an important abiotic factor that helps make the connection between the details of a specific ecosystem and the global context. Increased energy in the atmosphere affects both wind and water currents, affecting weather and climate patterns.
- ▶ Canadian initiatives include technology development, especially the development of “green” technology that has a small ecological footprint, and a system of national parks that protect ecosystems.
- ▶ Explicitly consider the Kyoto Protocol in terms of technology use and development.
- ▶ Clean emissions testing monitors the production of various waste materials from vehicles, including carbon monoxide, but not carbon dioxide.
- ▶ Government policy and support for “green” technology can be explored and assessed.
- ▶ The belief in the need for sustainable activity underlies some policy choices and technological innovation. As more people are affected by the consequences of change, they begin to understand the need for sustainable practices.

Chemistry: Chemical Reactions and Their Practical Applications

Focus Questions

What are some of the chemical products of vehicle emissions?

How can the products of one chemical reaction affect the reactions of other substances in the environment?

What are some of the greenhouse gases (GHGs)?

How do GHGs affect the environment?

How do we assess the environmental impact of a chemical process?

How is the chemical nature of the atmosphere changed with the addition of some of the wastes of human processes?

Climate Change Connections

- ▶ Many industrial and technological processes have a chemical impact on the environment. Reactions of interest should include combustion of carbon compounds to form greenhouse gases, and the products of oxidized metal, which can result from increased air pollution.
- ▶ Products formed by the combustion of organic compounds such as oil, wood or natural gas are released into the environment.
- ▶ Simple chemical equations help explain the processes that form various greenhouse gases.
- ▶ The concentration of greenhouse gases changes the impact of these gases on ecosystems and global climate patterns.
- ▶ Use specific greenhouse gases (including carbon monoxide) and other carbon compounds to reinforce students' understanding of the components of the carbon cycle.
- ▶ Carbon dioxide is the product of many reactions. Identify technology that exists that measures the concentration of carbon dioxide, carbon monoxide and other greenhouse gases. (Ontario's Drive Clean program presents an example of how monitored emissions are used to help track the impact of vehicles on the environment.)
- ▶ Different "green" products or choices can be explored. Sometimes products are "green" because an output (water bottle) is added to a new system that cycles the matter (as fleece clothing). Other products are "green" because they are produced through efficient energy use.

Earth and Space Science: Weather Systems

Focus Questions

What is the global radiation balance?

How does CO₂ concentration in the atmosphere affect the global radiation balance?

What is the flow of energy in the atmosphere and hydrosphere?

How does human activity affect the global radiation balance?

How do changes to the global radiation balance affect us?

What are the potential consequences for climate change?

Climate Change Connections

- ▶ Explain the global radiation balance in terms of energy arriving from the sun and energy leaving the planet to outer space. Then consider how changes to the atmosphere caused by greenhouse gases affect this balance of incoming and outgoing energy. The greenhouse gases absorb outgoing radiation, so less energy leaves the Earth. The solar radiation arriving is almost constant, so the imbalance increases and high levels of energy are retained.
- ▶ With a net change that results in more energy in the atmosphere, the transfer of energy changes affects both trade wind patterns and ocean current patterns. Climate change is a consequence of these energy changes.
- ▶ Heat transfer is studied in terms of changes in the hydrosphere. This is where heat transfer takes place and where the consequences develop.
- ▶ Consider the consequences of shifting wind patterns and ocean current patterns. This is like climate modeling, and allows students to consider possible future scenarios.

Physics: Motion and Its Applications

Focus Questions

How can transportation systems be defined?

What are the costs and benefits of different transportation systems [in terms of energy use or in terms of CO₂ production]?

What is the environmental impact of different transportation systems?

Why are some transportation systems preferred over other systems?

How do the choices relate to individual needs, various commercial interests and flexible transportation options?

Climate Change Connections

- ▶ Transportation systems can be defined and compared in terms of energy use and CO₂ production.
- ▶ Compare these systems' energy use or CO₂ production to assess the environmental cost of transporting a number of people from one place to another. An example could be a measure of CO₂ production by different students as they travel to school (by bus, car, bike, walk, other).

Resources

Textbooks

See “How Approved Textbooks Link to Learning about Climate Change” (page 45-48) for a strand-by-strand list of climate change topics in Science textbooks.

Websites

Carbon budget

<http://www.climatechangesolutions.com/science/greenhouse/budget.shtml?o=gases&r=budget>

Simple explanation of model with sample values.

<http://geochange.er.usgs.gov/pub/carbon/fs97137/>

This is a very helpful site that puts the idea of the carbon budget in the climate change context, with specific reference to the Mississippi Valley.

Ecosystems

http://www.ec.gc.ca/ecos_e.html

This site from Environment Canada has information about ecosystems across Canada, and in the Great Lakes region.

<http://www.climatehotmap.org/impacts/greatlakes.html>

This is an American site that looks at how human activity has compromised, and continues to compromise, the Great Lakes region.

<http://www.ucsusa.org/greatlakes/>

This excellent site from the Union of Concerned Scientists has links to many PDF files. The focus is to link climate change to ecosystems in the area with an overall view of climate models, extreme weather and actions we can choose.

<http://www.epa.gov/glnpo/ecopage/>

This site has many links that are useful for ecosystem studies.

Vehicle Exhaust

http://www.lungusa.org/air/airout00_diesel.html

This site is simple and points out that diesel exhaust includes many different compounds that affect human health.

<http://www.osha.gov/SLTC/dieselexhaust/chemical.html>

A good list that includes many components of diesel exhaust. Each chemical listed links to a chemical sampling information page.

http://www.planetdrum.org/guard_fox_watch.htm

A site devoted to finding sustainable solutions by developing bioregional activities. This page looks at the environmental impact of transportation routes and vehicular traffic in an environmentally sensitive area (The Winter Olympics in Nagano).

<http://www.nutramed.com/environment/carschemicals.htm>

There are many links on this site. This site identifies health risks from exhaust chemicals.

<http://www.nrdc.org/air/transportation/ebd/chap2.asp>

Good site with health risks outlined and specific chemical products listed.

Weather

http://www.ec.gc.ca/TKEI/cc_weather/s_weather_e.cfm

This site explains what is meant by “severe weather” and uses Canadian examples as illustrations.

<http://www.epa.gov/glnpo/atlas/glat-ch2.html>

Some basic information about climate in the Great Lakes region.

<http://www.ucsusa.org/greatlakes/pdf/temperature.pdf>

More detailed look at the impact of climate change on the Great Lakes region.

<http://www.great-lakes.net/envt/refs/weather.html>

A site that provides weather information for local areas.

Transportation

<http://www.vtppi.org/tca/tca0514.pdf>

Chapter 14 of the Victoria Transport Policy Institute’s *Transportation Costs and Benefits Analysis* guide focuses on “Land Use Impacts.” It provides a comprehensive and detailed account that may be helpful background information for the teacher wanting to have a more detailed understanding of the connections between urban sprawl and transportation modes.

In particular, the “Environmental Degradation” section (pages 5 - 8) in this chapter bears very directly on the culminating task outlined above.

<http://www.niwa.cri.nz/ncces/co2calc/>

This New Zealand Residential CO₂ Calculator site allows students to calculate the amount of CO₂ produced by cars using gas or diesel, when distance (in km) is used.

<http://www.ene.gov.on.ca/cons/371706.htm>

Ontario’s Drive Clean Program site.

<http://www.eia.doe.gov/oiaf/1605/gg96rpt/chap2.html>

This site shows that CO₂ emissions from transportation produces about one-third of USA carbon emissions.

Other Sites

<http://www.ekes.org/climate/individaction.html>

Individuals taking action to help the environment.

http://climatechange.sea.ca/climate_change.html

An overview of climate change – brief history, the debate, the greenhouse effect, the causes/sources, implications of temperature rise and the Kyoto protocol.

Appendix 1.1 *Checklist of Preparation - Urban Sprawl and the Environmental Impact of Transportation Choices*

As you work through the course of study, remember to use the checklist periodically to track the key ideas and skills you are acquiring as you prepare for the final assignment.

Checklist of Preparation

I can

- identify short-term and longer-term changes in an ecosystem.

- research information about an ecosystem

- identify costs and benefits of change

- identify chemical products of vehicle exhaust

- identify the greenhouse gases produced by various transportation systems

- describe safety factors for various transportation systems

- identify activities that relate to meeting the goal of the Kyoto Protocol to reduce greenhouse gas emissions

- assess the environmental impact of different methods of transportation

Appendix 1.2 *Summary of the Kyoto Protocol*

Countries around the world have recognized that climate change affects us all. The volume of greenhouse gases produced by human activity, added to the gases occurring naturally in the atmosphere, has led to extreme weather events, temperature changes and the melting of the Arctic icecaps.

In December 1997, Canada and more than 160 other countries met in Kyoto, Japan, and agreed to targets to reduce greenhouse gas emissions. The agreement that set out those targets, and the options available to countries to achieve them, is known as the Kyoto Protocol. Canada's target is to reduce its greenhouse gas (GHG) emissions to 6 percent below 1990 levels by the period between 2008 and 2012. The goal of Kyoto is to reduce the total emissions of industrialized countries to 5.2% below 1990 levels.

The Government of Canada and the provincial/territorial and municipal governments are working together to achieve reductions in greenhouse gases. Investment in new technologies will help business to operate in a more efficient way and Canadians will benefit by having a cleaner environment. The Kyoto Protocol allows the presence of carbon sinks to count toward a country's commitment to reduce greenhouse gases. A "sink" is any process that removes greenhouse gases from the atmosphere. For example, forests form a carbon "sink" through the process of photosynthesis – trees and other plants take

up carbon dioxide (CO₂) and break it down. The oxygen (O₂) is released and the carbon (C) becomes part of the tree.

The Kyoto Protocol allows countries to buy carbon credits from other countries. This means that countries that reduce their greenhouse gas emissions by more than is required under Kyoto can sell their unused carbon credits to countries that find it difficult or expensive to reduce emissions¹. This is called emissions-reduction trading. In other words, countries that have "overperformed" (met and exceeded their target for reduction) may sell their "unused right to pollute" to countries that have failed to meet their emissions reduction target. Canada believes that a solution that uses the market has a part to play in achieving an overall reduction of greenhouse gases globally.

It is important that countries that have signed the Kyoto Protocol comply with the rules. To that end, Canada is working to build an effective way to measure whether everyone is doing their part. This is a way of checking that countries obey the rules agreed upon, giving them strong incentives to take their commitments seriously.

Based in part on information found at www.climatechange.gc.ca.

For a glossary of terms, please see the Resources section at the end of this document.

¹ While it may appear strange that one country can buy the right to pollute from another country, remember that the total emissions of participating countries selling and buying carbon "credits" are to reach the agreed upon targets between 2008 and 2012. Some believe that countries being able to pay others in order to keep polluting is wrong; others say that it is a way of encouraging those who can to make greater reductions while penalizing those who don't.

Appendix 1.3 *Student Task and Expectations: Urban Sprawl and the Environmental Impact of Transportation Choices*

Purpose: Recommend a public transit strategy for a proposed new suburb and assess the impacts of public and private transportation on ecosystems and (over the longer term) climate.

Background: The Greater Toronto Area has gone through rapid growth, with urban areas growing into areas that were rural. People that move to these new areas tend to rely on cars for travel. The increase in car traffic requires more roadways and other support structures, such as gas stations. Rapid public transit could reduce the volume of car traffic, but people require reliable service.

Long-time residents of these small towns and rural areas are concerned that various ecosystems are at risk with increased car traffic and building projects. Others focus on how more cars in the area mean more greenhouse gas emissions. They believe that better town planning and transportation planning will mean that fewer cars are needed. Some people want all future development stopped. The provincial government at Queen's Park is reviewing these concerns.

Scenario: Plans for a new suburb to be built next to the town of Mediumville are awaiting final government approvals. It is located 100 kilometres outside of Toronto, and will provide housing for people who work in the city but cannot afford homes there.

This new suburb will be built on land that is currently a large farm. It has a wetland and a small forest between the planned subdivision and Toronto. No thought has been given to any kind of organized public transit strategy, either within the suburb, or between it and Toronto. You are asked to identify a public transit strategy for this planned new suburb, in the hopes of addressing some of the current residents' concerns about its impact on the surrounding environment.

Assignment: Complete Appendix 1.4 *Environmental Assessment*, Appendix 1.5 *Cost-Benefit Analysis Report Form*, and a letter to your Member of Provincial Parliament (MPP) at Queen's Park. In the letter, suggest a plan of action that helps to meet the goal of the Kyoto Protocol to reduce greenhouse gas emissions.

Expectations: Use this list of expectations, along with Appendix 1.1 *Checklist of Preparation* to help you complete your assignment:

- ▶ describe how different ecosystems respond differently to short-term stresses and long-term changes
- ▶ through investigations and applications of basic concepts, identify a current local concern or issue involving an ecosystem [such as the impact of building roads and houses in areas that were fields and forests]

- ▶ through investigations and applications of basic concepts select and integrate information from various sources, including electronic, print, and community resources, to answer the question chosen
- ▶ assess the impact of technological change on an ecosystem
- ▶ identify and evaluate Canadian initiatives in protecting Canada's ecosystems [such as the Kyoto Protocol]
- ▶ name and write the formulae for common ionic and molecular compounds [such as combustion products of cars]
- ▶ use scientific nomenclature to identify common consumer products relate chemical reactions to familiar processes encountered in everyday life [such as greenhouse gases]
- ▶ identify the impact of climate change on economic, social, and environmental conditions
- ▶ perform a cost-benefit analysis, including environmental and safety factors, of technologies which have enabled us to attain ever-faster speeds on land and water and in the air, and of alternative modes of transportation
- ▶ investigate the benefits and risks to the community and the individual of alternatives to motor-vehicle transportation

Appendix 1.4 *Environmental Assessment*

Summary of the proposed subdivision:

- ▶ To be built next to the town of Mediumville (current population: 10,000), 100 kilometres outside of Toronto
- ▶ Currently, a mix of low density suburban and rural dwellings in the area
- ▶ Building project will mean 3000 new, fully detached houses located just south of Mediumville—expected population increase of approximately 10,000 people

ENVIRONMENTAL ASSESSMENT

A. Ecosystems

Features of the ecosystems in the housing development area:

The proposed housing development is situated on farmland that has a wetland and a small forest between the subdivision and Toronto.

Predicted Short-term Ecosystem Changes	Predicted Longer-term Ecosystem Changes
▶	▶
▶	▶
▶	▶

B. Greenhouse Gases

List the greenhouse gases that will be produced as a result of this new subdivision.

* Provide names and formulas.

Cars, trucks and heavy machinery	Homes (through heating/cooling and other processes)
▶	▶
▶	▶
▶	▶

C. The Kyoto Protocol

What is the main goal of the Kyoto Protocol?

What is the link between the Kyoto Protocol and this new subdivision?

D. Reducing Greenhouse Gas Emissions

Reduce greenhouse gas emissions by suggesting different strategies to meet new residents' transportation needs.

Within the new housing development, and between it and the adjacent town of Mediumville	Between the new housing development and Toronto
<ul style="list-style-type: none">▶ ▶ ▶	<ul style="list-style-type: none">▶ ▶ ▶

Appendix 1.5 *Cost-Benefit Analysis Form*

Compare the costs and benefits of personal and public transportation.

Transportation Mode	Individual Cost	Environmental Cost	Individual Benefit	Environmental Benefit	Safety
Personal Car					
Public Transportation					

Appendix 1.6 *Environmental Assessment - sample answers*

NOTES FOR THE TEACHER

Depending on the resources students are given (and the extent to which the Focus Questions have been used), students' answers may be considerably more extensive.
This sample should not be considered comprehensive.

A. Ecosystems

Features of the ecosystems in the housing development area:

The proposed housing development is situated on farmland that has a wetland and a small forest between the subdivision and Toronto.

Predicted Short Term Ecosystem Changes	Predicted Longer-term Ecosystem Changes
<ul style="list-style-type: none"> ▶ <i>migration of small animals/insects</i> ▶ <i>soil erosion as land is being cleared for buildings/roads</i> 	<ul style="list-style-type: none"> ▶ <i>loss of productive farmland</i> ▶ <i>loss of water filtration capacity as wetland is degraded</i> ▶ <i>lower water quality as rainwater will run off straight into the river when homes and roads are built</i> ▶ <i>increase in CO₂ and other greenhouse gases from home energy consumption and vehicle exhaust</i> ▶ <i>trees and landscaping may be done by homeowners, changing/replacing the forest and wetland habitats</i>

B. Greenhouse Gases

List the greenhouse gases that will be produced as a result of this new housing development.

* Provide names and formulas.

Cars, trucks and heavy machinery	Homes (through heating/cooling and other processes)
<ul style="list-style-type: none"> ▶ CO₂ carbon dioxide ▶ N₂O nitrous oxide 	<ul style="list-style-type: none"> ▶ CO₂ carbon dioxide ▶ N₂O nitrous oxide ▶ Halocarbons/chlorofluorocarbons (CFCs)

C. The Kyoto Protocol

What is the main goal of the Kyoto Protocol?

The Kyoto Protocol asks countries to reduce their greenhouse gas emissions which contribute to climate change (6% below 1990 levels in the period 2008-2012).

What is the link between the Kyoto Protocol and this new subdivision?

This new housing development will work against Canada's obligations to the Kyoto Protocol since it decreases our carbon sinks (the farmland, the wetland) and increases our carbon sources (through automobile use). Only adding a public transit strategy that gets people out of their cars will help to reduce additional greenhouse gas emissions.

D. Reducing Greenhouse Gas Emissions

Reduce greenhouse gas emissions by suggesting different strategies to meet new residents' transportation needs.

Within the new housing development, and between it and the adjacent town of Mediumville	Between the new development and Toronto
<ul style="list-style-type: none">▶ <i>Develop municipal public transit</i>▶ <i>Create bike/walking trails from the subdivision into Mediumville</i>▶ <i>Start a walk-to-school program to ensure that students walk rather than be driven</i>▶ <i>Encourage people to walk/carpool by charging a fee in all town parking lots</i>	<ul style="list-style-type: none">▶ <i>Link up with GO Transit bus or rail system</i>▶ <i>Provide free parking at the GO Transit or railway station</i>▶ <i>Organize car pools</i>

Appendix 1.7 *Cost-Benefit Analysis—sample answers*

NOTES FOR THE TEACHER

Depending on the resources students are given (and the extent to which the Focus Questions have been used), students' answers may be considerably more extensive.

This sample should not be considered comprehensive.

Transportation Mode	Individual Cost	Environmental Cost	Individual Benefit	Environmental Benefit	Safety
Personal Car	<ul style="list-style-type: none"> ▶ <i>Purchase price of car</i> ▶ <i>Maintenance</i> ▶ <i>Fuel</i> ▶ <i>Insurance</i> ▶ <i>License</i> 	<ul style="list-style-type: none"> ▶ <i>Most burn non-renewable resources</i> ▶ <i>GHG emissions</i> ▶ <i>Requires roads that disturb ecosystems</i> 	<ul style="list-style-type: none"> ▶ <i>Available any time (convenient)</i> ▶ <i>Comfortable</i> 		<ul style="list-style-type: none"> ▶ <i>Risk of accident is higher than when on public transportation</i>
Public Transportation	<ul style="list-style-type: none"> ▶ <i>Cost of ticket</i> 	<ul style="list-style-type: none"> ▶ <i>Some construction along route</i> ▶ <i>GHG emissions (fewer per person than private automobile)</i> 	<ul style="list-style-type: none"> ▶ <i>Travel time is freed up for activities such as reading, sightseeing, relaxing, sleeping!</i> 	<ul style="list-style-type: none"> ▶ <i>Produces proportionately fewer GHG emissions than car</i> ▶ <i>Fewer cars on the road</i> 	<ul style="list-style-type: none"> ▶ <i>Risk of accident is lower than when using personal car</i>

Appendix 1.8 *Sample Letter to MPP*

Names and address of Members of the Provincial Parliament (MPPs) may be found on the Legislature’s website: <http://olaap.ontla.on.ca/mpp/contact.jsp>

Refer to Appendix 1.11 *Evaluation Rubric for Letter* to make sure you have met the requirements of this assignment.

Date

Your Name

Your Address

MPP Name

MPP Address

Dear Mr./Ms. _____:

I am concerned about climate change and I am writing about the subdivision that is planned for Mediumville. I understand that people need a place to live, but I think the subdivision could be built in a way that reduces the impact on the environment.

Canada’s commitment to the Kyoto Protocol means that we will reduce our greenhouse gas emissions to 6% below 1990 levels. The proposed suburb will pave over farmland which produces food and acts as a “sink” to absorb carbon. The subdivision will also create more CO₂ emissions when people use their cars to go to Toronto. Wildlife habitat will also be destroyed.

One of the ways to keep our promise to reduce our greenhouse gas emissions is to get people out of their cars. We need public transportation systems that are affordable and convenient. There should be a local public transit service that links up with the GO Transit system to take people to Toronto. We need sidewalks, bike paths and walking trails so that people will not have to use their cars for all their errands.

I hope you will address the transportation needs of people who will live in Mediumville’s new subdivision so that greenhouse gas emissions will be reduced. In this way, the Ontario government is helping to meet Canada’s Kyoto commitments.

Sincerely,

Your Name

Appendix 1.9 *Evaluation Rubric for Environmental Assessment*

Description	Level 1	Level 2	Level 3	Level 4
K/U Understanding of concepts	Concepts are simple, with gaps.	Concepts are mostly simple and complete.	Ideas are developed in some depth.	Concepts are complete and developed with insight.
C Accurate use of scientific terminology, symbols, conventions and SI units	Limited accuracy of scientific terminology, symbols, conventions and SI units	Moderate accuracy of scientific terminology, symbols, conventions, and SI units	Considerable accuracy of scientific terminology, symbols, conventions, and SI units	A high degree of accuracy of scientific terminology, symbols, conventions, and SI units
C Use of information technology for scientific purposes	Researches appropriately, using the given resources	Researches appropriately using the given resources and useful additional sites	Researches appropriately using the given resources and additional sites that are effective	Researches appropriately using given sites and a variety of additional sites that are highly effective
MC Assessment of impacts of science and technology on the environment	Identifies how an ecosystem is at risk from a specific activity	Explains how an ecosystem at risk is affected by a specific activity	Explains how an ecosystem can be affected by aspects of the specific activity	Explains the impact of different elements of the specific activity on aspects of an ecosystem

Appendix 1.10 *Evaluation Rubric for Cost-Benefit Analysis*

Description	Level 1	Level 2	Level 3	Level 4
I Analysis and interpretation of data	Limited analysis and interpretation of data	Moderate analysis and interpretation of data	Considerable analysis and interpretation of data	Thorough analysis and interpretation of data
C Use of information technology for scientific purposes	Researches appropriately, using the given resources	Researches appropriately using the given resources and useful additional sites	Researches appropriately using the given resources and additional sites that are effective	Researches appropriately using given sites and a variety of additional sites that are highly effective
MC Assessment of impacts of science and technology on the environment	Identifies how an ecosystem is at risk from a specific activity	Explains how an ecosystem at risk is affected from a certain activity	Explains how an ecosystem can be affected by aspects of the specific activity	Explains the impact of different elements of the specific activity on aspects of an ecosystem
MC Analyses social and economic impact of transportation choices	Social and economic impacts are identified	Social and economic impacts are identified and linked to choices	Social and economic impacts are identified and effectively linked to choices	Social and economic impacts are explained and linked to choices effectively and with insight

Appendix 1.11 *Evaluation Rubric for Letter to MPP*

Description	Level 1	Level 2	Level 3	Level 4
K/U Understanding of concepts presented	Concepts presented are simple, with gaps.	Concepts are mostly simple and complete.	Concepts are developed with some depth.	Concepts are complete and developed with insight.
K/U Understanding of relationships between concepts	Concepts are presented with limited connections.	Concepts presented show simple connections.	Concepts have clear connections presented.	Concept connections are supported and developed thoroughly.
C Communication of information and ideas	Information and ideas are vague and presented with doubt.	Information and ideas are complicated or difficult to understand.	Information and ideas are presented clearly and understandably.	Information and ideas are presented simply, clearly and are easy to understand.
C Communicates with a purpose for the given audience	Audience and purpose varies.	Audience and purpose consistent.	Clear and consistent sense of audience and purpose.	Strong, clear sense of audience and purpose.
C Use of letter format	Text shows limited command of the formal letter	Text shows moderate command of the formal letter	Text shows considerable command of the formal letter	Text shows extensive command of the formal letter
MC Proposing courses of practical action in response to problems identified	Extends analyses of problems into courses of practical action with limited effectiveness	Extends analyses of problems into courses of practical action with moderate effectiveness	Extends analyses of problems into courses of practical action with considerable effectiveness	Extends analyses of problems into courses of practical action with a high degree of effectiveness