saskatchewan land surveyors association

LOCATION, LOCATION, LOCATION!!

Educational Guide for

SURVEYOR in a CRATE

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Note: Some activities in the Crate have been replace or modified from those proposed by the original authors.

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Introduction

“Location, Location, Location!!!” is the resource manual for the “Surveyor in a Crate” educational resource. It is designed to address the Western Canadian Curriculum Protocols (Science and Mathematics) and Saskatchewan Curriculum specifically where applicable for Grades 6 to 9. The design philosophy of this package is, however, that science and mathematics are best taught in an integrated forum. This includes integrating general objectives such as creative and critical thinking, communications, personal values and numeracy into the package.

The philosophy behind this package layout was to include enough information about each of the activities, demonstrations and projects to give teachers without a land surveying background some level of comfort before undertaking them in their classrooms. A background section is included to give some additional information and perhaps an approach to some of the activities.

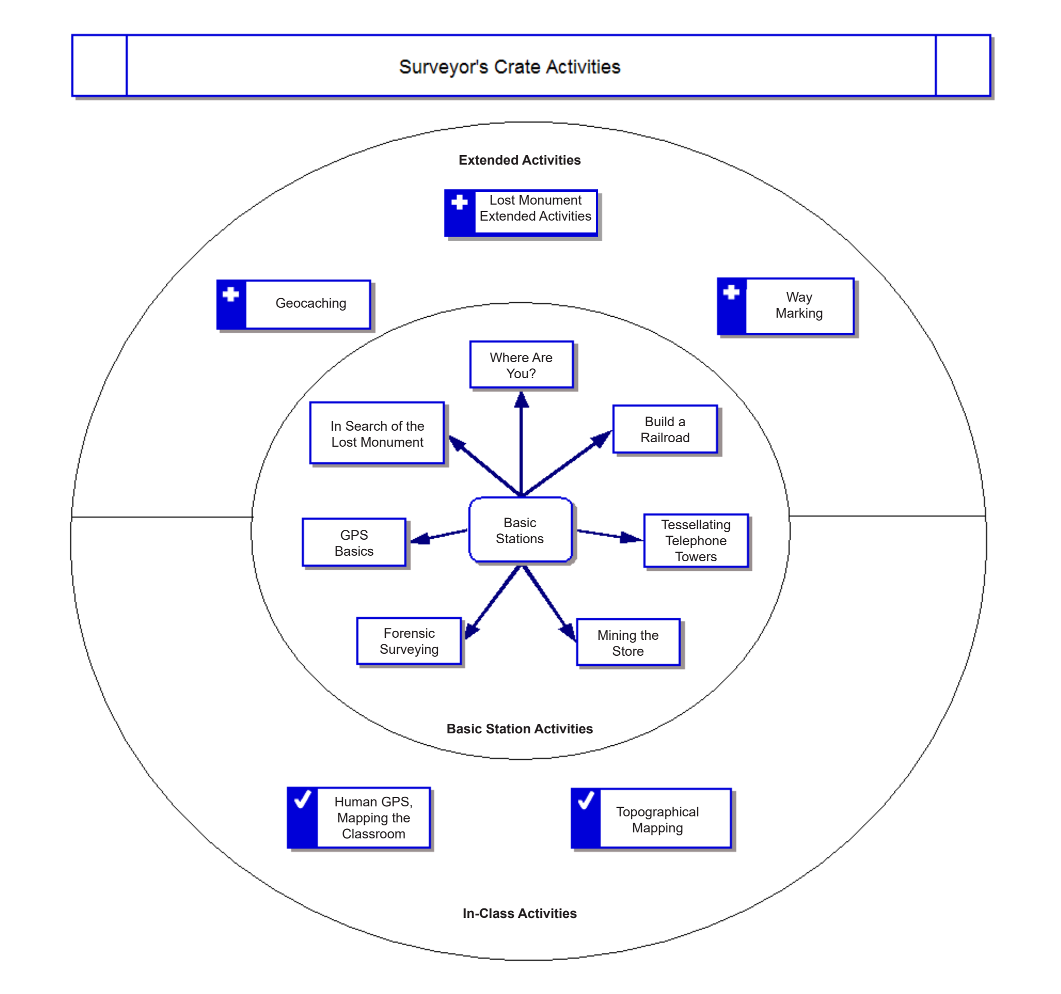
The activities included in this crate are broken into three general types: stations, in-class activities and outside-class activities. There are seven primary activities that can be carried out as part of a series of stations - activities that can be carried out as part of a larger group and may last more than one class period, and extension activities that may extend outside the classroom.

This resource manual is broken down into ten sections:

- Section one is this introduction.
- Section two gives the background information connected with the curriculum components, science, mathematics and social studies.
- Section three describes how the activities are laid out.
- Section four is an activity grid which identifies how each of the activities is connected to the curriculum and what type of activity it is.
- Sections five, six and seven detail the activities. Each activity includes, where appropriate:
  - An overview
  - Material and tools (Note—some activities require school supplied materials)
  - Time required
  - Activity Type (station, group or extended)
  - Background
  - Teacher Preparation if required includes the preliminary information the students need
  - Activity Directions, and
  - Activity pages (an answer sheet for the teacher and blank student pages).
- Section eight identifies any references quoted in the manual.
- Section nine identifies the permissions obtained in order to use some of the materials.
- Section ten includes the appendices—materials lists and a copy of all of the student activity pages for ease of copying. This ensures a second copy of these pages is available. Pages are identified by activity.

We recommend that, prior to beginning to prepare for any of the activities or demonstrations, the teacher read the whole activity and attempt it.

A smaller version of the student sheets are included in the appropriate activity in this manual to supply continuity. Full size versions are included with each activity within the crate and copies are included in the appendix.



This entire manual, including do-it-yourself instructions and graphics, are available on-line at:

www.slsa.sk.ca/teacher.php

Informational Background

Background to Surveyor in a Crate

Surveying and, in particular, the surveying of land, is one of the oldest professions of humans. From the simple determination and marking of territory to the sophisticated identification of boundaries, surveying and surveyors are critical to the effective management of activities within nations.

Historically, and even today, Land Surveying is required to plan and execute most construction, oversee the sectioning of lands to identify ownership, set out roads, railways and structures, and to create accurate records of how things were actually built.

Other branches of surveying involve the accurate determination of marine features (Hydrographic Survey), the identification of geological significant features (Geological Survey), investigation and reconstruction of accidents and crimes (Forensic Survey), and maps and features of ruins and ancient habitations (Archeological Surveys), to name a few. These are all included in the recently coined term "**Geomatics**".

Surveying is a critical precursor to map-making because, to accurately represent a body of land, water, mountain range or to determine political boundaries, accurate location information is needed.

The Egyptians used surveying to position the Great Pyramids. Land Surveying became a profession under the Romans, who used it to define the boundaries of part of their empire and to assess taxes. The English, in 1086 produced the "Domesday Book" which made reference to the ownership and description of lands in England although no maps were included. In 1808 Napoleon Bonaparte created Europe's first cadastre (a comprehensive register of the real property of a country, which commonly includes details of the ownership, the precise location, the dimensions (and area), the cultivations, if rural, and the value of individual parcels of land).

In Western Canada land is surveyed according to the Dominion Land Survey System similar to the rules used by the United States when they opened their land to settlement. The purpose of the survey, among other things, was to uniquely identify plots of land in Western Canada that could be easily found by groups coming to settle the land.

Survey instruments began as simple lengths of rope or chain to measure distances and an alidade or a compass to measure angles. Technology and the need for more accurate measurements required the development of new surveying equipment, tapes, levels and theodolites (an instrument for measuring both horizontal and vertical angles, used in triangulation networks and mounted on tripods).

Modern "Total Stations" (electronic versions of the theodolite that include a distance measurement device and a computer interface) are used for highly accurate survey measurement. Global Positioning Systems are sometimes integrated with "Total Stations" and can add to the range and accuracy of the measurements.

Activities

The three sections after the Activities Grid describe, in detail, the activities in each of the three categories. Information contained in each of the activities includes, when appropriate:

Activity Header containing:

- A single paragraph descriptor
- Materials
- Vocabulary
- Grade Level
- Time Required
- Curriculum Connections
- Science and Math Concepts
- Teacher Background
- Procedure
- Student Activities

The materials, laminated student sheets and other equipment for the activities—except for common classroom equipment such as pens, paper, protractors, globes, wall maps and calculators—are included in the Surveyor's Crate. Outside-the-classroom activities may refer to GPS units, which are also not included in the crate.

Activity Grid

Activity		Social Studies	Science	Mathematics
Station Activities				
Building a Railroad		X		X
CSI Surveyor			X	X
GPS Basics			X	X
Mining the Store				X
In Search of the Lost Monument		X		X
Tessellating Telephone Towers				X
Where are You?		X	X	
In-Class Activities				
Human GPS – Map the Classroom		X	X	X
I Spy (Topographical Mapping)		X	X	X
Extended Activities				
Geocaching		X	X	
Waymarking		X	X	
Lost Monument - Extended Activities		X	X	X

Station Activities

Background

Seven station activities are included in the crate. All of the activities require a minimum 120 cm x 120 cm table top. Station activities are designed to be used by up to four students each and are all approximately the same duration—about 20–30 minutes. This allows the station activities to be completed in a three hour time slot. Should more students need to participate, additional paper copies of the materials may be copied and recycled once the Stations are complete.

NOTE: PLEASE USE DRY ERASABLE or WASHABLE MARKERS ON THE LAMINATED SHEETS. A set of markers should be included in the Crate, however, should one become dry it can be replaced by a similar one as long as it is erasable.

Each of the activities will be self contained. We do not recommend removing these from this Manual; however, for some of the activities, pages from this resource manual may need to be copied. **A complete copy of this Educational Guide, including do-it-yourself graphics and specifications (identified by an asterisk *), is available at www.slsa.sk.ca/teacher.php**.

Build a Railroad

Activity Description:

Activity: Students use a contour map to plot the best route for either a railroad track or a super highway from one city to another. Students must take into account the restrictions that apply to changes in the slope allowed for each of the different transportation methods.

Materials:

- Contour Map supplied with the Crate
- Magnets representing railway and roadway segments, also supplied with the Crate

Time Required:

Introduction – 10 minutes

Activity – 20 minutes

Vocabulary:

- Slope
- Grade
- Friction
- Contour
- Percent

Curriculum Connections: Social Studies

Saskatchewan	Grade 7 – Reviewing Map Interpretation Skills. Know that different types of maps provide different information and serve different purposes.
Western Canadian Math Protocol	Grade 8 – Numbers Demonstrate an understanding of percents greater than or equal to 0%.

Science and Math Concepts

- Slope
- Percent
- Grade

Teacher Background

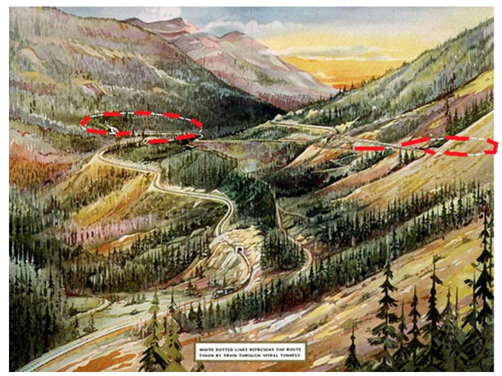
A **contour map** (topographic map) uses contour lines (often just called a "contour") to join points of equal elevation (height above sea level) and thus show valleys, hills, and the steepness of slopes (Wikipedia, 2007). It is also used for other purposes, most commonly to show the lines of equal pressure (isobars) or temperature (isotherms) on weather maps. For the purpose of this activity, the contour map will be used to represent height of land.

A **grade** is used to express the steepness of slope on a hill, stream, roof, railroad or road, where zero indicates level (with respect to gravity) and increasing numbers correlate to more vertical inclinations. It is the pitch of a slope and is often expressed as a "percent tangent," or "rise over run." The most common type of measurement is as a percentage: the ratio of the height change to the horizontal distance.

Railway, Roadway Construction - Grade

Because railways are built for vehicles with steel wheels on steel tracks where the friction is low, locomotives are not capable of climbing high grades. Grades of 2%, a rise of 2 metres over a distance of 100 metres, is considered the maximum, with grades of less than 1% preferred. *(NOTE: This is not the normal interpretation of "%." An alternate description could be "2 in 100" grade or a 2:100 grade.)*

For roadways, the grade may be considerably higher, with grades of 10% not uncommon. Mountain roads may be as high as 20% (a rise or drop of 20 metres over a length of 100 metres), although this grade makes it virtually impossible to haul heavy loads.



CPR Spiral Tunnel in Kicking Horse Pass
Red lines indicate tunnels

A Quick Demonstration of Grade

Measuring grade using a metre stick and a ruler: At one end, stand a ruler on its end and raise the end of the metre stick to the 10 cm mark. The slope of the metre stick would represent a 10% grade. Challenge the students to construct 1%, 5%, 10%, 50% and 100% grades or slopes. Have them draw these slopes on graph paper.

Knowing that railways and roadways have a limit to how steep the grade can be, discuss the problems in building railways and roadways in places such as the prairies, hills and mountains.

Other Concerns that surveyors have when Laying out Roadways

Although grade considerations are very important, surveyors need to be concerned with how sharp turns are when making roadways and railways. Trains must make gentle turns to ensure that the train cars do not fall over or bind on the railway tracks. Sharp turns on highways require cars to slow down or risk slipping off the roadway into the ditch.

What other things would surveyors have to take into consideration when planning a railway or road? Surveyors need to consider if hills need to be cut down so that valleys or dips can be filled (known as "cut and fill"). Roads also need wide ditches, which can impact the amount of land needed to create a roadway.

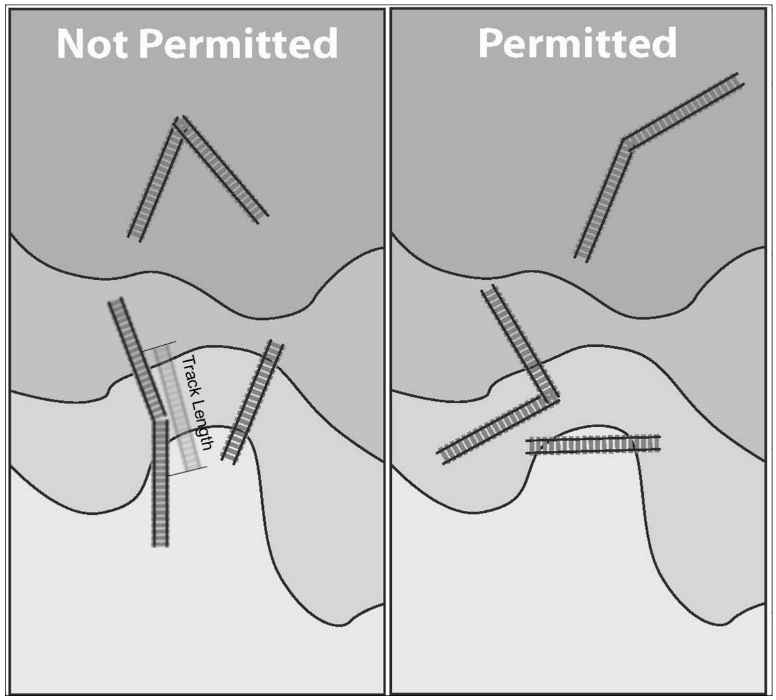
Activity

Students work in groups of two to plot, on the contour map, the best route for a railway and a roadway from City A to City B. Best is considered to have the fewest railway or road sections that do not violate any of the criteria outlined at the right and on the map itself.

Railway and Roadway

The goal of this activity is to link the cities (A and B) on the laminated map to each other with the fewest number of sections. Crossing one contour line with a railway or roadway segment represents the maximum allowable grade (2% for railways and 10% for roadways).

Students may lay the railway or road segments end to end with no less than a 90-degree turn between them. At no point along the track may a distance corresponding to one length of track cross more than one contour line. The diagram shows permitted and not-permitted placement of the rail markers.



The same is true with the road segments.

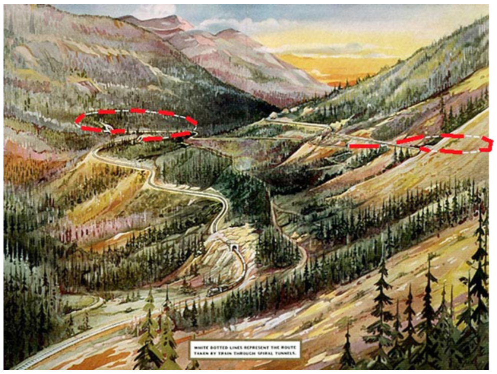
(Hint: the minimum number of railway sections that will work is 12 and the minimum number of highway sections that will work is 19.)

Note: Some areas on the map may exist that make building either a road or a railway undesirable. These are identified by a solid colour and may be boggy areas, lakes or other physical barriers. Also note that the railway/road sections are not to the same scale as the contour maps, so grade calculation cannot be performed using this map.

If students are interested in "scoring" their designs, give one point for each length of track or road used and count the number of contour lines crossed. Multiply the number of contour lines crossed by 3 and add that number to the number of railway or roadway segments used. The lower the final number means the "better" the design.

	+		=	
# of pieces of track/road		(# of contour lines crossed X 3)		Total (The lower the number, the better)

Building a Railroad - Student Instructions



You are a surveyor. You are contracted to plan the route for a railway and/or a roadway between two cities. You must link the cities (A and B) to each other on the magnetic map with the least number of rail or road sections.

Work in pairs:

1. **With the magnetic contour map as your project base, use the magnetic track pieces to plan the route for your railway or roadway.**

When your route is complete, find out how well your route scores with the calculation sheet provided.

Things to remember:

1. **The closer together the contour lines are, the steeper the slope.**
2. **Railways cannot climb steep slopes because they have steel wheels and steel tracks, so the friction is low.**
3. **Grades of 2%, a rise of 2 metres over a distance of 100 metres, is considered the maximum, with grades of less than 1% preferable (1 metre over a distance of 100 metres).**
4. **Roadways may be considerably steeper than railways. Grades of 10% are not uncommon (10 metres over a distance of 100 metres).**
5. **Mountain roads can be as high as 20% (a rise of 20 metres over a length of 100 metres), although this grade makes it virtually impossible to haul heavy loads.**

How sharp the turns are is also important for building roadways and railways. Trains must make gentle turns to ensure that the train cars do not fall over or bind on the railway tracks. Sharp turns on highways require cars to slow down or risk slipping off the roadway into the ditch.

Student Sheet for Scoring the Railway Constructions

Find out how well your route scored :

1. **Multiply the number of contour lines you crossed with your railway or roadway segments by 3.**
2. **Add that number to the number of segments you used. The lower the final number, the "better" the design.**

Track 1

	+		=	
# of pieces of track/road		(# of contour lines crossed X 3)		Total (The lower the number, the better)

Track 2

	+		=	
# of pieces of track/road		(# of contour lines crossed X 3)		Total (The lower the number, the better)

Track 3

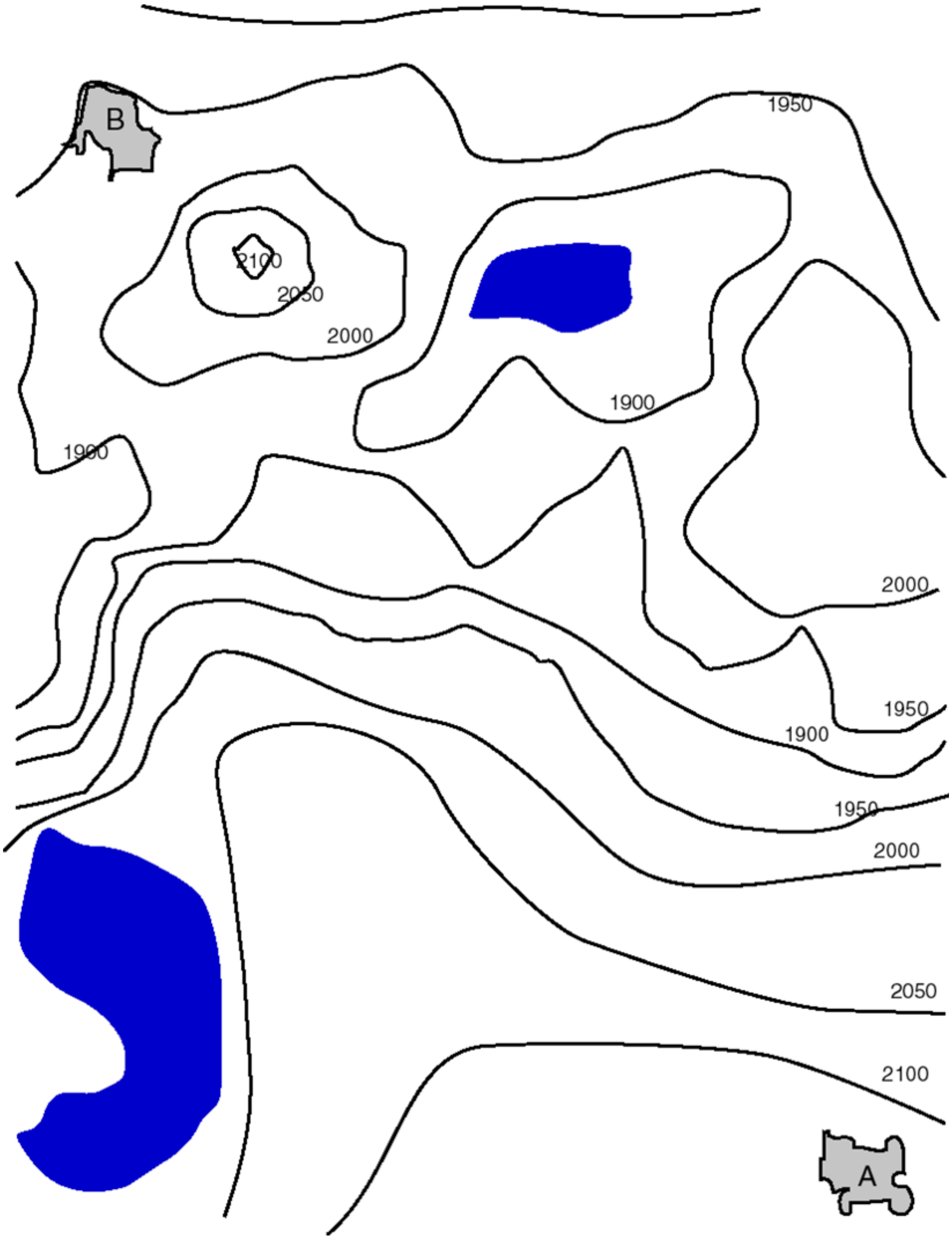
	+		=	
# of pieces of track/road		(# of contour lines crossed X 3)		Total (The lower the number, the better)

Track 4

	+		=	
# of pieces of track/road		(# of contour lines crossed X 3)		Total (The lower the number, the better)

Track 5

	+		=	
# of pieces of track/road		(# of contour lines crossed X 3)		Total (The lower the number, the better)



Numbers represent an arbitrary height in metres.

Small scale representation of the student map.

Note this activity is not to be used to calculate slope or grade. The contour lines and the lengths of railway and roadway segments are for location only.

CSI Surveyor

Activity Description:

Students take the role of a forensic surveyor trying to reconstruct an automobile accident. They measure skid marks and calculate the speed of the cars.

Materials:

- Laminated Accident Scene (approximate 1:100 scale)
- Laminated student sheets
- Tape measure (in cm)
- Scientific calculator

Time Required:

- Introduction – 5 minutes
- Activity – 20 minutes

Vocabulary:

- Skid mark
- Drag factor (coefficient of friction)
- Braking efficiency

Curriculum Connections: Mathematics

Western Canadian Math Protocol

Grade 8 – Patterns & Relations

Model and solve problems using linear equations of the form: $ax + b = c$

Grade 8 – Number Operations

Estimate, compute (using a calculator) and verify approximate square roots of whole numbers and of decimals

Science and Math Concepts

- Square roots
- Estimation
- Scale diagrams
- Metric units specifically m, km, tonnes

Teacher Background

One of the branches of surveying is that of the forensic surveyor. Forensic surveyors may be called upon to create detailed maps of crime scenes and road accidents. Some of the measurements they might take at the scene are skid marks and/or the angle of the sun with respect to the driver or the traffic lights. Forensic surveyors are often called to testify as expert witnesses, and those qualified to do so are in high demand. These days, a survey instrument called a Total Station is used to take all the detailed measurements needed. These might include distances, angles between vehicles and directions of travel, and angles of rotation of vehicles involved in the accident. In this activity, students measure skid marks on a scale model collision scene to determine the minimum speed of the vehicle involved in the collision.

Skid Marks

Skid marks are defined as the marks on the road made by a tire that is locked and not turning. The marks are usually quite light at the beginning, becoming darker as the skid progresses and coming to an abrupt halt as the vehicle stops at the end of the skid. Skid marks are usually straight but may be a bit curved if the road slopes. Skid speed is defined as the speed of the vehicle at the beginning of the visible skid mark. Because wheels don't lock at the instant the brakes are applied, the speed determined by measuring skid marks is considered to be the minimum speed of the vehicle. The length of the skid mark or skid distance is not the only factor needed to calculate the speed of the car. The other two basic factors used are the drag factor (coefficient of friction) of the road surface and the braking efficiency of the car.

Drag Factor

Different road surfaces will have different drag factors or resistance to skid and will slow the vehicle down at different rates due to the amount of friction provided by the surface.

- Asphalt: 0.50 – 0.90
- Gravel: 0.40 – 0.80
- Ice: 0.10 – 0.25
- Snow: 0.10 – 0.55

Braking Efficiency

All four tires contribute a certain amount of the total braking force available to the car. When all four are working evenly, the braking efficiency is 100%, or 1.00. Approximately 40% of the braking force is provided by the rear wheels on a car, so if they're not working properly the braking efficiency is 60% or .60. The brake force for rear wheel drive cars is typically 30% for each of the front wheels and 20% for each back wheel.

For the purposes of this activity, we'll assume vehicle braking efficiency to be 100% or 1.0 so it will not affect the calculations.

Source: http://www.harristechnical.com/

Vehicle skid speed calculator

http://www.harristechnical.com/skid33m.htm

Basic formula for minimum skid speed:

S = 15.9 √d x μ x Be

Where:

S =	Speed, in km/h
15.9 =	A constant value used in this equation to account for the effect of gravity on the collision
d =	Skid Distance, in metres
μ =	Drag factor for the road surface in question
Be =	Braking Factor

Procedure: Skid Mark Measurements

Instructions:

1. Students find the minimum speed of the vehicle by using the length of the skid mark on the scale model collision scene. Calculation steps are given on the laminated student work sheet.
2. First, measure the skid mark in cm on the scale drawing.
3. Find the actual measurement in metres by multiplying the number of cm from the skid map by 4 and change the unit to metres (1 cm on the map represents 4 metres).
4. Calculate the product of the skid distance, brake efficiency and drag factor.
5. Find the square root of the product.
6. Multiply the square root by the constant 15.9 to get the minimum vehicle speed.
7. Carry out this calculation for each vehicle.
8. Determine which, if any, of the cars was speeding at the time the driver hit the brakes.

Student Role Sheet

You are a forensic surveyor and you've been called to the scene of a motor vehicle accident. Three cars have skidded to a stop and a large plate glass window has been destroyed, seriously injuring the two people carrying the window. All of the drivers maintain that they were traveling the speed limit and that the window "Just jumped out in front of me!" Because the people carrying the window were seriously hurt, they are considering suing the motorists for damages. It is your job to measure the skid marks left by the three cars and, using the information about each car, calculate which, if any, of the cars was speeding. The residential speed limit is 50 km/h. You will be called into court to testify as an expert witness when the case goes to trial, so it's important to be sure your calculations are correct.

The length of the skid mark is not the only thing that affects the speed of a vehicle. The "stickiness," or friction of the road surface, is also part of the calculation (drag factor). Different surfaces (and tires) have drag factors which are shown by different numbers (e.g. pavement is about 0.70, but ice is about 0.18). A smaller number means the surface is not as sticky, so a car will go further in a skid and the skid mark will be longer. Each vehicle has another factor related to how well the brakes operate. This is known as the Brake Efficiency and is given as a percent or decimal. A brake efficiency of 100% (1.0) means that the brakes hold the wheels from spinning when applied, while an efficiency of 70% (0.70) means that there is a small amount of rotation when the brakes are locked.

15.9 is a constant number that allows you to change distance (length of the skid mark) into the speed of the car. The constant is a number that takes into account the effect of the force of gravity on the collision.

CSI - Surveyor - Storyline and Vehicle Descriptions

You are a forensic surveyor and you've been called to the scene of a motor vehicle accident. Three cars have skidded to a stop and a large plate glass window has been destroyed, seriously injuring the two people carrying the window. All of the drivers maintain that they were traveling the speed limit and that the window "Just jumped out in front of me!" Because the people carrying the window were seriously hurt, they are considering suing the motorists for damages. It is your job to measure the skid marks left by the three cars and, using information about each car, calculate which if any of the cars were speeding. The residential speed limit is 50 km/h. You will be called into court to testify as an expert witness when the case goes to trial so it's important to be sure your calculations are correct.

Car 1:
Super Sport Coupe, V8 Gas Guzzler with Red Flame markings

Weight = 3 tonne

Braking Efficiency = 0.80

Drag Friction Factor = 0.61

Car 2:
Smart Car with a hybrid Engine Racing stripes and a sun roof.

Weight = 1 tonne

Braking Efficiency = 0.64

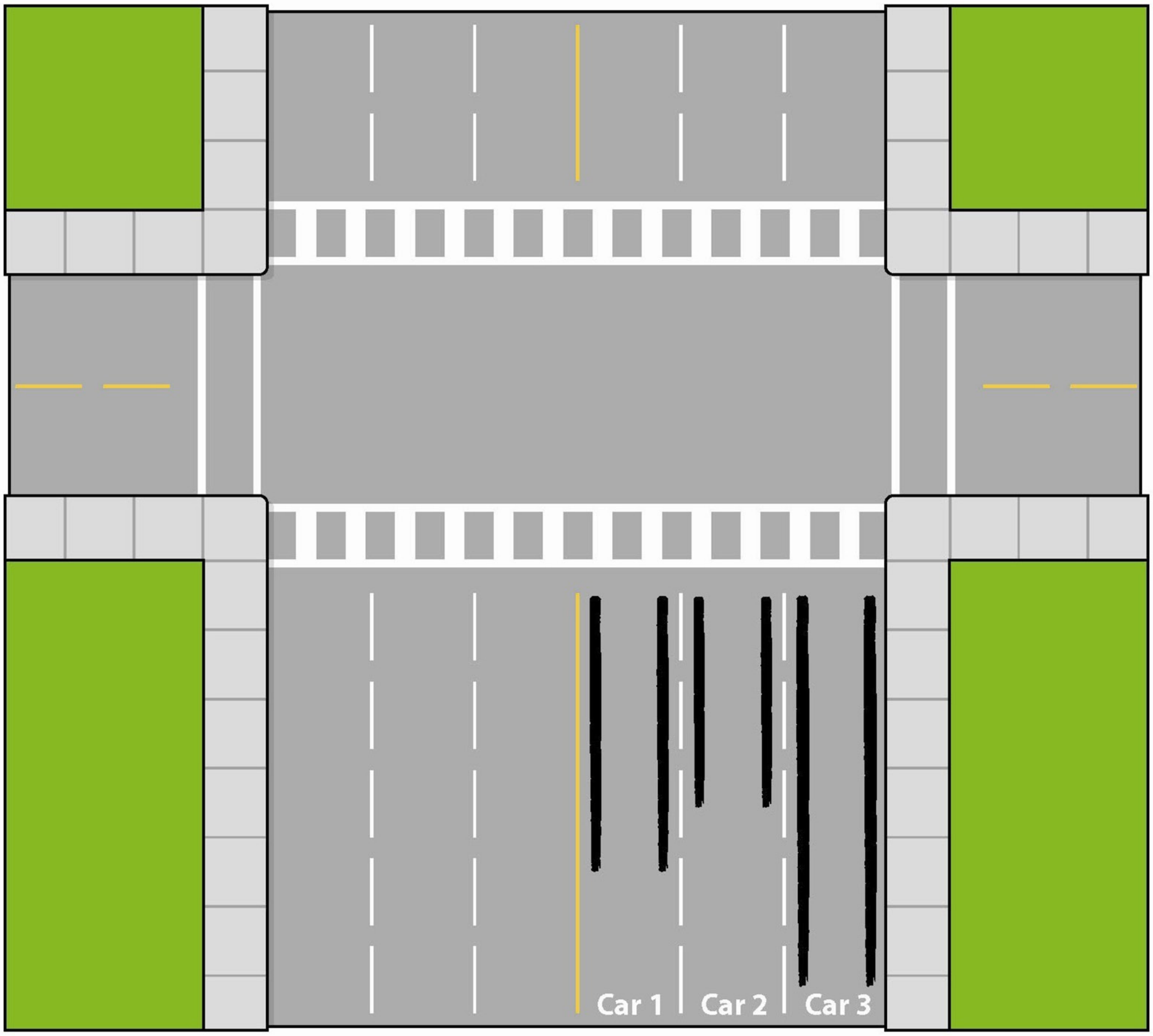
Drag Friction Factor = 0.58

Car 3:
Soccer Mom Sedan, V4 Standard Powder Blue with Silver Trim

Weight = 2.1 tonne

Braking Efficiency = 0.72

Drag Friction Factor = 0.60



Intersection Layout

Student Calculation Sheet for CSI Surveyor

s = speed of the car in km/h
15.9 = gravity constant
d = length of the skid mark in metres
μ = drag factor
Be = brake efficiency as a decimal fraction

1. Measure the length of the skid mark on the model in centimetres using the tape measure provided.

Car 1 [ ] Car 2 [ ] Car 3 [ ]

length of skid mark in m = length of measured skid marks in cm X 4

[ ] [ ] [ ]

2. Find the product of the skid mark length (d), the drag factor (μ) and the braking efficiency (Be).

$$d \times \mu \times Be = \_\_\_\_\_\_\_\_$$

Car 1 [ ] Car 2 [ ] Car 3 [ ]

3. Find the square root of the above product using the square root key on the calculator provided

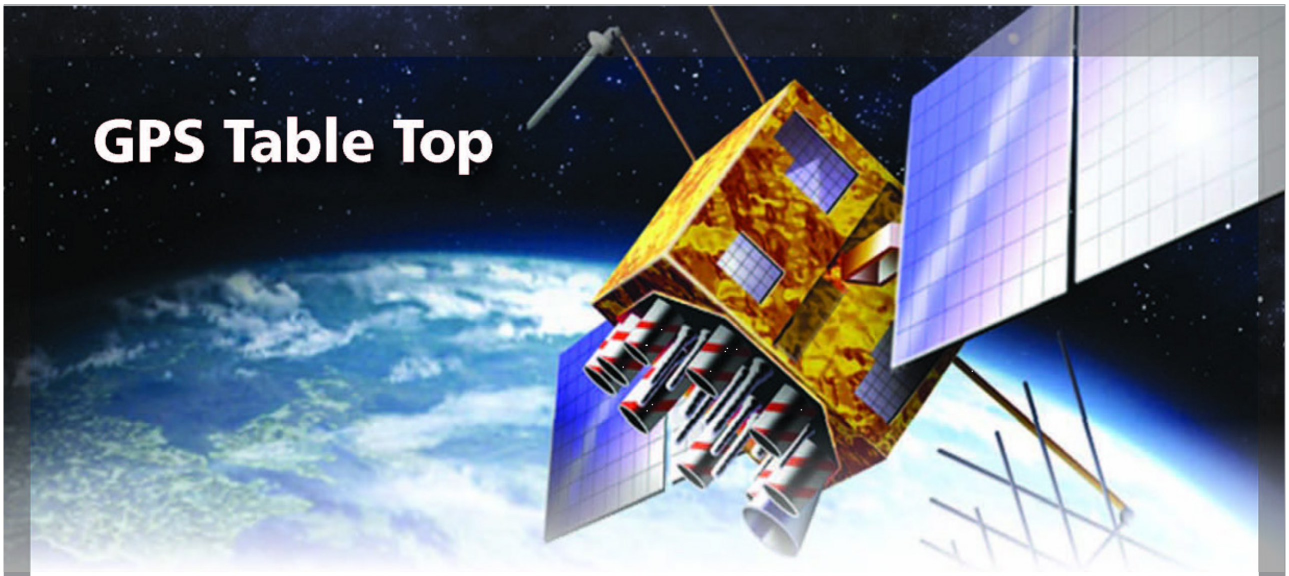
$$\sqrt{d \times \mu \times Be}$$

Car 1 [ ] Car 2 [ ] Car 3 [ ]

4. Multiply the square root by the gravity constant to find the minimum speed of the vehicle.

Car 1 [ ] Car 2 [ ] Car 3 [ ]

Speeding? ______ Speeding? ______ Speeding? ______



Activity Description:

Students use a tabletop representation of a GPS system to gain an understanding of how GPS works.

Materials:

- GPS Map - supplied with the Crate
- Coloured Discs—Set of three, representing satellites and GPS signals - supplied with the Crate
- 3 Colours of Dry Erasable Markers
- Dry Erasable Brush
- Photocopies of the 3 GPS triangles located in the Student Activity Pages

Time Required:

- Introduction – 10 minutes
- Activity – 20 minutes

Vocabulary:

- Global Positioning Systems
- Active Measurement
- Intersection
- Pythagoras
- Pythagorean Theorem

Curriculum Connections: Social Studies

Saskatchewan	Reviewing Map Interpretation Skills
	Know that different types of maps provide different information and serve different purposes

Science and Math Concepts

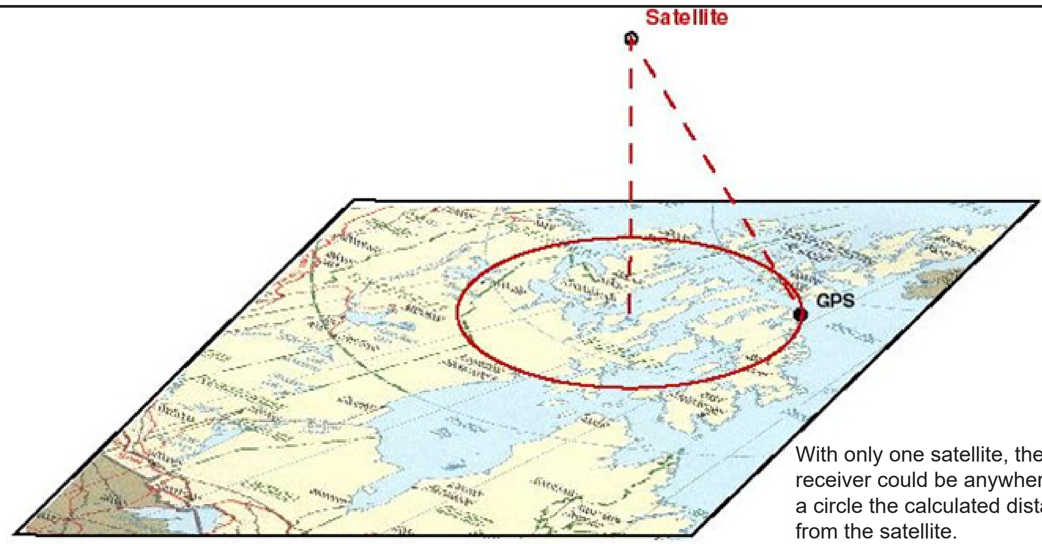
- Hypotenuse
- Right Triangle
- Radius

Teacher Background

A Global Positioning System (GPS) uses a system of orbiting satellites to calculate the location of a point on the surface of the Earth. Each GPS satellite is constantly broadcasting the time and information about its precise location. The signals from satellites require 'line of sight' meaning that they will be blocked by the earth and distorted by the earth's atmosphere. A satellite must therefore be at least 30 degrees above the horizon to be 'seen' by a GPS receiver,

A GPS receiver must be able to 'see' and receive information from at least four satellites at the same time. The distance to each satellite can be calculated by measuring the time it takes the satellite's signal, travelling at the speed of light, to reach the receiver. Using the distances to each satellite it can 'see', and knowing where each is located at any moment in time, the GPS receiver is able to determine its position using triangulation.

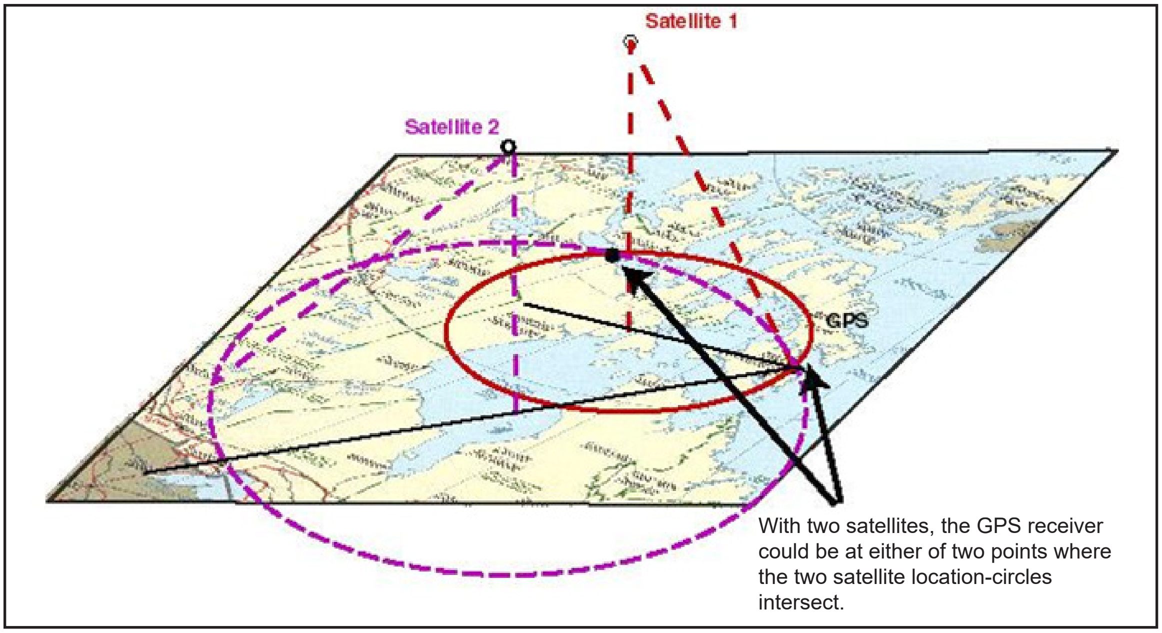
With one satellite, a GPS receiver can only tell it is somewhere on the surface of an imaginary sphere whose radius is the distance from the satellite. If we assume that the earth is smooth, that distance-sphere intersects the surface of the earth forming a location-circle as depicted in the drawing below. The GPS receiver could be at any point around the circumference of that location-circle.



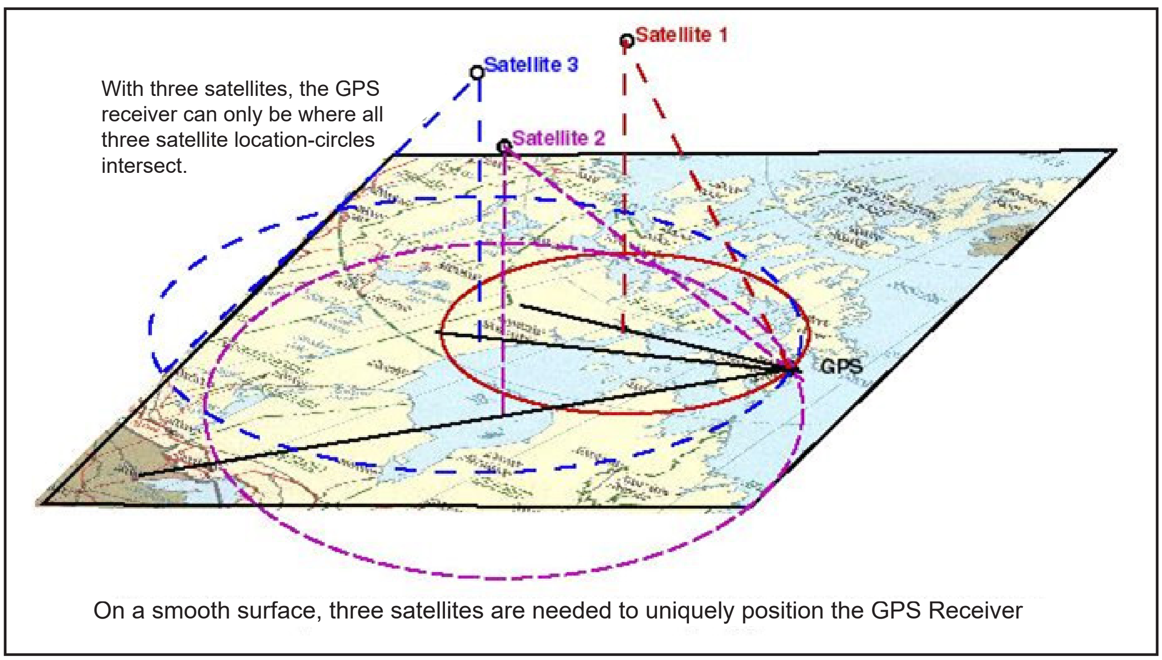
With only one satellite, the GPS receiver could be anywhere on a circle the calculated distance from the satellite.

Dozens of GPS satellites are constantly circling the earth, each in its own orbit. Some are military satellites; others were put there for commercial purposes. Newer GPS receivers can receive signals from more than one system of GPS satellites. The more satellites a GPS receiver can 'see' the greater will be the accuracy of its location calculations.

With two satellites, there are location-circles from each satellite. These usually overlap at two places, either of which could be the position of the receiver.



A third satellite adds one more location-circle and the GPS receiver must be located where all three location-circles intersect.

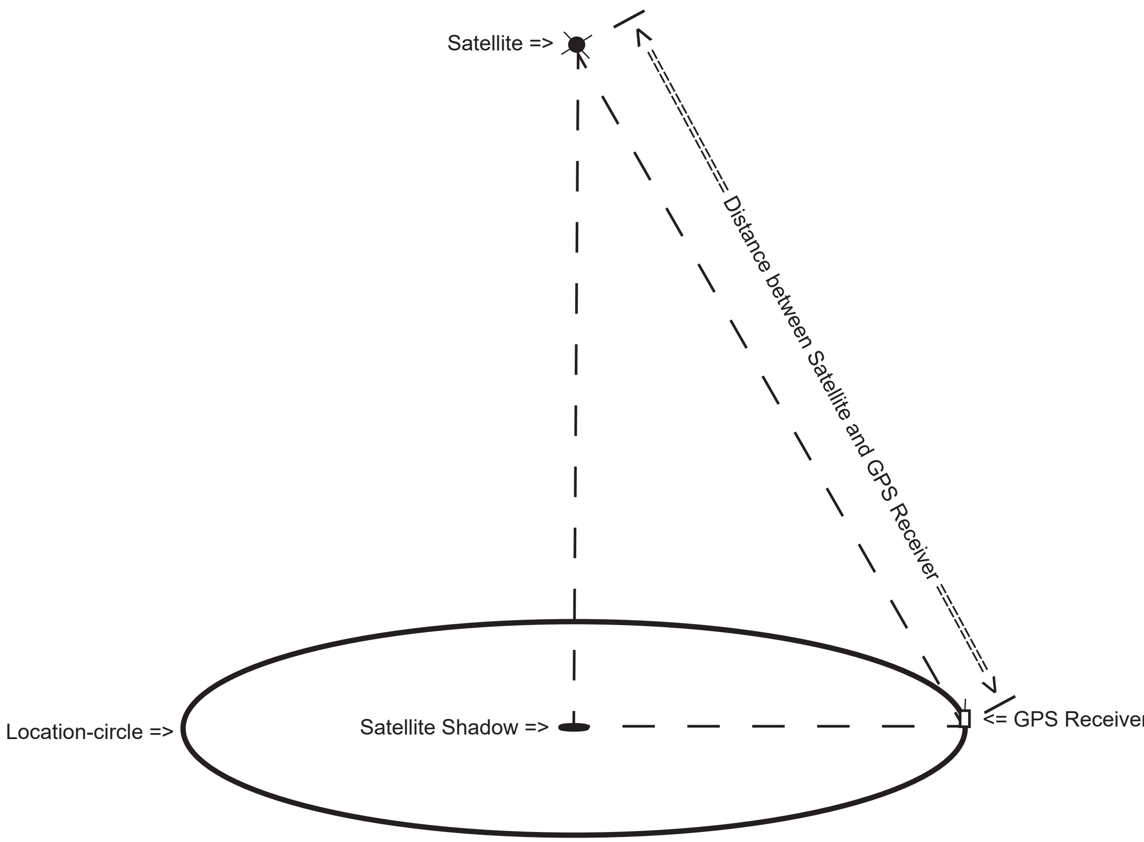


This is a simple description and assumes Earth is smooth. GPS also works for positions off the surface of Earth, (i.e. aeroplanes and low-flying spacecraft). The altitude above Earth can only be calculated using a fourth satellite. For more details, go to **www.nasm.si.edu/gps/work.html**

To carry out the calculations is somewhat complex; however, we can demonstrate the use of the three satellites to determine receiver position visually, using the Tabletop GPS Map and discs of different sizes.

The preceding three diagrams show how students can use the equipment to understand how GPS works using three satellites and a smooth Earth.

The three triangles provided in the student activity pages can be photocopied either onto coloured paper or plain paper identified as ‘Red’, ‘Green’ and ‘Blue’. These are then used to demonstrate the relationship between a satellite’s shadow, the satellite and the distance between the satellite and the GPS receiver.



Student Instructions – Tabletop GPS

Global positioning Systems (GPS) are made up of several parts:

- the GPS unit (in your GPS running watch, your car's navigation system or in highly precise survey equipment)
- a ground station
- a network of satellites

This activity shows how GPS systems work to find locations and why you need to have more than one satellite for the job.

Your Challenge:

Francine, the surveyor, is on the ground somewhere in Canada with her hand-held GPS unit. Your challenge is to find her location using the GPS satellites (the triangles and coloured discs).

Decide who will be Student 1 and who will be Student 2.

Student 1

- Use the red disc (S1 satellite).
- Place the centre of the disk on the S1 location (red dot) on the map. The red dot represents the shadow of the satellite on the earth with the sun directly overhead.
- Stand the red triangle on the disk so the corner marked "Satellite Shadow" is touching the hole in the centre of the red disk. The top of the triangle is where the satellite is located.
- The corner of the triangle marked "GPS Receiver" indicates the distance Francine's GPS unit is from the satellite. By turning the triangle around the satellite shadow on the map, you will see that the edge of the red circle represents all the places where Francine could possibly be based on her distance from the red S1 satellite.

Student 2

- Using a red dry-erase marker, trace around the disc to mark all the possible places Francine could be.

The circle traced by the S1 disc passes approximately through Winnipeg MB, Regina SK and Grand Prairie AB, as well as Resolute Bay in Nunavut.

GPS Satellites cover a very large area, which means that many locations can be the same distance that Francine and her GPS receiver are from the satellite (she can be anywhere on the circle you traced).

The distance from the satellite to the hand-held GPS is the hypotenuse of the red S1 triangle. The radius of the S1 circle and the distance from the satellite to the ground (orbital height) make up the other sides of that triangle.

Student 2

- Use the blue disc (S2 satellite).
- Place the centre of the disk on the S2 location (blue dot) on the map.
- Position the blue S2 triangle on the disk.

Student 1

- Using the blue dry-erase marker, trace around the disc to show all the possible places Francine could be based on her distance from the blue S2 satellite.

Notice that the two circles intersect in two places. You've now narrowed Francine's location down to two possibilities. Most of the time, if you use only two satellites, you'll get two possible locations. On the Map of Canada we are using, what are the names of the towns or cities nearest to where Francine might be?

(Edson, Alberta) (Brandon, Manitoba)

You now need more information to find Francine. You'll need the data from the third satellite.

Student 1

- Use the green disc (S3 satellite).
- Place the centre of the disk on the S3 (green dot) location on the map.
- Set the green triangle up so it points straight up and down. It indicates the distance Francine is from the S3 satellite.

Student 2

- Using the green dry-erase marker, trace around the disc to find Francine's location.

Notice that now the three circles intersect at only one spot. In all cases you need three satellites to find a single spot on a flat surface.

In which of the two possible towns or cities is Francine with her GPS receiver?

(Brandon, Manitoba)

The Earth is not flat; it is a three dimensional shape, almost a sphere. For the Earth then, except in very special circumstances, a minimum of four satellites are needed to find a single location.

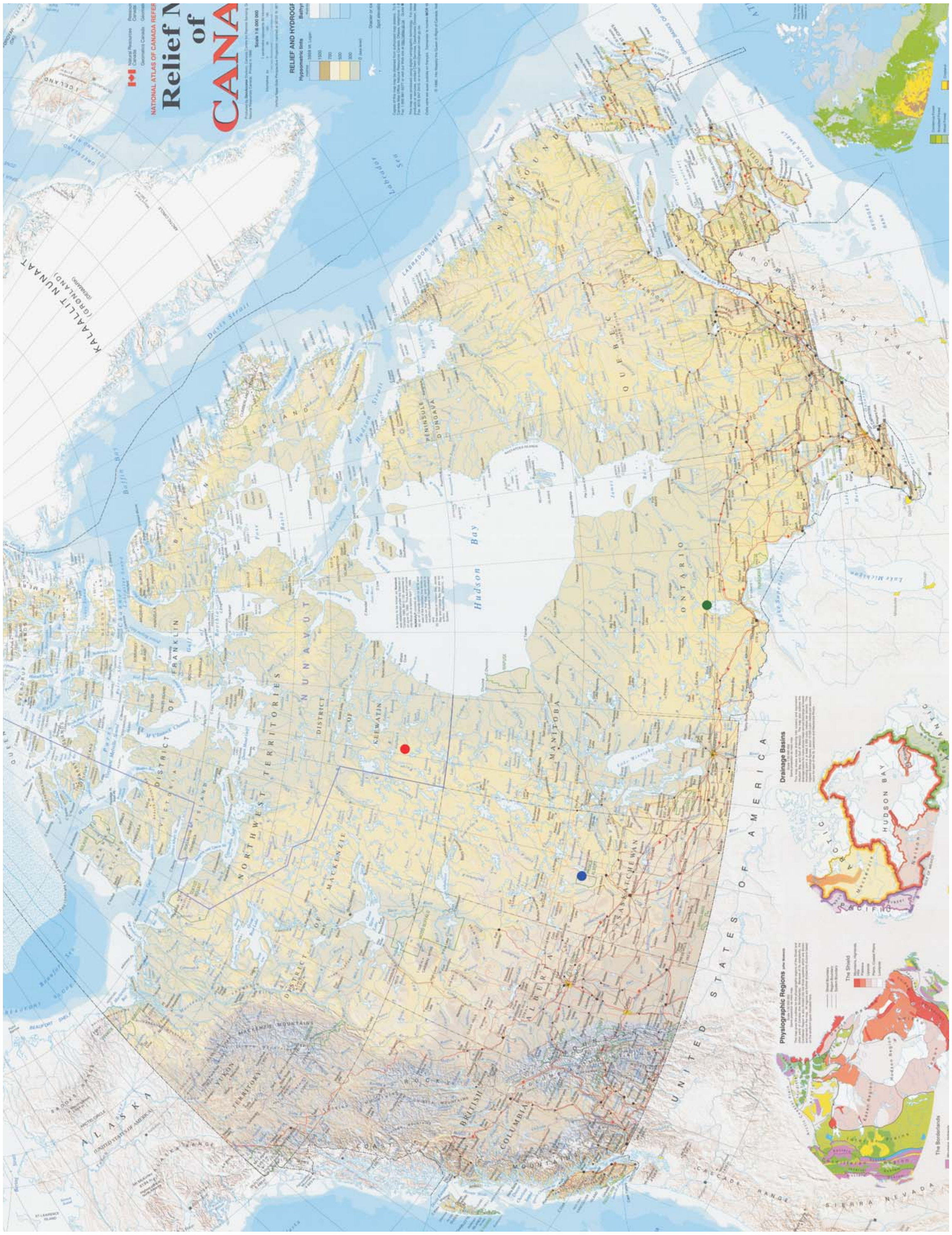
If more satellites are available, the GPS receiver can average the measurements to calculate its location more accurately.

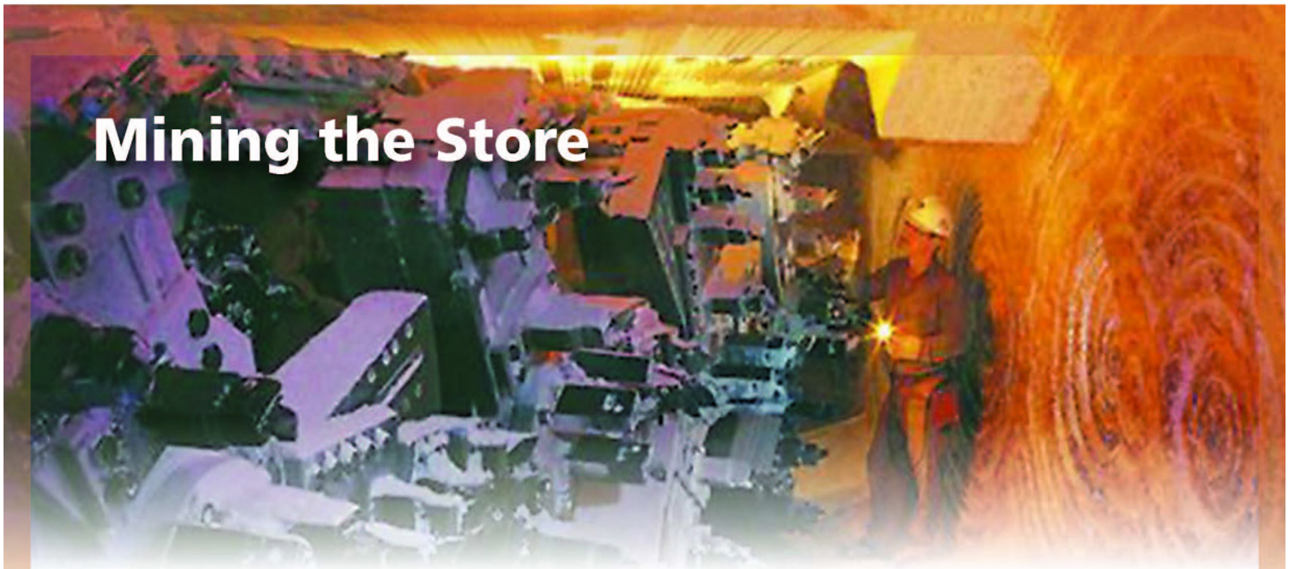
This activity assumes that the satellites were all stationary. In real life, the satellites are moving (orbiting the earth), so their positions are continuously changing. As a result, the GPS unit is constantly re-calculating its distance from each of the satellites it can "see" at that moment. For more information go to www.nasm.si.edu/gps/work.html.

Challenge:

Based on the positions of the three satellites, as indicated by the red, blue and green dots, what would the radii of the circles have been if Francine was in the following cities:

	Red Circle	Blue Circle	Green Circle
Yorkton, SK	(146 mm)	(50 mm)	(123 mm)
Calgary, AB	(182 mm)	(75 mm)	(218 mm)
Vancouver, BC	(238 mm)	(143 mm)	(282 mm)


Relief
of
Hudson Bay
ONTARIO
MANITOBA
UNITED STATES OF AMERICA
ALASKA
Davis Strait
Labrador Sea
Drainage Basins
Physiographic Regions
HUDSON BAY



Mining the Store

Activity Description:

Students take the role of members of a land survey crew who need to calculate the amount of material that has come out of a mine and compare it with the amount of room there is to put a pile of tailings back into the mine. Two students work on the mine shape and two students work on the tailing shape. At the end, they compare their numbers and make conclusions.

Materials:

- Laminated Student Sheets
- Dry Erasable Markers

Time Required:

- Introduction – 10 minutes
- Activity – 20 minutes

Vocabulary:

- Potash
- Tailings
- Decommission
- Milled
- Right Circular Shape

Curriculum Connections: Mathematics

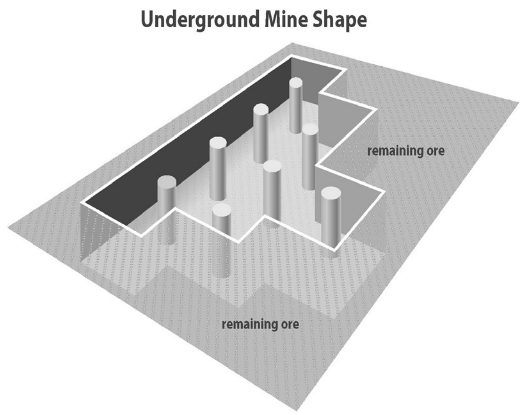
Western Canadian Math Protocol	Grade 8 – Shape and Measurement Develop and apply formulas for determining the volume of right prisms and right cylinders

Science and Math Concepts

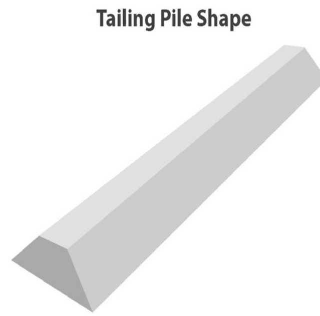
- Fractions
- Estimation
- Volume of right cylinders and complex shapes

Teacher Background

Surveyors are called upon to measure the quantity of earth or other materials needed to build such things as highways, embankments, overpasses and berms, or to measure how much material needs to be removed from construction sites such as underpasses or tunnels. In this activity, students are asked to calculate whether or not the amount of material in an outside tailings pile of a mine will fit back into a mine ready for decomissioned. You would expect that if you removed rock from a potash mine, for example, and then milled it to extract the potash, the remaining rock waste would have a smaller volume than the original rock. In a number of cases, however, the waste material volume is larger than the original rock volume due to the milling process that "fluffs up" the tailings.



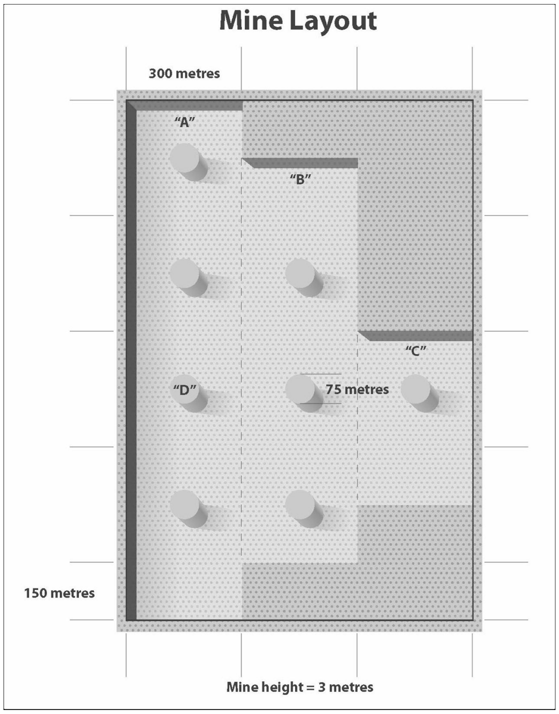
This activity asks the students to calculate the volume of a decomissioned mine and the surface tailings pile and compare the two. They are then asked to examine the remainder and calculate the size of a cylindrical-shaped hole that would be required to hold it.

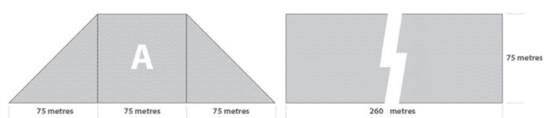


The mine to be decomissioned is located underground and is a large room with pillars strategically placed to hold the ceiling up, as the diagram at the right indicates.

The tailings on the surface are a long pile that has been built up by years of dumping and has, roughly, the shape at the right.

Laminated Student Sheets with Answers





Calculation of Tailings:

Area of the end of the Pile:
The two triangular ends of the pile when considered together make a square of 75 metres on a side. This is the same as the centre portion on the pile so that the area is:

11,250 m^2

To finish calculating the volume, muliply the area of the end of the pile by the length of the pile.

2,925,000 m^3

MINE LAYOUT VOLUME CALCULATION SHEET

AREA "A" = 405,000 m^2

AREA "B" = 314,000 m^2

AREA "C" = 135,000 m^2

AREA "D" = 4,418 m^2

TOTAL AREA = AREA "A" + AREA "B" + AREA "C" - (8 x AREA"D")

819,654 m^2

TOTAL VOLUME = TOTAL AREA x HEIGHT

2,458,974 m^3

IS THIS MORE OR LESS THAN THE VOLUME OF THE TAILINGS?

____

Comparison

Is the Tailing Pile larger than the Mine? ❑ Yes ❑ No

If the Tailing Pile is larger, how deep should a round hole 10 metres across be made to hold all of the excess tailings? (Hint: Remember how the calculation of the mine pillar was carried out)

77.03 m

Procedure

Mine Volume Calculation

- Students examine the dimensions of the mine and calculate the volume. Calculation is given on the laminated student work sheet.
- First calculate the Area "A."
- Then the Area "B."
- Then the Area "C."
- And then one of the Areas "D."
- The total amount of area available for the tailings is Area A plus Area B Plus Area C minus (Area D times the number of pillars).
- This total area is then multiplied by the height of the cavity.

Tailings Pile Volume Calculation

- The volume is calculated by breaking the mound into different sections.
- The central volume is calculated by the volume of a rectangular prism added to the volume of the right triangle mound. The calculation is given on the laminated student work sheet.

Comparison

Students compare the mine volume calculation with the tailings pile volume calculation to determine which one is bigger.

If the mine calculation is greater, then all of the tailings will fit into the mine, while if the tailings calculation is greater, some will be left on the surface.

Follow-up Calculation

If the amount of tailings are greater, calculate the depth of a hole 10 metres across needed to store the remainder.

Student Instructions – Mining the Store

Surveyors are called upon to measure the quantity of earth or other materials needed to build such things as highways, embankments, overpasses and berms, or to measure how much material needs to be removed from construction sites such as underpasses or tunnels.

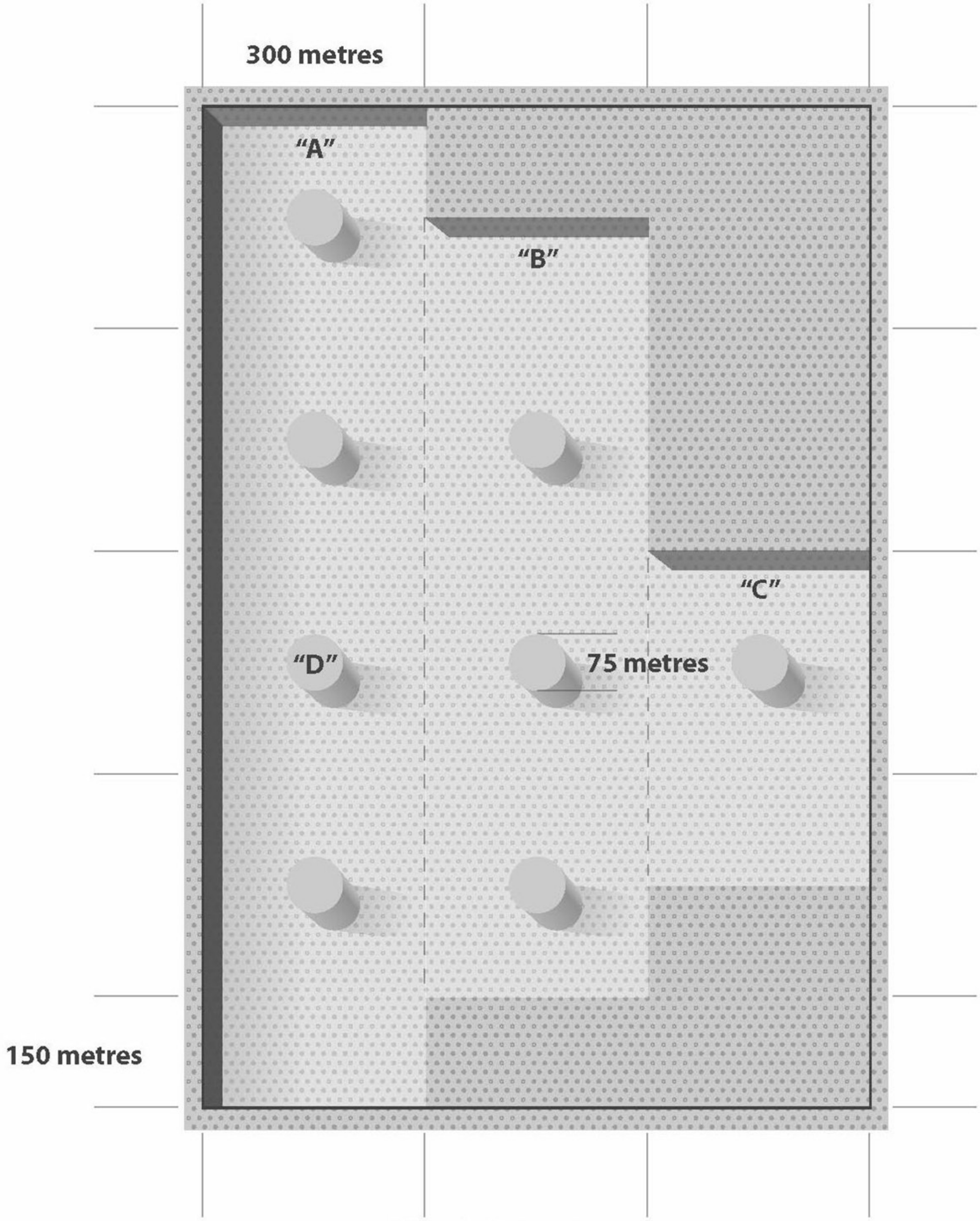
The Acme Potash Mine is being closed down. They have been ordered by the Environment Ministry to place the tailings pile (waste products from the mining process) back into the underground space as part of the cleanup required.

Your survey contract in this activity is to advise Acme Mining Company if they have enough room underground to store the tailings pile.

If the tailings pile is too large to fit back into the mine, you'll need to find out how deep a hole is needed to store the extra tailings.

Calculation Sheets are provided for you.

Mine Layout



Student Instructions – Mining the Store

MINE LAYOUT VOLUME CALCULATION SHEET

AREA "A" = ______

AREA "B" = ______

AREA "C" = ______

AREA "D" = ______

TOTAL AREA = AREA "A" + AREA "B" + AREA "C" - (8 x AREA"D")

______

TOTAL VOLUME = TOTAL AREA x HEIGHT

______

IS THIS MORE OR LESS THAN THE VOLUME OF THE TAILINGS?

______

Comparison

Is the Tailings Pile larger than the Mine?

❑ **Yes** ❑ **No**

If the Tailings Pile is larger, how deep should a round hole 10 metres across be made to hold all of the excess tailings? (Hint: Remember how the calculation of the mine pillar was carried out.)

______

Tessellating Telephone Towers

Activity Description:

Students, working in a team of four, create cell tower networks. The cell towers must cover all major populated and recreational areas with tessellating shapes.

Materials:

- Laminated Map - supplied with the Crate
- Cell Tower Markers - supplied with the Crate

Time Required:

- Introduction – 10 minutes
- Activity – 20 minutes

Vocabulary:

- Tessellation
- Height of land
- Dodecagon

Curriculum Connections: Mathematics

Western Canadian Math Protocol	Grade 8 – Shape and Space (Transformations)

Science and Math Concepts

Demonstrate an understanding of tessellation by:

- explaining the properties of shapes that make tessellating possible,
- creating tessellations,
- identifying tessellations in the environment.

Background

Cell phone towers are usually placed on heights of land to ensure maximum coverage. Receivers/transmitters situated on the towers broadcast in all directions, sometimes better in some directions than in others.

Surveyors are required to locate the position of the towers based on the requirements for coverage. In this activity, students (working in pairs) act as the surveyors, placing towers at locations to maximize the coverage.

For this activity, there are three types of towers: basic towers, a high power towers and specialty towers. The basic tower gives coverage in all directions at a very limited range, the super tower increases the range of the basic tower in each direction, and the specialty tower allows for increased reception/transmission in one direction while being limited in the others.

The basic signal coverage footprint of each type of tower forms a tessellating shape. A tessellating shape is one that, when translated in particular directions, will fit together to completely cover a surface with no space and no overlaps (see tessellating shapes later in this lesson). The particular polygons used here form a semi-regular tessellation.

The footprint shapes of the different send/receive patterns for each tower are shown on the next page, as is the tessellating pattern they form. Note that the tower is located in the middle of the shape.

Set up in this way, the shape is a tessellating one. The basic tower is a square, the high power tower is a dodecagon and the specialty tower is a dumbbell shape.

Procedure

Working in pairs, students use the shapes (cell phone towers) provided to discover the tiling (tessellation) pattern that will cover the whole map (see below for the pattern). Once the pattern has been discovered, the task will be to take away selected shapes in an effort to achieve maximum coverage with the minimum number of towers (shapes). As long as the towers touch, they will be able to communicate with other towers. However, building cell towers is an expensive proposition so the objective is to get the most coverage with the least number of towers.

Teacher Preparation

Tessellations

Tessellating shapes are shapes that will cover a surface with no overlaps and no spaces. Jigsaw puzzles are tessellations but with a variety of unusual shapes. Tessellations can be both regular and semi-regular with rules that govern each type.

Regular Tessellations

The tessellations (tiles) must cover the surface with no overlaps and no spaces.

Each vertex (the place where the corners of the shapes meet) of the tiling pattern must look the same.

Only three of these exist:

- equilateral triangles
- squares
- hexagons

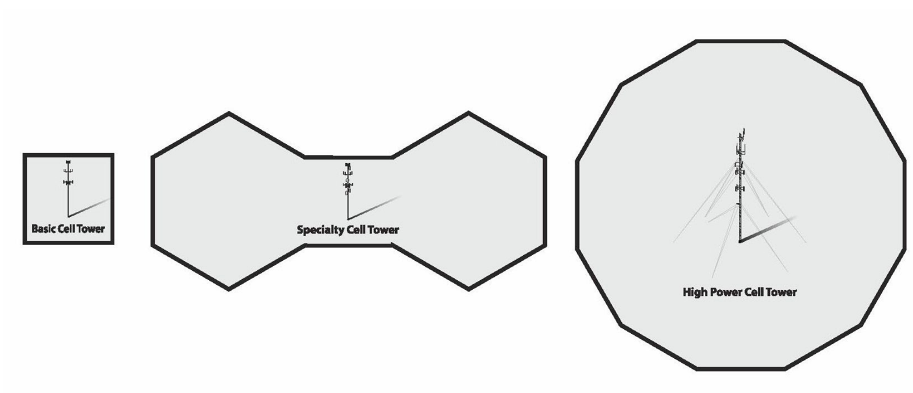
Semi-Regular Tessellations:

Semi-regular tessellations are made up of two or more regular polygons.

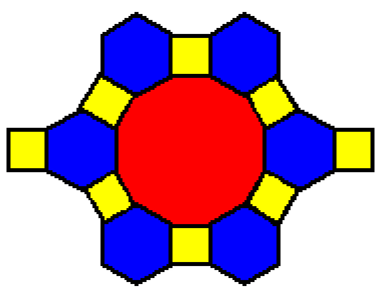
The rule remains the same that all vertices must look the same.

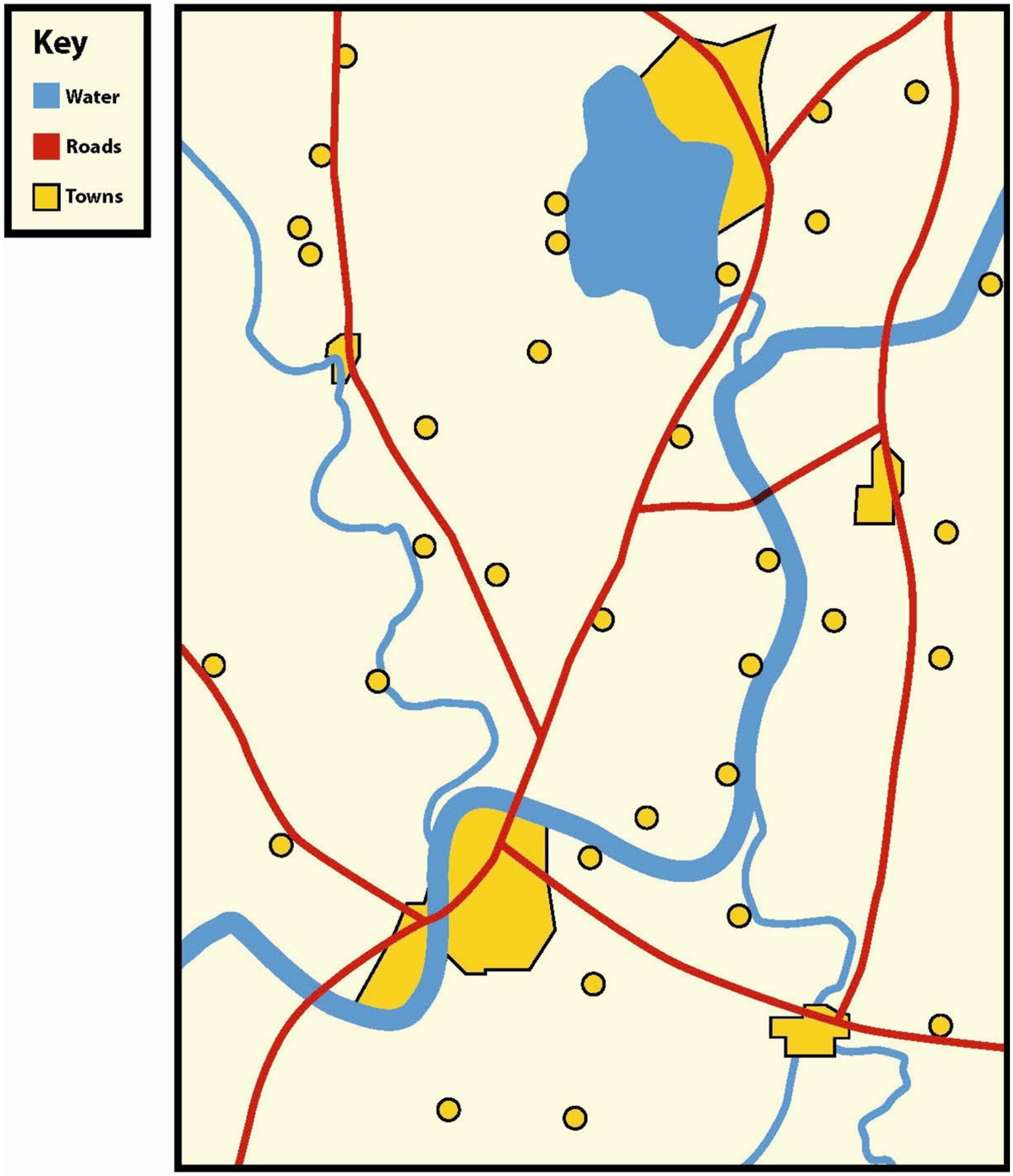
The pattern on the map is a semi-regular tessellation involving hexagons, squares and dodecagons (12 sided shapes).

Whether dealing with regular or semi-regular tessellations, you need regular polygons whose interior angles add up to 360° when the shapes are put together.



The pattern formed by the shapes provided is shown below.




Key
Water
Roads
Towns

Student Instructions – Tessellating Cell Towers

Surveyors are often required to locate the position of cell phone towers based on how much coverage is needed.

Your Survey Contract:

Your surveying company has been contracted to find locations for the cell towers in a network.

The network must provide cellular service coverage to as much of the mapped area as possible.

You have three types of towers (tile shapes) to use:

- The basic tower gives coverage in all directions at a very limited range.
- The high power tower has more range than the basic tower in each direction.
- The specialty tower has increased reception / transmission in two direction but is limited in the others.

Task #1

Work with a partner and use the towers provided to find the repeating pattern that will cover the map completely with no spaces and no overlapping pieces.

Task #2

Now build the network with the fewest towers possible. Cell phone towers are expensive, so your contract requires you to get the most coverage with the least number of towers. Take away some of the shapes in the pattern to do this. Your towers cannot overlap but will need to touch each other so they can communicate with other towers. You also need to be sure that all residential areas (coloured yellow) and travel routes (coloured red) are covered.

In Search of the Lost Monument

Activity Description:

Students, working in pairs, attempt to locate the apex of two triangles using non-standard and standard measurement tools.

Materials:

- Lost monument work sheet
- Coins (nickels work best) (10)
- Ruler
- Pencil

Time Required:

- Introduction – 10 minutes
- Activity – 20 minutes

Vocabulary:

- Triangles - right, isosceles, perfect
- Survey monument
- Reference monument

Curriculum Connections: Mathematics, History

Saskatchewan Grade 6 & 7

Science and Math Concepts

Demonstrate an understanding of triangles and measurement by:

- Using different instruments to measure distances
- Recognizing the characteristics of two different types of triangles

Teacher Background

Figure 1

Land surveyors use a number of tools to measure distances and angles, and to locate the positions of property corners. Often, the property corners are marked using a iron pin or—in the early days—iron or wooden posts in the centres of mounds of earth or stones. All of these markers are referred to as **survey monuments**. Over several years, survey monuments can be damaged or lost completely. A land surveyor must then attempt to figure out where the original monument was and replace it with a new one.

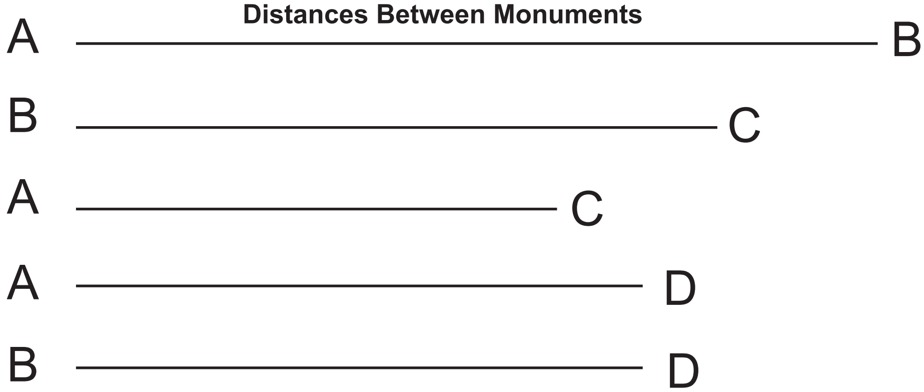
Sometimes there is evidence of the original monument. For example, a steel pin driven into the ground 100 years ago might now appear as a rusty column of soil (figure 1). In other cases, the evidence of the original monument might be completely missing or, at best, ambiguous.

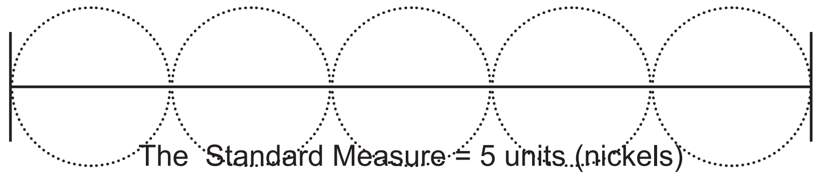
To confirm the location of a missing survey monument, surveyors often have to refer to the measurements and angles to other monuments in the area as recorded in the field notes of the surveyor who placed the original monument years or decades earlier.

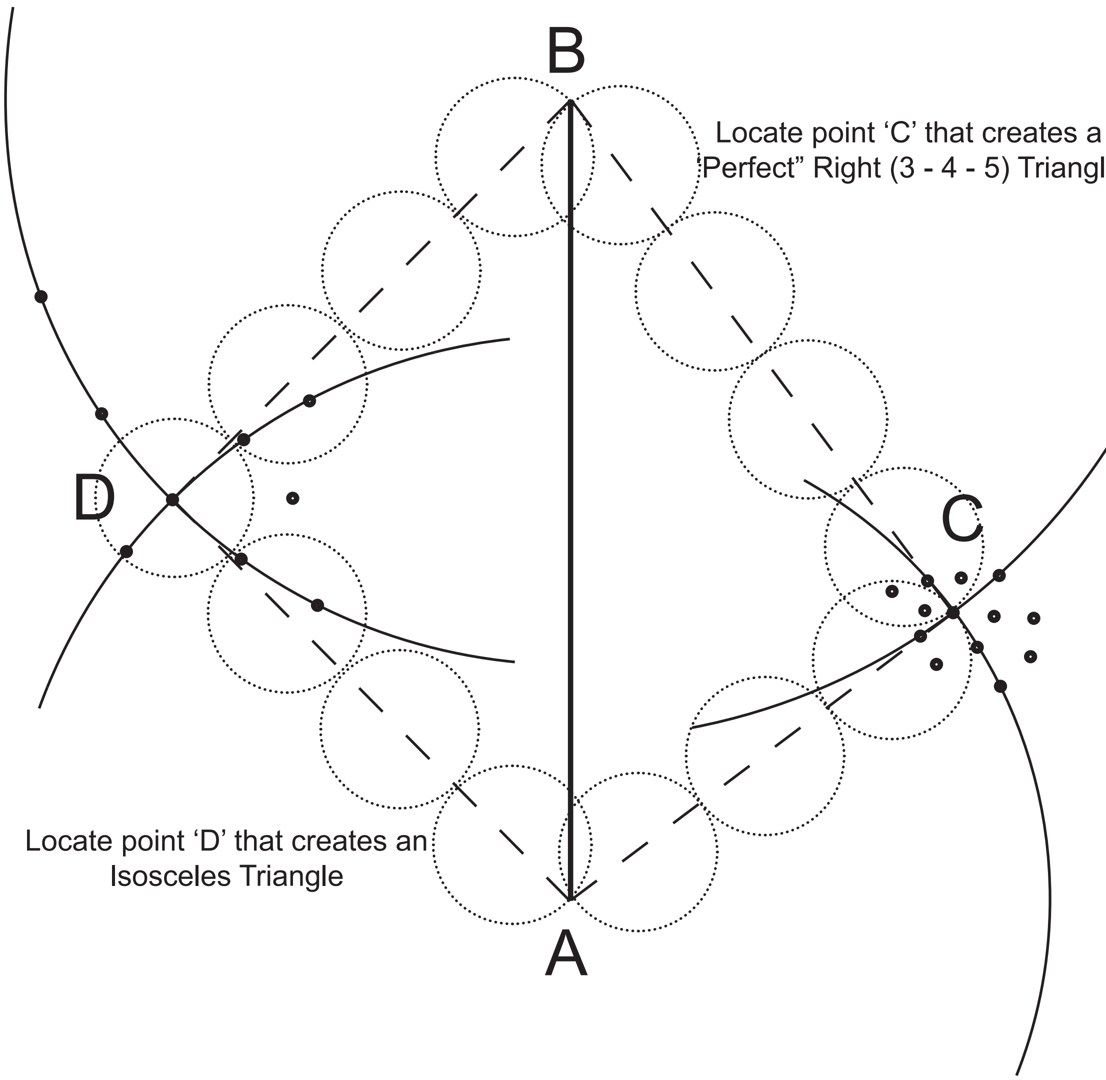
Activity

Students work in pairs while they attempt to locate two missing survey monuments on the work sheets provided. They are told that the reference monuments A and B are exactly 5 standard units apart. One of the points on the right of the line is monument C and, according to the original surveyor's field notes, the lines connecting A, B & C form a perfect (3 - 4 - 5) right triangle. Similarly, one of the points on the left is monument D and lines connecting points A, B and D form an isosceles triangle. First, using coins (nickels will work best), the students try to figure out which of the dots are missing monuments C & D. They can then use a ruler and the scales below to confirm their guesses.

Distances Between Monuments







All points on the arcs on the left are 3½ standard units from A or B. Only one point is 3½ units from **both** A and B (i.e. where the arcs intersect.)

All points on the arcs on the right are either three standard units from A or four standard units from B. Only one point is exactly three units from A **and** four units from B (i.e. where the arcs intersect).

Where are you?

Activity Description:

Students locate themselves using different kinds of mapping and coordinate systems.

Time Required:

- Introduction – 10 minutes
- Activity – 20 minutes

Materials:

- Laminated map of one Saskatchewan rural municipality - supplied with the Crate

Materials: (School Supplied)

- Access to Google Earth
- Globe
- Map of the Earth
- Map of Canada
- Map of Saskatchewan

Vocabulary:

- Latitude, High Latitude, Low Latitude
- Longitude
- Meridian
- Township
- Section
- Prime Meridian
- Correction Line

Curriculum Connections: Social Studies

Saskatchewan	Grade Seven	– Location – Relative and Absolute
		– Location – Latitude & Longitude

- Know that locating places on Earth in absolute terms means stating the latitude and longitude.
- Know that a grid system can be used to determine absolute locations.
- Know that lines of latitude and longitude create a grid system used to provide absolute location of places on Earth.

Teacher Background

The purpose of surveying is to unambiguously locate people/objects or boundaries in space, predominantly on the surface of the Earth. This activity introduces different ways of describing a location on the Earth and asks students to describe their locations.

Latitude and Longitude

Latitude gives the location of a place on Earth north or south of the equator. Lines of Latitude are the horizontal lines (on a globe or map) shown running east to west. Technically, latitude is an angular measurement in degrees (marked with °), ranging from 0° at the Equator (low latitude) to 90° at the poles (90° N for the North Pole or 90° S for the South Pole; high latitude).

Longitude describes the location of a place on Earth east or west of a north-south line called the Prime Meridian. Longitude is given as an angular measurement ranging from 0° at the Prime Meridian to +180° eastward and −180° westward. Unlike latitude, which has the equator as a natural starting position, there is no natural starting position for longitude. Therefore, a reference meridian had to be chosen. British cartographers had long used the Greenwich Meridian in London, while other countries had used other lines of longitude as the starting reference. In 1884, the International Meridian Conference adopted the Greenwich Meridian as the Universal Prime Meridian or zero point of longitude.

Each degree (°) of longitude is further sub-divided into 60 minutes (′), each of which is divided again into 60 seconds (“). A longitude is thus specified, for example, as 23°27′30”E. This notation is also used for latitude using North or South.

Latitude and longitude measurements are absolute measurements, since the two numbers are unique. Identifying latitude and longitude essentially specifies a point on Earth so when they are specified together they are sometimes called “point measurements,” as they refer to a specific point.

Dominion Land Survey (DLS)

The Dominion Land Survey is a method of surveying used in Western Canada, from Manitoba to BC, which is based on dividing the land into one-square-mile sections. The survey was begun in 1871. The terminology of the Dominion Land Survey has become a part of the western vocabulary (“I farm 14 quarter sections” or “I live in the township of Thode”) and is an important part of Western Canadian culture. The survey is based on meridians (longitude) and baselines (east-west lines similar to latitude). The principal or First Meridian passes just outside of Winnipeg, Manitoba at 97°27′28.41″ West. The First Baseline is the 49th Parallel, or the Canada-US border. This survey system was set up to identify tracts of land that might, for example, be used when granting a homestead to early settlers, or areas of land to the Hudson’s Bay company or the Canadian Pacific Railroad.

The 2nd Meridian forms part of the boundary between Saskatchewan and Manitoba (but only along the Northern part of the provinces) while the 3rd Meridian is at 106° West Longitude (near Moose Jaw and Prince Albert) and the 4th Meridian is the boundary between Saskatchewan and Alberta.

Dominion Land Surveyors captured topography, the presence of resources like wood, water, clay, coal and suitability for farming, and laid out an ordered pattern of settlement on a wilderness the size of Western Canada.

While Latitude and Longitude describe points, the Dominion Land Survey describes tracts of land in relationship to the Meridians and the First Baseline. The description is somewhat more difficult to use, but is ideally suited for land area identification. The early settlers to Western Canada quickly learned how to use the DLS system, and the reference monuments established by the Dominion Land Surveyors, to locate the corners of their new homesteads.

The main tract of land is the “section”. This is a (more or less) one mile by one mile square of land. Since there are a large number of sections in Western Canada, the sections have been gathered into “townships” that consist of 36 sections each. The sections in each township are numbered for identification purposes as shown below.

RANGE

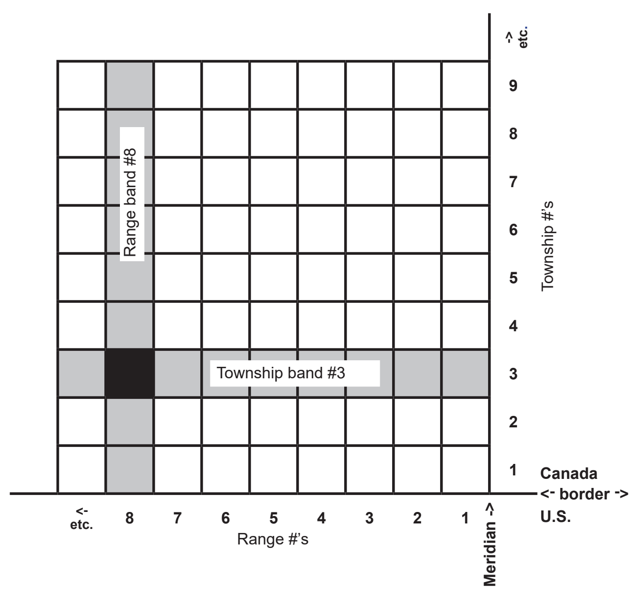
31	32	33	34	35	36
30	29	28	27	26	25
19	20	21	22	23	24
18	17	16	15	14	13
7	8	9	10	11	12
6	5	4	3	2	1

Section Layout in a Township

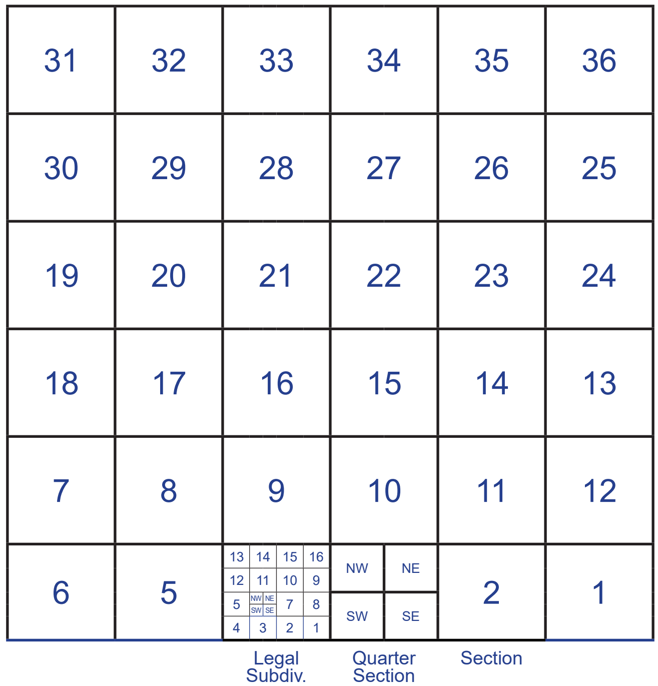
Townships still need to be identified if one is to find them on a map. This is done by numbering the township starting at the first baseline and heading north. All of the townships along the first baseline form a band referred to as Township 1, the second band is Township 2, and so forth as you proceed north.

An individual township’s Range is numbered starting at a meridian and heading west or, in the case of the principal meridian which is just west of Winnipeg, either east or west. All of the townships immediately west of a meridian form a band referred to as Range 1, the second band would be Range 2 and so forth.

For example, the 3rd township north of the Canada-US border, in the 8th range west of the 2nd meridian, would be identified as “Township 3, Range 8, West of the 2nd Meridian” or 3-8-W2.



For farming applications, sections may be broken down into quarters, labeled as SW, NW, SE and NE (for South West, North West, South East and North East). For oil and gas applications, sections may be broken down into 16 Legal Subdivisions (LSD), numbered in the same sequence as sections in townships. This allows a tract or plot of land to be more completely described.



Dominion Land Survey descriptions identify an area of land while latitude and longitude identify a point.

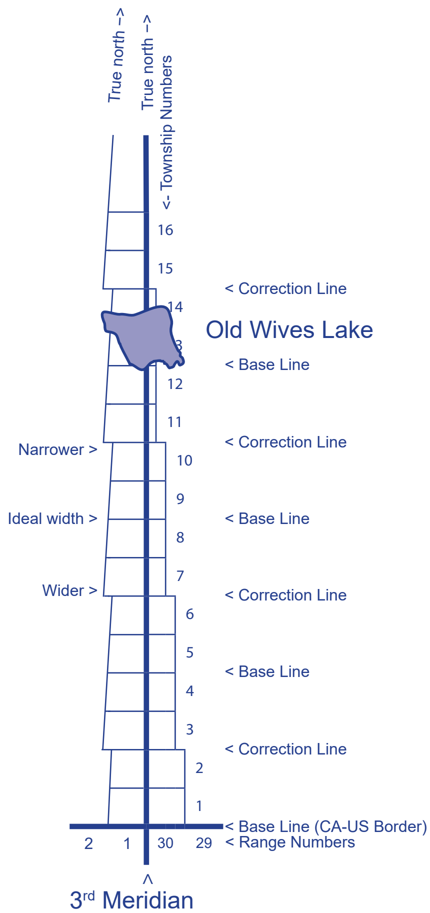
Teacher Background – Expanded

It's always difficult to represent a round or 3-dimensional object like Earth in a flat or 2-dimensional way such as a map. One way to think of the problems encountered when going from 2D to 3D is this:

> Assume you can take an orange and peel about half of it without tearing the peel on that half. Now try to flatten the peel out and you'll see that it cannot be done without some stretching and tearing of the peel. Taking a round object and flattening it out means you have to allow for some corrections (stretches or tears).

Another way to think of this problem, but going from 3D to 2D is trying to stick a postage stamp on a ping-pong ball without getting any wrinkles.

Because meridians - and the north-south boundaries of townships - are really lines of longitude, they get closer together as they go north toward the North Pole. If left uncorrected, this would lead to ever smaller Sections as one moved north from the baseline. To solve this problem, a new base line was established six townships north of the Canada-US Border and every four townships north there after. The widths of the townships were then adjusted so they would be one mile wide



along the base line but increasingly wider along the two townships south of the base line, and increasingly narrower along the two townships north of the base line. As indicated in the drawing on the left, this resulted in a jog between the townships half way between the base lines. These jogs became known as "correction lines" and have also become part of the lexicon of Western Canada, particularly in rural areas.

Extensions

Once students have an understanding of the basics of location using latitude and longitude, they are ready to look at GPS systems and how they work, and to participate in the Waymarking and Geocaching activities.

Student Activity Sheets Description

Latitude and Longitude

The World, Canada, and Saskatchewan Map activity sheets in this manual have the answers on them where applicable. Student sheets may be found in the appendices and you are encouraged to copy the activity sheets and supply them to the students.

The Activity Sheets ask the students to identify different locations on Earth, in Canada and in Saskatchewan, to give them a better understanding of how the point or line locations are described.

Dominion Land Survey

The Dominion Land Survey Activity Sheet in this manual also has the answers on it. Again, you are encouraged to make paper copies of the sheets in the appendices to distribute them to the students.

WHERE ARE YOU? Latitude and Longitude

Looking at the Globe or a Map of the World. (Map of the World)

1. Locate the Prime Meridian (Greenwich).	
a. Identify the three continents that the Prime Meridian passes through.	
	i (Europe, Africa, Antarctica)
	ii
	iii
b. Identify four of the countries that the Prime Meridian passes through.	
	i (United Kingdom, France, Spain, Algeria, Mali, Ghana, Burkina Faso [Upper Volta])
	ii
	iii
	iv

WHERE ARE YOU? Latitude and Longitude

Looking at the Globe or a Map of the World.   (Map of the World)

1. Locate the Equator.	
a. Identify the three continents that the Prime Meridian passes through.	
	i (South America, Africa, Asia)
	ii
	iii
b. Identify four of the countries that the equator passes through.	
	i (Somalia, Kenya, Uganda, Zaire, Congo, Gabon, Indonesia, Brazil, Columbia, Ecuador, and a number of small islands in the Pacific Ocean administered by the US and the UK)
	ii
	iii
	iv

WHERE ARE YOU? Latitude and Longitude

Looking at a map of Canada

For Canada Identify the:	
Easternmost Longitude	52° 37' W. (approximately)
Westernmost Longitude	140° 58' W. (approximately)

For Canada Identify the:	
Northernmost Latitude	82° 25' N. (approximately)
Southernmost Latitude	41° 55' N. (approximately)

For Saskatchewan Identify the:	
Easternmost Longitude	101° 26' 50" W.
Westernmost Longitude	110° W.

For Saskatchewan Identify the:	
Easternmost Longitude	60° N.
Westernmost Longitude	49° N.

WHERE ARE YOU? Latitude and Longitude

Looking at a map of Saskatchewan

Using the dot in the centre of the cities as their location, identify the latitude and longitude of:

Saskatoon	Latitude:	52° 08' N	Longitude:	106° 40' W
Regina	Latitude:	50° 26' N	Longitude:	104° 37' W
North Battleford	Latitude:	52° 47' N	Longitude:	108° 18' W
Prince Albert	Latitude:	53° 12' N	Longitude:	105° 46' W
Your town	Latitude:		Longitude:	

What is located at (approximately):

Latitude:	51°46'N	Longitude:	106°27' W	Mount Blackstrap
Latitude:	49°31'N	Longitude:	108°49' W	Eastend, Saskatchewan (home of Scotty the T-Rex)
Latitude:	53°56' N	Longitude:	106°05' W	Waskesiu, Saskatchewan

WHERE ARE YOU? Dominion Land Survey

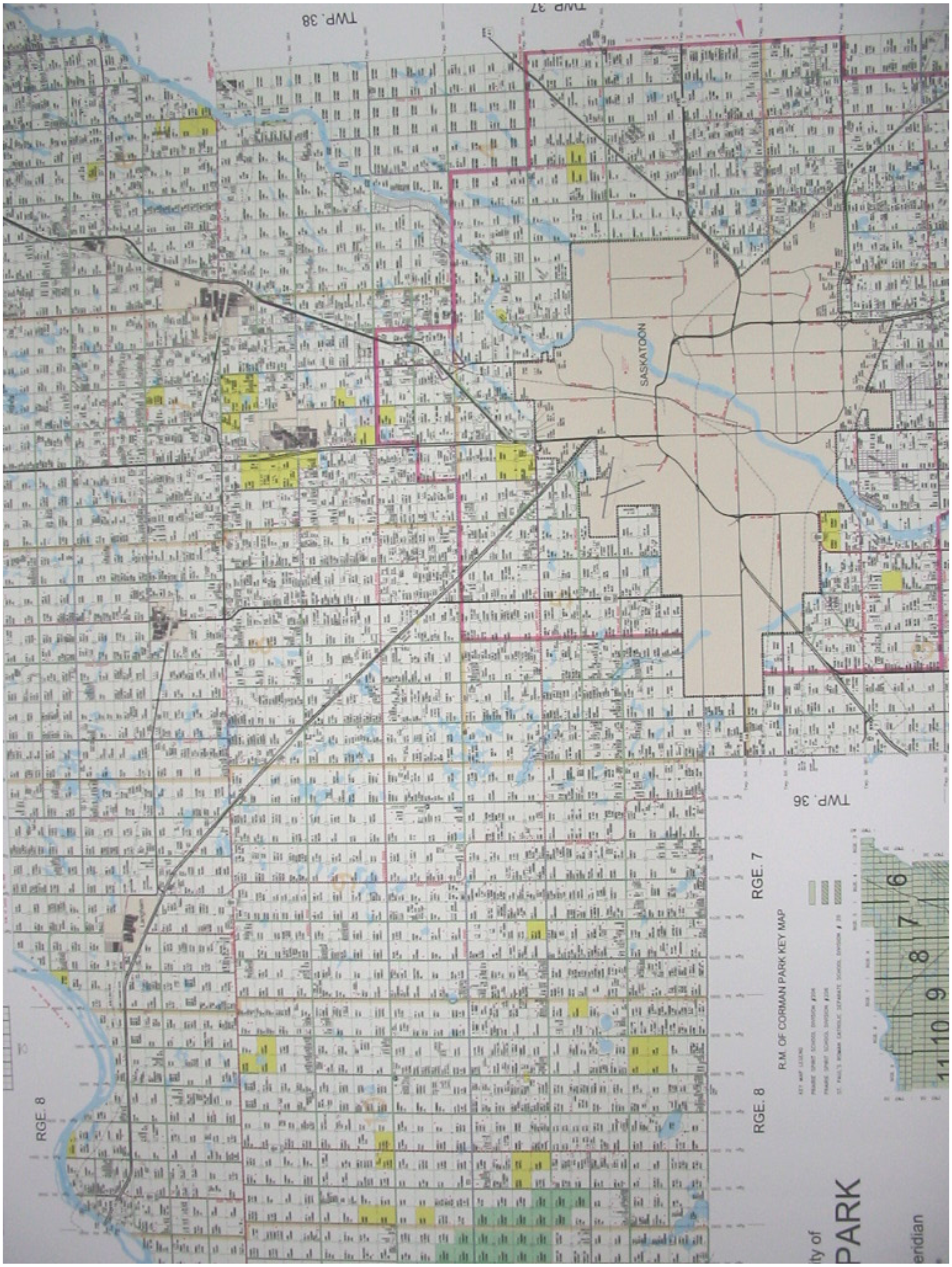
Looking at the Dominion Land Survey Map

Find the Land Owner of the following lands:

- NW-4-38-6-W3 (James Randal)
- SW-34-38-8-W3 (Peter Rawlik)
- NE-3-35-5-W3 (John and Bernice Williams)

There are three red dots on the map. Describe the locations.

Dot 1	NE-36-37-9-W3
Dot 2	NW-29-38-4-W3
Dot 3	SE-11-36-4-W3



Corman Park Land Survey Map as found in Crate

Extended In-Class Activities

Background

The three activities in this section apply the concepts developed during the station activities to wider and more practical problems. The first uses the “GPS Basics” and the “Where are you?” concepts to map the desks in a classroom. This activity shows that once you have reference points like GPS satellites or fixed points on the Earth then the accurate and reproducible location of objects, such as desks, can be determined simply and easily. This activity is approximately one half day.

The second activity uses the concept of mapping from satellite (remote sensing) to reproduce the contour of a land form. Students first create landscapes by carving them out of florist’s foam. Each student produces a landscape in a small shoe box or other appropriate container. They then seal the container and have other students try to map the surface. Concepts such as resolution can be discussed in the context of the landscapes, since the closer together the measurement points are, the better the reproduction of the scene. Graphing and scaling concepts are also presented in the activity. This activity takes approximately two half-day periods, separated by at least a day.

The third activity applies the concepts of measurement and triangulation covered in the “In Search of the Lost Monument” activity. Teams of surveyors establish reference survey monuments using simulated survey chains. From those reference monuments, they then place survey monuments at the apexes of two triangles. The precise location of those apexes then becomes confused when a number of false monuments are placed in the area. Using a variety of alternate measurement systems, the students must relocate the original, true monuments.

GPS – Mapping your Classroom

Activity Description:

Demonstration: This demonstration using three tape measures simulates the workings of a Global Positioning System (GPS).

Activity: Students use the tape measures to map the location of their desks and create a map of the classroom.

Materials:

- Three tape measures connected to simulated GPS unit. - all supplied with the Crate
- Pencils
- Rulers
- Student Sheets

Time Required:

- Demonstration – 15 minutes
- Desk Mapping Activity – 50-60 minutes

Vocabulary:

- Global Positioning System (GPS)
- Satellite
- Multipath Errors
- Geostationary

Curriculum Connections: Science

Pan Canadian Science Protocol	Grade 8 – Relationships between science and technology: Describe the science underlying particular technologies designed to explore natural phenomena, extend human capabilities, or solve practical problems (GPS).

Science and Math Concepts

- Scale drawings
- Mapping

Teacher Background

History:

In the 1960's, the US Navy and Air Force had a number of navigation systems but they did not work with each other. In 1973 the Defense Department ordered that the systems be made compatible and the Global Positioning System, or GPS, was born. It was based on an atomic clock carried aboard satellites. It was intended all along for use by civilians as well but without the same accuracy as the military data. It was not until 1983 and the crash of Korean Airlines flight 007 that GPS became available for all. It was determined that the crash could have been avoided if the crew had had access to more accurate navigational equipment. It was then that United States President Ronald Reagan ordered that GPS signals be made available to the world at no charge.

Global Positioning Systems consist of three components:

- a network or constellation of orbiting satellites
- a ground station for the control of the satellites
- a GPS receiver unit for the end user

The satellites transmit signals to the receiver-only GPS unit on the ground. These receivers work best with an unobstructed view of the sky. GPS operations require a very accurate time reference, which they get from atomic clocks at the U.S. Naval Observatory. Each GPS satellite has an atomic clock on board.

Each satellite transmits data showing its location and the precise time. These repeating signals are transmitted at regular intervals and at precisely the same time. The GPS receiving unit calculates the distance (D) by using the time (T) it took for the signal to get to it (D=RT where the rate (R) is the speed of light). The unit uses the distance from at least four satellites to calculate its position in three dimensions (latitude, longitude, and height above Earth), although the locations are usually only given as a latitude and longitude (e.g. 36° 45.029' N, 092° 24.170' W).

Determining Position (http://www.nasm.si.edu/gps/work.html)

A GPS receiver "knows" the location of the satellites, because that information is included in satellite transmissions. By estimating how far away a satellite is, the receiver also "knows" it is located somewhere on the surface of an imaginary sphere centered at the satellite. It then determines the sizes of several spheres, one for each satellite it can see, from which it can find the location where the spheres intersect—its location.

The demonstration simulates the workings of a Global Positioning System using three tape measures and five students. One student represents the person on the ground with the GPS.

Teacher Preparation

First Session: Demonstration

You'll need to have room to carry out this activity, perhaps in a gym. You could also do it outside if part of your playground is paved, then the locations found for each example could be marked out on the Tarmac with chalk.

Use the three tape measures provided in the crate. Mark them A, B and C by attaching a little tag to each.

You'll need five student volunteers for this activity. One will represent the GPS user, the second will be the GPS position recorder and the other three will be satellites.

Have the three Satellites take up positions in an arc as widely separated as possible in the space you're using, but making sure that the tape measure from each Satellite can reach the GPS Receiver. Have all of the Satellites mark their positions on the floor or Tarmac with chalk or a circular sticky label. Then hand each Satellite the reel-end of one of the tape measures. Attach the zero ends of the tape measures to the snaps provided on the hand-held GPS "receiver". Instruct each of the satellites to take up any slack to the GPS receiver. Gentle tugging will show that the GPS receiver is fixed in one location and that there is only one spot where the three tapes intersect (e.g. the position of the GPS receiver).

Using chalk or circular stickers, mark five or six points in the area between the satellites for which the locations are to be recorded. Move the GPS receiver to one of these markers and have the satellites call out the measurement to their positions. These measurements are then recorded by the GPS position recorder.

Now have the GPS user move to another marker and repeat the process. The measurements will be different. Again the GPS recorder will note the measurements to this location. Point out to students that there is only one combination of measurements for each location within the range of the three satellites. To confirm this, have the satellites adjust their tape measures back to the readings from the first maker. The GPS receiver should again be positioned over the first marker.

This method can also be used to demonstrate how errors happen when the signal from a GPS bounces off something. Keep the student demonstrators in the last position used. Instruct the Satellites to stay firmly on their spots and allow the GPS receiver to move, should it need to. Have a 6th student come up and pull up on one of the tapes. To compensate for this interference, that satellite must let out more tape, giving an inaccurate position.

Second Session: Mapping the Classroom using the Human GPS System

You should be able to use this method to map the location of each student's desk in the classroom (or the playground equipment in the school yard).

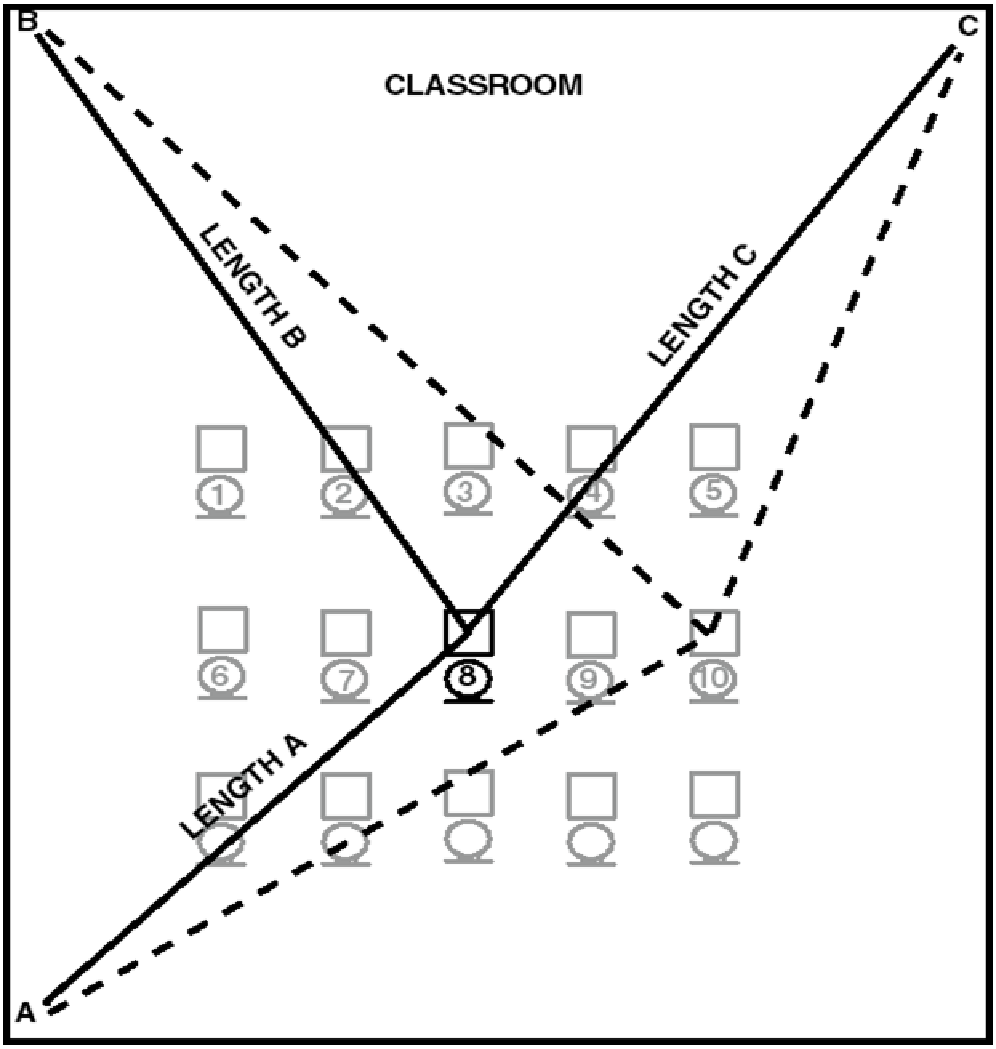
Use three corners of the room to represent satellites (corner of the tarmac on the playground).

Students work in pairs to measure the distances from each satellite to the centres of their desks, using the tape measures included in the Surveyors' Trunk.

Record measurements on a large sheet of chart paper.

Have students measure the classroom. You, the teacher, make a large-scale map on a bulletin board using large sheets of graph paper taped together. Each student can make a small-scale cut-out of their desk and paste it on.

Measurement note: Choosing the scaling factor for your classroom model will depend on the size of your classroom and the size of your model. It is easiest if you build a model which is 1/10th of your room (all division is by 10). Another scale could be determined by dividing the length of your classroom by the length of the model and rounding down to a whole number. For example, if you have a 10-metre square classroom, then an 80-cm square scale model gives a scaling factor of 12.5, which could be rounded down to 12.



Scale Drawing of Classroom

Make a number of copies of the sheet on the next page and assign groups of students to fill them in.

Suggest to the students that they build scale cut-out models of their desks/tables/chairs to complete the map.

Student Name (Desk number)	Tape A (m)	Tape B (m)	Tape C (m)	A to scale	B to scale	C to scale
Amanda(6)	4.7	8	12.5			
Jeff (8)	7.5	9.6	10.1			
Keegan (10)	10.1	11.6	8.5			
Brianna (1)	7.5	6.5	11			

Student Sheet - Mapping your Classroom

Student Name

Distance from A: m Scale Distance from A:

Distance from B: m Scale Distance from B:

Distance from C: m Scale Distance from C:

Student Name

Distance from A: m Scale Distance from A:

Distance from B: m Scale Distance from B:

Distance from C: m Scale Distance from C:

Student Name

Distance from A: m Scale Distance from A:

Distance from B: m Scale Distance from B:

Distance from C: m Scale Distance from C:

I Spy

(used with permission)

Activity Description:

Students working in pairs simulate the process of remote sensing by creating a landscape in a shoe or donut box and then trying to map it with the box closed.

Materials:

- One donut box per eight students—Shoe box for one or two students
- Florist's Styrofoam (Oasis = brand name)
- Bamboo Meat Skewers
- Nails (slightly larger in diameter than the bamboo skewers 2 ½ – 3 inch or 8-10d)
- Centimetre or ¼ inch Graph Paper (2 or 3 sheets per student)
- Glue
- Pencils
- Rulers
- Tape
- Spoons
- Red and Blue Markers
- Student Sheets
- Scissors

Time Required:

- Introduction and box building 50-60 minutes
- Box Mapping: 50-60 minutes
- Model Building: 50-60 minutes

Vocabulary:

- Remote sensing
- Resolution
- Radar
- Radarsat
- Contour

Curriculum Connections: Math & Science

Science and Math Concepts

- Graphing on a co-ordinate system
- Linear measurement
- Subtraction

Teacher Background

This teacher background is directed at those teachers who wish to have a basic understanding of the science of remote sensing. Remote sensing is the investigation of an object or objects without direct physical contact. Generally, humans use remote sensing to take in a vast majority of their daily information. The human senses of sight, smell and hearing are personal instruments for remote sensing.

Observing a planet from space using satellites requires the use of instruments that employ some part of the electro-magnetic spectrum, be it visible, infrared, microwaves, or some other portion of the spectrum. Some observations look for the topography of Earth, while others look at specific features such as vegetation, ice thickness or even soil moisture (RADARSAT).

The activity simulates the measurement of physical features of Earth (or some other planet) known as height of land and, while not an exact replica of the process of remote sensing, it is a good analogy. Students investigate a landscape hidden inside an envelope or donut box, using a simple process in an attempt to discover what is inside the box.

An actual remote-sensing satellite takes an average measurement over a particular area rather than isolated measurements at particular points. The size of the area included in each sample is known as “resolution” (30 metres for the Landsat Satellite and 10 metres for RADARSAT) and makes up one pixel in the final image.

This activity requires approximately three class periods of an hour each. The first period introduces students to the concept of remote sensing. It also requires students to create their own landscapes for analysis. To shorten the amount of time used in the classroom, the construction of the landscapes could be assigned as homework, thus eliminating one period.

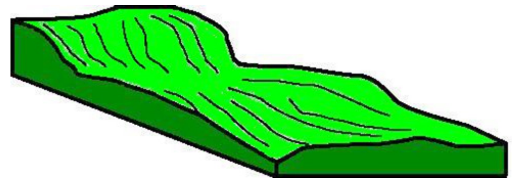
The second period has the students carry out the physical measurements needed to interpret the contents of the landscape donut box, while the third period has students interpret the information collected in an attempt to reproduce the landscape.

Teacher Preparation

First Session: Introduction and box building

These instructions assume students are working in pairs (four pairs to one donut box) to construct landscapes. Each pair needs a piece of florist’s foam, ¼ the area of the box and ¾ of its depth. The four landscapes created will be fitted together to cover the bottom of the whole box. A box of about 32 cm x 25 cm should work for 8 students (4 pairs). The larger the box, the more foam is needed and the longer the measurements and analysis will take.

Pairs of students can each construct a landscape for homework and turn it in the next class period. This reduces the time required for the activity from 3 to 2 class periods.



1. You'll need 4 pieces of foam for each group of 8 (each donut box). Cut the florist's foam into pieces big enough to fit 1/4 the area of the donut box so that when fitted together they completely cover the bottom of the box to a depth of about ½ to ¾ of its total depth. Try to use as few pieces of foam as possible. Do not glue the foam together at this point.

2. Remove the foam from the box and, using the spoon (or other implement), scrape the foam into a landscape. Make the landscape severe so that there are hills and valleys, riverbeds, etc. Do not worry about house shapes or vegetation. Ensure that the contours of the landscape continue from one piece of foam to another. Once the landscape is built, place it in the box and add finishing touches.

3. Once the landscape is complete, tape on the box lid and label the bottom of the box with the names of the students who created the box.

Perhaps the art teacher will co-operate with you and have the students do the landscapes in conjunction with a sculpture class, or the English teacher might assign students to create landscapes related to a particular novel being studied. This may work especially well if the novel has some spy connotations or WWII content. It could also be based upon current events and on-going conflicts (in Afghanistan, Iraq, the Middle East).

Note: For an historic connection, examine the terrain of strategic importance during early military campaigns or as natural barriers to commerce (St. Lawrence River/Plains of Abraham, Niagara Escarpment, wide rivers or mountains/foothills). Perhaps the Rogers Pass or some other pass of historic surveying significance might be used as a model. Had Canadian surveyor Rogers had access to remote sensing information, the work needed to locate a pass through the Rocky Mountains would have been considerably easier.

Second Session: Measurement of the landscape

Background:

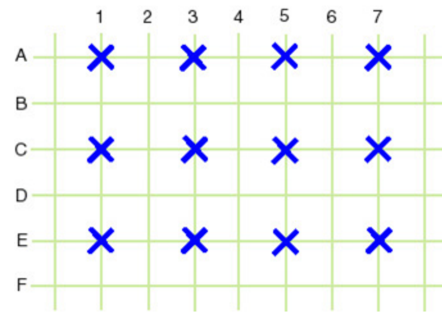
Students will use the bamboo skewers, pushed through holes in the box top, to measure the distance from the top of the box down to the landscape surface. They will use a grid attached to the top of the box (graph paper) as a guide to sampling the surface in the box. Not every square need be used, as the distance between the sample points is connected to the "resolution" of the remote sensing technique. Here we will be using point measurement (at the grid point) to represent the height in the neighbourhood at that point. Remote sensing satellites generally average measurement over a small area.

1. Assign each eight students a landscape box that is not the one they created.
2. Ensure each pair of students has two sheets of graph paper, a nail, a ruler, a pencil, a bamboo skewer and access to glue.
3. Cut 4 pieces of centimetre graph paper, which together will fit the top of the donut box. On one sheet of the paper, mark a blue

RESOLUTION:

Resolution is a term that describes how well one can make out details. Using the blue Xs only, objects smaller than two cm cannot be consistently detected. Some objects as large as about 3 cm can be missed (think of a large peak 2.7 cm wide and 3 cm high centered under a red 'X'.

X every 2 centimetres where the lines cross. Label the graph as shown in the diagram. There should be a blue ‘X’ on points A-1, A-3, A-5 … and C-1, C-3, C-5 …. Now place a red ‘X’ on points B-2, B-4, B-6 … and D-2, D-4, D-6.

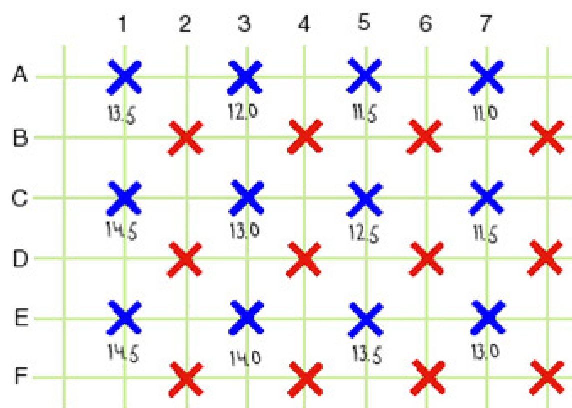


Box Top Graph

4. Glue or tape the paper onto the top of the box smoothly and even with the edges of the box lid. Save the other piece for the team who maps this box.

5. Exchange boxes with another group of 8 students.

6. With each pair of students working on a different quadrant of the box, using the nail, punch a small hole (big enough to drop in a meat skewer easily) in the middle of each X. One of the pair will measure and the other will record the data. Switch jobs halfway through.



Second Sheet of Graph Paper

7. Starting with the first blue X on the grid (A-1), drop the skewer through the hole so that it is perpendicular to the box top and just touches the surface of the landscape in the box. Using the ruler, measure the distance from the top of the box to the top of the skewer.

8. Record this number on the second piece of graph paper.

9. If time permits, make measurements at the red Xs. This increases the resolution of the overall set of measurements. Most objects under 2 cm wide, and all objects under 3 cm wide, will be detected.

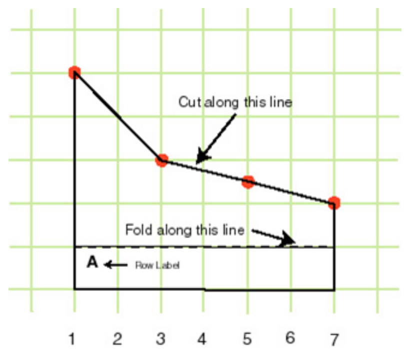
Third Session: Analysis of the data

In this session, the students use the information taken in Session Two and attempt to recreate the landscapes in their respective boxes. The procedure is not difficult, but it is time consuming.

The information that has been taken on the data graph-paper sheets needs one more piece of information before a close representation of the surface inside the box can be created. That information is “where is zero height?” In the remote sensing of Earth, this “zero height” is taken at sea level but for distant planets without a sea level the question is a bit more difficult to answer. In most cases, the zero may be chosen arbitrarily because we are only looking for variation in a surface. To conserve graph paper, the students will reduce the values of their measurements by a constant amount. It is recommended that this value be 2 cm less than the smallest measurement (e.g., smallest measurement is 11 cm, then all measurements should be reduced by 9 cm).

For each quadrant of data for the box-top, the students will be plotting, on graph paper, the data for each row (or column).

The students will graph a row (or column) on graph paper, using the height as calculated above and the spacing the same as on the box top. The graphed points are then joined by straight lines. The students then label inside the curve with the name of the row (see below).



Measurement	13.5	12.0	11.5	11.0
- “zero height”	9.0	9.0	9.0	9.0
= Graph Value	4.5	3.0	2.5	2.0

Example for Row “A” above

The students will then cut out the curve and fold up the bottom centimetre of the graph so the Row Label is visible.

Do this for each of the rows (or columns) marked with the blue Xs.

Mount each of the graphs on a table or other flat surface, 2 cm apart and parallel to one another. This will then be a representation of what is inside the box.

You will need to tape your 4 surfaces together to represent the whole landscape inside your box.

If time permits, carry out this procedure with the rows (or columns) marked with the red Xs. These can be placed between the graphs of blue Xs, offset by one cm to give a more detailed representation of what is in the box.

Open the box and compare what you have created with what is in the box.

STUDENT SHEET 1 – Landscape Creation – I Spy

MATERIALS:

1 Donut Box	Red & Blue Markers
Spoon or Other Carving Instrument	Tape
Ruler	Nail
Florist's Foam	Centimetre graph paper, 2 or 3 large sheets

Building Your Box

Carve the florist's foam into a landscape. Consider including some of the following items in your landscape.

Hills

Valleys

Rivers

Join your landscape with the other 3 pairs from your box.

Cut 2 pieces of centimetre graph paper to fit ¼ of the top of your group's donut box. On one sheet of the paper, mark a blue X every 2 centimetres where the lines cross. On every other (alternate) row and column, mark a red X. Label the graph with rows and columns as shown in the diagram. (see Diagram A).

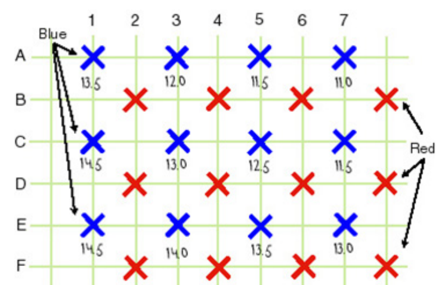


Diagram A

Glue the four graphs onto the top of the box to cover it smoothly. Make sure the edges are straight with the edges of the box lid and the box edge is parallel to the lines in the paper. Save the other pieces for the team who maps your box.

Using the nail, punch a small hole (large enough to drop in a meat skewer) in the middle of the Blue X's on one of the sheets.

STUDENT SHEET 2 – Landscape Mapping – I Spy

Mapping Your Box

Exchange boxes with another group of students.

You will create a topographical map of the contents of your new box using remote sensing techniques. Your goal is to determine what the surface of the contents of the box looks like without looking inside.

Starting with the first blue X, on the grid (A-1), drop the skewer through the hole so it is perpendicular to the box top (straight up and down) and just touches the inside landscape. Using the ruler, measure the distance from the top of the box, to the top of the skewer.

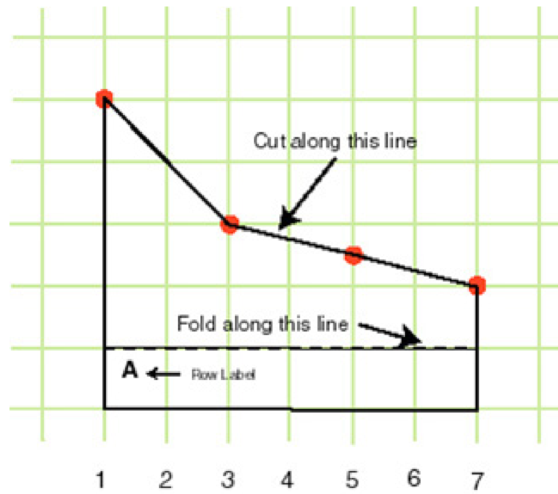
On the second piece of graph paper at the corresponding X, record the measurement. Measure to the nearest millimetre. This is a measure of the height of the surface inside the box except that a zero height has not been determined. Since we are only looking for what the surface looks like and not its height from the bottom of the box, we may set the zero height at an arbitrary value. We will do this in the next section.

Repeat #3 and #4 until all blue Xs have been measured. Transfer your measurements to the chart provided.

For better resolution, repeat steps 3 and 4 after punching all the red Xs.

Row/ Column	1	2	3	4	5	6	7	8
A								
B								
C								
D								
E								
F								
G								
H								
I								
J								
K								
L								
M								
N								
O								
P								
Q								
R								
S								
T								
U								
V								

STUDENT SHEET 3 – Landscape recreation – I Spy



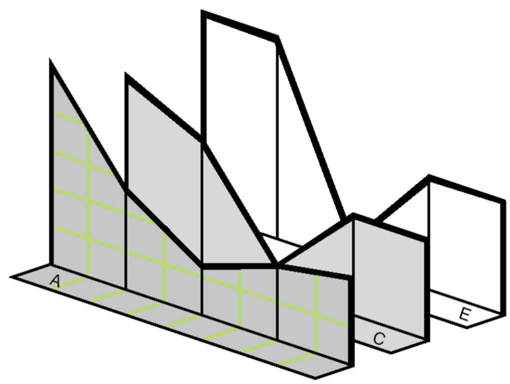
1. Using another sheet of graph paper, plot the height measurement for each point of a particular row or column (see Diagram B). Transfer the measurements for one row at a time. To reduce the height of the graph, subtract the smallest of all your measurements from each of your other measurements and then add two centimetres. This is known as setting the zero for the measurements.

2. Join the points using straight lines.

3. Cut out the graph and fold along the dotted line. Make sure the Row or Column label is visible.

4. Glue (or tape) the cut-out graph onto the spare grid as shown in Diagram C.

5. Continue transferring measurements until all the contours have been built and glued onto the grid.



Graph Paper

The Lost Monument (continued)

Activity Description:

This activity takes the "In Search of the Lost Monument" activity closer to the real world. Students form teams of surveyors working either outdoors or in a large room such as a gymnasium. They first layout survey monuments using simulated surveyor chains. The locations of some of their survey monuments then become confused so they must use other measurement systems to relocate them.

Materials:

(All materials supplied with the Crate)

- Surveyors chains (5)
    - Black - five-unit chain (1)
    - Red - three-unit chain (1)
    - Yellow - four-unit chain (1)
    - White - isosceles chain (2)
- Carpenter's tape measures (2)
- Painter's tape, circular sticky labels or (if outdoors) large spikes
- Simulated Electronic Distance Measurement (EDM) Equipment (available only upon special request)

Curriculum Connections: Mathematics, History

Saskatchewan Grades 8 & 9

Time Required:

- Introduction - 15 minutes
- Activity
    - Stage 1 - 30 minutes
    - Stage 2 - 60 minutes

Vocabulary:

- Triangles - right, isosceles, perfect
- Survey monument
- Reference monument
- Chainman
- Surveyors chain
- Electronic Distance Measurement (EDM) Instrument

Teacher Background

The surveyors who laid out the Dominion Township System in Western Canada used tools called **chains** to measure distances. In the earliest years of the survey, these tools were literally chains consisting of 100 steel links. They were called Gunter's Chains. The standard length of a Gunter's Chain was 66 feet (20.1168 metres). Gunter's Chains were very cumbersome to use and subject to error due to wear, stretching and extremes in temperature which would cause the metal to expand or shrink. Later on, the Gunter's Chain was replaced with a single metal tape on a reel similar to the tape measures used by carpenters and construction workers today. However, surveyors still referred to these new metal tapes as chains even though they were up to 300 feet (100 metres) long.

A Gunter's Chain

In later years, surveyors began to use electronic distance measuring (EDM) instruments to measure distances. EDMs emit a beam of infrared light that bounces off a prism mirror—usually on top of a rod—positioned at the point to be measured. The EDM then translates the time required for the beam of light to travel from the EDM to the mirror and back again, into distance. EDM's are extremely accurate and can measure distances within 1 mm.

Most recently, surveyors use Global Positioning Systems (GPS), often in combination with EDM's to measure distances. The advantage of GPS technology is that it does not require a clear line of sight between points and can measure extremely long distances.

In the end, each type of technology is just a measurement tool with certain advantages and disadvantages. It is up to the surveyor to make sure that any limitations are recognized and potential errors in measurements are minimized.

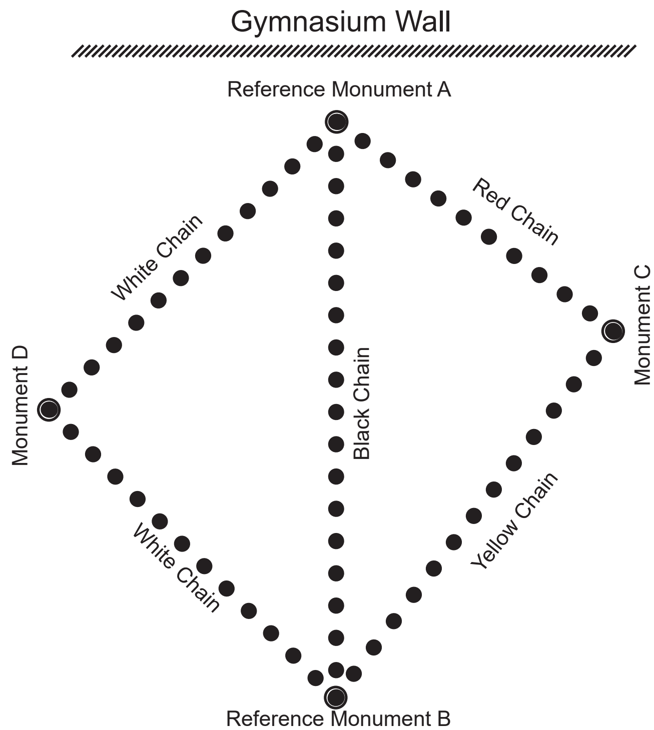
Activity

The simple triangle exercises used in the classroom are expanded to a larger space such as a gymnasium or playground and simulated survey equipment is used to establish survey monuments and then relocate those that have become lost.

Stage 1 - The Set-up

One or more groups of four students form early day survey teams whose task is to lay out pairs of two triangles using three different lengths of survey chains. Three of the students in each team will be "chainpersons" and the fourth will be the surveyor.

First, each survey team must establish two reference monuments. Two of the chainpersons on each team take one end of the five-unit (black) chain and pull it tight. (If working in a gymnasium, the reference monuments should be more-or-less perpendicular to the long gymnasium wall to allow room for laying out the triangles on either side.) Each team's surveyor will then place a survey monument at the centre of the rings at each end of the chain. These will be reference monuments A and B. If working in the gymnasium, each monument could be a circular sticky label or piece of painter's tape. If working in the playground, the monuments could be large spikes driven into the ground. (Care must be taken to remove all spikes after the exercise is complete.) The reference monuments should be clearly marked in some way as monuments A and B.



All three chainpersons then take two other chains. For the perfect right triangle, they will use one red (3 unit) and one yellow (4 unit) chain. For the isosceles triangle, they will use the two white (3½ unit) chains.

Chainperson #1 will need to hold one ring from the end of both chains to establish the locations of monuments C and D. Chainpersons # 2 & 3 will take the rings at the other ends of the chains and hold them securely over the two reference monuments. For the perfect right triangle, the end of the red chain should be at reference monument A and the end of the yellow chain should be at reference monument B. Chainperson #1 will then hold both rings with a single finger and pull the chains tight. The surveyor will then mark the position of these two rings as the third point (monument C or D) on each of the two triangles.

The survey crew will repeat the process for the other triangle but on the opposite side of the two original markers. Alternatively, a different survey crew could be laying out the second triangle.

After the two triangles have been created, and unseen by any of the other students, two people (students or teachers) called "Time" and "Environmental Factors" will create confusion about the locations of monuments C and D by placing six or eight false monuments in the area around them. These false monument should be arranged about 15 - 25 cm apart and in a pattern that will not give away the position of the correct monuments (e.g. not leaving the original monument in the centre of the group.

Stage 2 - Locating the Missing Monuments

Working in groups of three, our modern day surveyors may use a variety of measurement methods to locate the missing monuments. Two students in each group are chainpersons and the third is the surveyor.

- Method 1 - Pacing the distances

  One of the oldest methods of measuring distance is to pace it off. This can be fairly accurate if the length of the pace remains constant. For short distances such as this, the heel-to-toe method can be even more accurate.

  First, the team must calibrate its measuring tool. Starting at reference monument A and facing reference monument B, one of the chainpersons paces off the distance from A to B. She will start with the heel of one shoe just ahead of the first reference monument. Then, placing the heel of the other shoe against the toe of the first, the team will count the number of shoe lengths between the two monuments The surveyor records this number including any fractions of a shoe length at the end. Partial shoe lengths can be rounded to the nearest ½ shoe length. The surveyor then divides the number of shoe lengths by five to determine the number of shoe lengths in the standard unit of length (again rounding to the nearest ½ shoe length).

# of shoe lengths between monuments A and B	5 =	# of shoe lengths in one standard measure
32½	5 =	6½

Next, the surveyor needs to calculate the number of shoe lengths on the other two sides of each triangle.

For the perfect right triangle

# of shoe lengths in one standard measure		# of shoe lengths between reference monument A and monument C
6½	x 3 =	19½
		# of shoe lengths between reference monument B and monument C
6½	x 4 =	26

For the isosceles triangle

# of shoe lengths in one standard measure		# of shoe lengths on the other two sides of the isosceles triangle
6½	x 3.54 =	23

This entire process could be repeated using a different chainperson to show that the same result can be reached, even if the length of their shoes are significantly different.

Next the team tries to figure out which markers are the missing monuments.

For monument C, the chainperson starts with his heel at reference monument A, and paces in a straight line toward the centre of the cluster of markers in the area of monument C. When the required number of shoe lengths is reached, the team tries to determine which of the markers are likely to be that distance from reference monument A. (There could be more than one.)

Next, the chainperson starts with her heel at reference monument B and paces in a straight line toward the centre of the cluster of markers in the area of monument C. When the necessary number of shoe lengths have been measure off, the team again tries to figure out which of the markers are at that distance from reference monument A. Only monument C will be the necessary distances from both A and B.

For the isosceles triangle, the process will be repeated except that the number of foot lengths to monument D will the same from both A and B.

- Method 2 - Tape Measure

  More recent and accurate than the Gunter's Chain is the steel tape. Used carefully, it can provide millimetre accuracy.

  First one chainperson will hold the zero end of the tape measure on reference monument A while the other chainperson reads off the distance to reference monument B. The surveyor records this number to the nearest centimetre. The surveyor then divides the measurement by five to get the number of metres in the standard unit of measure.

# of metres between monuments A and B	5 =	# of metres in one standard measure
7.50	5 =	1.50 m

Next, the surveyor needs to calculate the length of the other two sides of each triangle.

For the perfect right triangle

# of metres in one standard measure	x 3 =	Distance between reference monument A and monument C
1.50 m	x 3 =	4.50 metres
	x 4 =	Distance between reference monument B and monument C
1.50 m	x 4 =	6.00 metres

For the isosceles triangle

# of metres in one standard measure	x 3.53 =	lengths of the other two sides of the isosceles triangle
1.50 m	x 3.53 =	5.30 m

Next the team tries to figure out which markers are the missing monuments.

To locate monument C, one chainperson holds the zero end of one tape measure at monument A while a second chainperson holds the zero end of a second tape measure at monument B. The surveyor then extends the two tape measures until reaching the calculated distances from A and B. The surveyor then pinches the tapes together at those distances. By pulling the tape measures tight, the intersection of the two tapes will be at, or very close to, monument C.

For the isosceles triangle, the process will be repeated except that the distances to monument D will be the same from both A and B.

- Method 3 - Electronic Distance Measurement (EDM)

Modern day surveyors frequently use EDMs to measure distances. These, too, can be highly accurate but there are limitations.

For this exercise, the group of three consists of a surveyor, an instrument person and a rod person.

First, the instrument person sets up the EDM[1] over reference monument A and points the telescope at monument B. The rod person mounts the transceiver on the rod and turns it on. Holding the rod at reference monument B, she checks that the transceiver is level.

The instrument person turns on the EDM making sure it is set to the 60 m range. When the rod person confirms that the transceiver is level, the instrument person presses the READ button on the EDM. After a few seconds, a number (in either metres of feet) will appear on the display. The instrument person reads out the number to the surveyor.

The surveyor calculates the distance between reference monuments A and B by adding 5 centimetres to the reading. (Five centimetres is the distance from the zero point on the scale on the top of the EDM instrument to the centre of the tripod.)

Reading from EDM	+ .05 =	Distance (in metres) between reference monuments A and B
7.45 m	+ .05 =	7.50 m
# metres between monuments A and B	5 =	# of metres in one standard measure
7.50 m	5 =	1.50 m

1 Details for setting up the EDM are included in the instrument kit.

Next, the surveyor needs to calculate the number of metres on the other two sides of each triangle.

For the perfect right triangle

# of metres in one standard measure		Distance between reference monument A and monument C
1.50 m	x 3 =	4.50 metres
		Distance between reference monument B and monument C
1.50 m	x 4 =	6.00 metres

For the isosceles triangle

# of metres in one standard measure	x 3.53 =	Lengths of the other two sides of the isosceles triangle
1.50 m	x 3.53 =	5.30 m

Next the team tries to figure out which markers are the missing monuments.

For monument C, with the rod person still holding the rod on monument B, the instrument person sights through the telescope and rotates the EDM until the rod is centred in the field of view. The surveyor notes the **original angular reading** on the black, horizontal scale on the EDM.

From monument A, the angle between monuments B and C is approximately 53°.

If the EDM needs to be turned to the left to point at monument C, 53° needs to be **subtracted** from the **original angular reading**. If the EDM needs to be turned to the right to point to monument C, 53° needs to be **added** to the **original reading on the scale**.

The telescope will now be pointing along a line toward monument C. The rod person moves the rod so that it is centred in the telescope. By moving toward or away from the EDM, the survey crew should be able to tell which of the markers are along the line through monument C. While holding the rod level on each of the possible markers, the instrument person checks the distance. Remember that 5 cm must be added to the reading to get the proper distance. This is repeated until monument C is located.

If time permits, and to confirm the location of monument C, set up the EDM over monument B and confirm that the angle between A and C is 37° and the distance is as calculated above.

For the isosceles triangle, the process will be repeated except that the angles at reference monuments A and B, to monument D, will both be 45°.

Outside Class Activities

Background

There are two activities in this section, both of which use GPS or other coordinate systems to find locations of objects in either the neighbourhood or the world in general. Both also employ research skills in an attempt to identify the objects being searched.

Waymarking is an activity that is first carried out in the classroom or in the computer lab that involves searching for an item or landmark, given its geographical coordinates. Once students have identified all the locations in the lesson plan, they are encouraged to find a landmark in their community and record its geographical coordinates in this manual for other groups to find. We also encourage them to include a picture and name of the landmark so that other classes will know when they have the answer.

The second activity in this set is a community-centred, geocaching activity. Students are asked to plant a number of geocaches throughout their school communities using either map- or GPS-coordinate systems. They are then tasked with finding and recording where the other geocaches are. This activity takes students outside the schools and may require additional resources, such as GPS systems and chaperones, as the students seek out the geocaches.

Waymarking Scavenger Hunt

Activity Description:

Students work with the Manual to identify the object, land formation, or building that corresponds to the coordinates given on the site. Once this first step has been completed, students, working with the teacher, identify a landmark to be posted to the site for other classrooms to identify.

Materials:

- Access to Atlas or other set of maps
- Access to the Internet
- GPS Unit (for accurate coordinates)
- Access to Google Earth (for finding locations)

Time Required:

- Extended class periods – minimum of 2 periods on different days

Vocabulary:

- Waymarking

Teacher Background

Social Studies – Location Topics One to Three

- Topic One: Reviewing Map Interpretation Skills
- Topic Two: Location - Relative and Absolute
- Topic Three: Location - Latitude and Longitude

The purpose of this program is to take the students on a virtual scavenger hunt, using GPS information, in an attempt to identify landmarks of significance. This activity is a follow-up on the "Where are you?" station activity where students are introduced to the terminology of point and area identification.

Waymarking: Identify the landmarks described in the table below. Use whatever map or Internet resources you need. Once you have zeroed in on the location, you may need to further investigate using Internet facilities to identify the landmark.

There are five locations in the table below. The identification of the first one has been done for you, along with the steps in the investigation.

A copy of this table, with additional spaces for contributed waymarks, is included, (Teacher Waymarking Table, p. 84), as well as a student form for identifying and choosing local landmarks (Student Worksheet - Waymarking, p. 86).

Sample Waymarking Table

	GPS Coordinates		
	Latitude	Longitude	Landmark
1	52°07’37.42”N	106°39’51.93”W	Statue of Mahatma Gandhi - Saskatoon
2	51°16’11.48”N	105°59’38.69”W	World’s Largest Tea Pot — Davidson, Saskatchewan
3	46°28’25.51”N	81°02’63.41”W	Science North Science Centre, Sudbury Ontario
4	25°20’38.55”S	131°02’11.49”E	Ayers Rock, Australia
5	17°55’30.23”S	25°51”25.04”E	Victoria Falls, Zambia

Strategy #1

Use a map with latitude and longitude measurements on it to narrow down where the landmark is. In this case, 52°07’ and 106°39’ is located very close to Saskatoon, SK. By looking at maps with finer and finer resolution, the location may be narrowed down to downtown Saskatoon.

If you are in Saskatoon, you could go and look, however, if you are not, you could contact friends, relatives or other schools to see if they could tell you what you might find at those coordinates.

Alternately you could use the Internet to search: “Saskatoon Downtown, landmarks, statues.”

Looking through the different sites, you will find one that identifies the statue of Gordy Howe on 1st Ave and 20th Street. This is incorrect as the statue is no longer there. The Web site has not been updated—a hazard in using only the Internet to locate information. Investigation of other sites may lead you to a reference to Midtown Plaza shopping mall and a bust of Mahatma Gandhi down the street. This is the correct answer, although a statue of John Diefenbaker is also close to those coordinates and could count as another answer.

Strategy #2

Use Yahoo Maps (“hybrid”) or Google Earth to center on the worksheet coordinates to find that they correspond to the intersection of 2nd Ave and 21st Street. You will need a map of Saskatoon so that you can match the Google Earth image with the street map.

Send an email to friends, family or the tourism office to ask what landmark/statue is at that location.

Teacher Note: If you wish to assess the search strategies of individuals or groups of students, a Student Worksheet is included.

Adding a Waymark

Once you have identified the 5 landmarks on the Waymarking Table, it is time to add a landmark from your community to the crate. As it is unlikely that others will be traveling to your community, pick a landmark that is identifiable and physically fixed. For example, if you have “The World’s Largest” something, that would be a suitable landmark. Now use either strategy #1 or #2 to find the GPS coordinates of the landmark. Have your teacher write those coordinates in the table in the Surveyor’s Crate Teacher Manual. If a number of landmarks are potential candidates for Waymarking, use an appropriate technique (student vote, name from a hat, consensus, etc.) to choose one. Make sure you include a picture and description of the landmark so that others will know what you have included.

If you want to make it easy for others to find the landmark, and to publicise your community, you can go to Google Earth and place a “Placemark” and picture at the site of the correct coordinates.

Be sure to include an email or postal address of your school or the community tourism office so that others may contact your community to find out what is at your coordinates.

For more information on Waymarking, check out:

http://www.waymarking.com/

http://en.wikipedia.org/wiki/Waymarking

http://www.flickr.com/groups/waymarking/

TEACHER WAYMARK TABLE:

Once you have located all of the unknown landmarks in this table, please identify one from your community and include it in the table.

	Latitude		Longitude	Landmark
1	52°07’37.42”N		106°39’51.93”W	Statue of Mahatma Gandhi - Saskatoon
2	51°16’11.48”N		105°59’38.69”W	
3	46°28’25.51”N		81°02’63.41”W	
4	25°20’38.55”S		131°02’11.49”E	
5	17°55’30.23”S		25°51”25.04”E	
6				
7				
8				
9				
10				
11				
12				
13				
14				

	Latitude		Longitude	Landmark
15				
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25				
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28				
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30				

STUDENT WORKSHEET - WAYMARKING

LATITUDE [ ] LONGITUDE [ ]

APPROXIMATE LOCATION (COUNTRY, PROVINCE, "NEAR TO ..."

[ ]

IS LOCATION ON GOOGLE EARTH? YES ☐ NO ☐

IS LANDMARK ON GOOGLE EARTH? YES ☐ NO ☐

SEARCH STRATEGY:

WEBSITES INVESTIGATED:

[ ]

E-MAIL CONTACT: [ ]

OTHER STRATEGIES:

[ ]

Activity Description:

Students in groups of 2 or 3, with maps and/or GPS units, identify places in their community where caches could be placed. Caches are then built and placed at the selected locations. Starting each with their own cache, student groups—using the coordinates given to them by their peers—seek out the additional caches.

Materials:

- Access to Atlas (or map of the community)
- Simple GPS Unit (for each group)
- Tin or Resealable Container (for geocaches)
- Tokens (one set per team, to identify that they have visited a geocache)
- locations)

Time Required:

- Extended class periods – minimum of 2-3 periods on different days

Vocabulary:

- Geocaching

Curriculum Connections: Mathematics

Western Canadian Math Protocol	Grade 7 – Shape and Space (Transformations) Identify and plot points in the four quadrants of a Cartesian plane, using integral ordered pairs

Teacher Background

The purpose of this activity is to give students an introduction to Geocaching using maps and, if available, basic GPS equipment. No GPS equipment is contained within the crate, so this activity will be described using the map technique.

Geocaching is an outdoor treasure-hunting game in which the participants use a Global Positioning System (GPS) receiver or other navigational techniques to hide and seek containers (called “geocaches” or “caches”) anywhere in the world. A typical cache is a small waterproof container containing a logbook and “treasure,” usually toys or trinkets of little value. For this activity, students will create caches from containers such as re-sealable margarine containers or small boxes that may be left out in the environment for a short period of time. This version of geocaching allows participants to enjoy the principles of the sport without venturing far from the community or purchasing expensive equipment. Participants work alone or in pairs to identify the location of a cache in the community. They then place a cache at that location. The locations are carefully located on a map or with a GPS system and recorded in a master table in the classroom.

Once the teacher has approved the site, students are asked to position their caches at the locations they have chosen. This can happen either during a classroom period or after school. It is important that the other teams do not see the master table or observe the students placing the caches.

During the field trip, students and their chaperones scour the community looking for the caches, using a map or GPS unit as navigational devices.

Contents of Geocache

The cache should be marked by the teacher. Unique identifying marks or symbols on each of the top, bottom and sides of the cache should be marked. This is to ensure that the students actually find the caches and record in their log book the symbols or letters. This is one way to prevent teams from identifying a cache by asking other teams.

As well as being marked, the caches should contain a number of small items that can be recorded by the various teams.

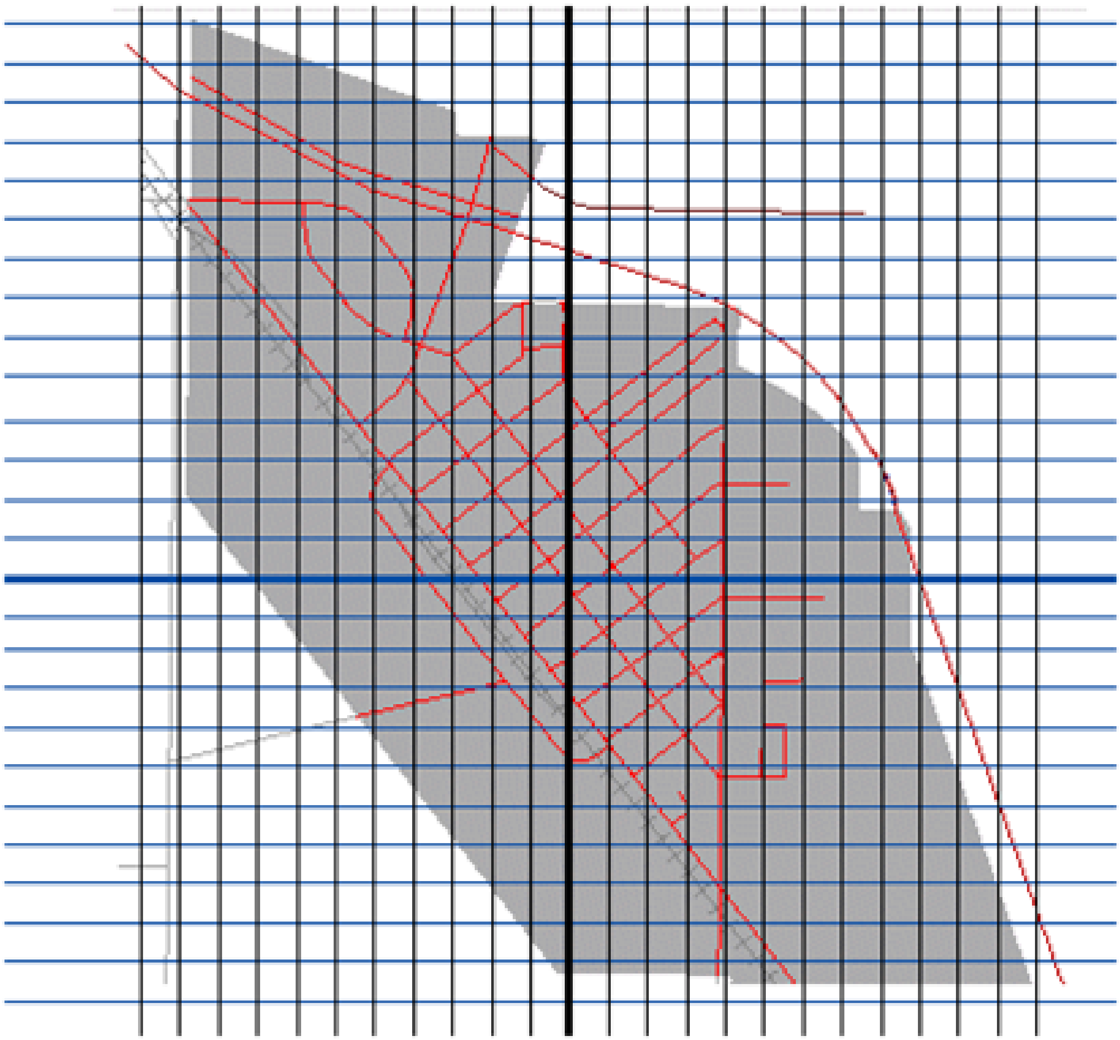
Instead of giving each team a description of all of the cache locations, the teacher may include in one group’s cache the location of the next cache to find. In this way, students must devise a search strategy for each cache individually, as opposed to devising a global strategy based on all of the locations of the caches on the map.

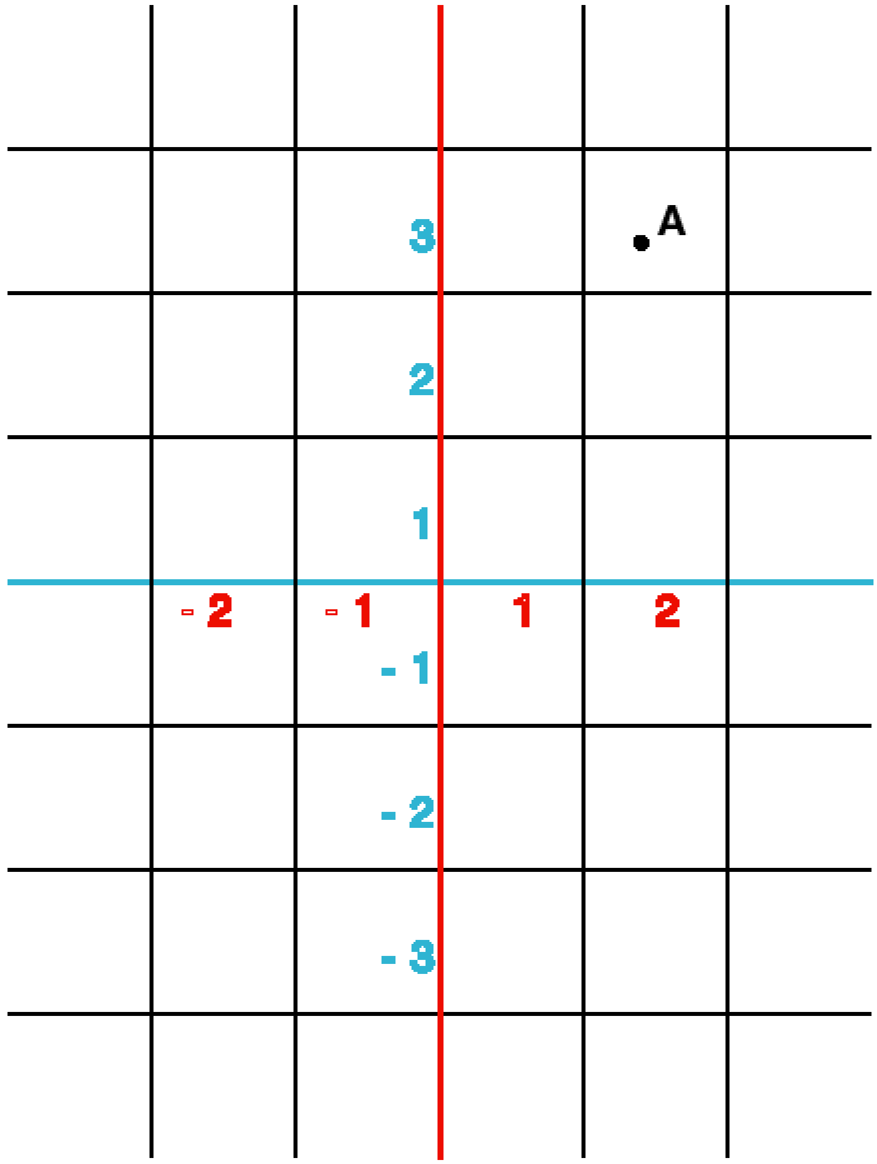
Creating a Map

Begin with a map of the community, no larger than 8 ½ x 11 with landmarks, streets or low-resolution GPS coordinates on it (see the example below).

Students decide on a location on the map and record the grid number where the cache is placed. Alternately, they may attempt to better quantify the location by estimating where inside the grid the cache is located (see next example).

Geocaching—Community Map





Point A is in sector 2 : 3 SW quadrant

Point A is at 2.4 : 3.3

Instead of quantifying a location to a tenth of a grid mark as in the example above, students may divide the sectors into quarters or quadrants. Point A above would be in the Southwest Quadrant of sector 2: 3.

Before the caches may be hidden, obtain permission from the land owner.

Finding the caches

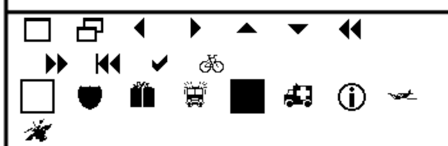
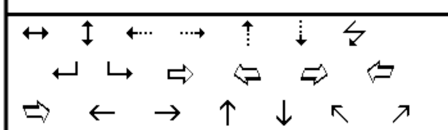
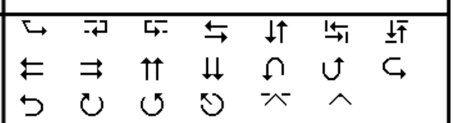
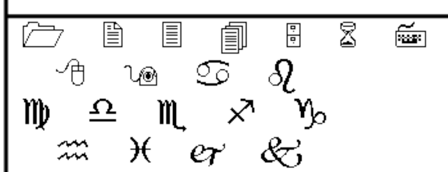
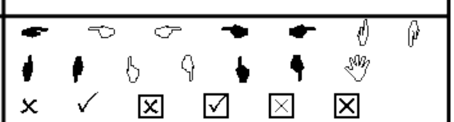
Various techniques may be used to find the caches:

- Students travel as a class to each of the cache sites in an attempt to find them.
- Students in their groups of two try to locate the caches in any order they feel appropriate.
- Students in their groups of two are given a search strategy (such as A then B then C … then Z), with the students ending at their own particular cache.
- Information about the next cache may be included in each cache.

To track student groups and monitor success in finding all of the caches, affix a series of unique symbols (as shown below) to the side, bottom or top of each cache. Assign a different symbol number to each group to record in their log books. To discourage students from sharing location information, assign each group their symbol only as they leave to find their caches.

If needed to track the student groups, or to monitor their success in finding all of the caches, a series of symbols, such as the ones below may be fixed to the side, bottom or top of the caches. The group is then assigned a symbol number to record (fourth symbol, sixth symbol, etc.) to report in their log books. Each group could have a different symbol number. Their specific symbol number would be given them as they go out to find the caches. This is done to prevent the sharing of location information.

Typical symbol sequences for the various caches:

1,2,3,4,5,6,7,8,9,10,11,12, 13,14,15,16,17,18,19,20		A,B,C,D,E,F,G,H,I,J,K, L,M,N,O,P,Q,R,S,T
		1 2 3 4 5 6 7 8 9 a b c d e f g h i j k
		
		

Student Geocaching Record

Number	Cache Coordinates	Cache Contents	Symbol #	Symbol	Initials

Permissions

"I Spy" is used and modified with permission of eclecthink international.

Appendices

A1: Crate Contents and Materials Lists

A2: Student Activity Sheets

APPENDIX A1: — Crate Contents and Materials List. School-supplied materials in RED

- Shipping Crate
- Teacher's Manual
- Activity Envelopes
  - Build a Railroad
    - Magnetic map
    - Magnetic railway pieces
    - Magnetic roadway pieces
    - Student sheet
  - CSI Surveyor
    - Map
    - Ruler
    - Student sheets
  - GPS Table Top
    - Map
    - Coloured disks (3)
    - Coloured triangle (1)
    - Student sheets
    - Erasable markers
  - Mining the Store
    - Mine layout
    - Student sheets
  - Tessellating Telephone Towers
    - Magnetic map
    - Magnetic tower pattern outlines
  - In Search of the Lost Monument
    - Student sheet
  - Where are you?
    - Map of the World
    - Map of Canada
    - Map of Saskatchewan
    - Corman Park Municipality map

Extended Class Room Activities

- GPS – Map Your Classroom
  - Carpenters' tape measures (3)
  - One Hand-held GPS model (wooden handle with three snaps)
  - Pencils
  - Rulers
  - Measuring tape
  - Student sheets
- I Spy (all materials supplied by school)
  - 1 donut box per eight students—Shoe box for 1 or 2 students
  - Florist's Styrofoam (Oasis = brand name)
  - Bamboo meat skewers
  - Nails (slightly larger in diameter than the bamboo skewers 2 ½ – 3 inch or 8-10d)
  - Centimetre or ¼ inch graph paper (2 or 3 sheets /student)
  - Glue
  - Pencils
  - Rulers
  - Tape
  - Spoons
  - Red and blue markers
  - Student sheets
  - Scissors
- The Lost Monument (continued)
  - Five chains: 1 red, 1 black, 1 yellow, 2 white
  - Carpenters' Tape Measures (2 from Map Your Classroom)

Out-of-Classroom Activities — all materials school supplied

- Waymarking
  - Access to atlas or other set of maps
  - Access to the Internet
  - GPS unit for accurate coordinates
  - Access to Google Earth for finding locations
- Geocaching
  - Access to atlas or other set of maps of the community
  - Simple GPS system for each group
  - Tin or resealable container for geocaches
  - Tokens, one set per team, to identify that they have visited a geocache

STUDENT ACTIVITY PAGES

Student Sheet for Scoring the Railway Constructions

Find out how well your route scored :

1. Multiply the number of contour lines you crossed with your railway or roadway segments by 3.
2. Add that number to the number of segments you used.

The lower the final number the "better" the design.

Track 1

	+		=	
# of pieces of track/road		(# of contour lines crossed X 3)		Total (The lower the number, the better)

Track 2

	+		=	
# of pieces of track/road		(# of contour lines crossed X 3)		Total (The lower the number, the better)

Track 3

	+		=	
# of pieces of track/road		(# of contour lines crossed X 3)		Total (The lower the number, the better)

Track 4

	+		=	
# of pieces of track/road		(# of contour lines crossed X 3)		Total (The lower the number, the better)

Track 5

	+		=	
# of pieces of track/road		(# of contour lines crossed X 3)		Total (The lower the number, the better)

Student Role Sheet for CSI SURVEYOR

You are a forensic surveyor and you've been called to the scene of a motor vehicle accident. Three cars have skidded to a stop and a large plate glass window has been destroyed seriously injuring the two people carrying the window. All of the drivers maintain that they were traveling the speed limit and that the window "Just jumped out in front of me!" Because the people carrying the window were seriously hurt, they are considering suing the motorists for damages. It is your job to measure the skid marks left by the three cars and, using the information about each car, calculate which, if any, of the cars was speeding. The residential speed limit is 50 km/h. You will be called into court to testify as an expert witness when the case goes to trial, so it's important to be sure your calculations are correct.

The length of the skid mark is not the only thing that affects the speed of a vehicle. The "stickiness," or friction of the road surface, is also part of the calculation. Different surfaces (and tires) have varying drag factors which is shown by different numbers (e.g. pavement is about 0.70, but ice is about 0.18). A smaller number means the surface is not as sticky, so a car will go further in a skid and the skid mark will be longer. Each vehicle has another factor related to how well the brakes operate. This is known as the Brake Efficiency and is given as a percent or decimal. A brake efficiency of 100% (1.0) means that the brakes hold the wheels from spinning when applied, while an efficiency of 70% (0.70) means that there is a small amount of rotation when the brakes are locked.

15.9 is a constant number that allows you to change distance (length of the skid mark) into the speed of the car. The constant is a number that takes into account the effect of the force of gravity on the collision.

CSI - Surveyor - Storyline and Vehicle Description

Your are a forensic surveyor and you have been called to the scene of a motor vehicle accident. Three cars have skidded to a stop and a large plate glass window has been destroyed, seriously injuring the two people carrying the window. All the drivers maintain they were traveling at the speed limie and that the window "Just jumped out in front of me!" Because the people carrying the window were seriously hurt, they are considering suing the motorists for damages. It is your job to measure the skid marks left by the three cars and, using information about each car, calculate which if any cars were speeding. The residential speed limit is 50 km/h. You will be called to court to testify as an expert witness when the case goes to trial so it is important to be sure your calculations are correct.

Car 1:
Super Sport Coupe, V8 Gas Guzzler with Red Flame markings
Weight = 3 tonne
Braking Efficiency = 0.80
Drag Friction Factor = 0.61

Car 2:
Smart Car with hybrid Engine Racing striped and sun roof.
Weight = 1 tonne
Braking Efficiency = 0.64
Drag Friction Factor = 0.50

Car 3:
Soccer Mom Sedan, V4 Standard Powder Blue with Silver Trim
Weight = 2.1 tonne
Braking Efficiency = 0.72
Drag Friction Factor = 0.60

Student Calculation Sheet for CSI Surveyor

s = speed of the car in km/h
15.9 = gravity constant
d = length of the skid mark in metres
μ = drag factor
Be = brake efficiency as a decimal fraction

1. Measure the length of the skid mark on the model in centimetres using the tape measure provided.

Car 1 [ ] Car 2 [ ] Car 3 [ ]

length of skid mark in m = length of measured skid marks in cm X 4

[ ] [ ] [ ]

2. Find the product of the skid mark length (d), the drag factor (μ) and the braking efficiency (Be).

$$d \times \mu \times Be = \_\_\_\_\_\_\_\_$$

Car 1 [ ] Car 2 [ ] Car 3 [ ]

3. Find the square root of the above product using the square root key on the calculator provided

$$\sqrt{d \times \mu \times Be}$$

Car 1 [ ] Car 2 [ ] Car 3 [ ]

4. Multiply the square root by the gravity constant to find the minimum speed of the vehicle.

Car 1 [ ] Car 2 [ ] Car 3 [ ]

Speeding? ______ Speeding? ______ Speeding? ______

Student Instructions – Tabletop GPS

Global positioning Systems (GPS) are made up of several parts:

- the GPS unit (in your GPS running watch, your car's navigation system or in highly precise survey equipment)
- a ground station
- a network of satellites

This activity shows how GPS systems work to find locations and why you need to have more than one satellite for the job.

Your Survey Challenge:

Francine, the surveyor, is on the ground somewhere in Canada with her hand-held GPS unit. Your challenge is to find her location using the GPS satellites (the triangles and coloured discs).

Decide who will be Student 1 and who will be Student 2.

First, cut out the three satellite triangles provided by the teacher.

<u>Student 1</u>

- The red dot on the map represents the shadow of satellite #1 on the earth with the sun directly overhead.
- Stand the red triangle on the map so the corner marked "Satellite Shadow" is touching the red dot. The top of the triangle is where the satellite is located.
- The corner of the triangle marked "GPS Receiver" indicates the distance Francine's GPS unit is from the satellite. By turning the triangle around the satellite shadow on the map, you will see that Francine could be anywhere on a circle that represents all the possible distances from the red S1 satellite.
- Using the red disc (S1 satellite), place the centre of the disk on the S1 location (red dot) on the map.

<u>Student 2</u>

- Using a red dry-erase marker, trace around the disc to mark all the possible places Francine could be.

The circle traced by the S1 disc passes approximately through Winnipeg MB, Regina SK and Grand Prairie AB, as well as Resolute Bay in Nunavut.

GPS Satellites cover a very large area, which means that many locations can be the same distance that Francine and her GPS receiver are from the satellite (she can be anywhere on the circle you traced).

The distance from the satellite to the hand-held GPS is the hypotenuse of the red S1 triangle. The radius of the S1 circle and the distance from the satellite to the ground (orbital height) make up the other sides of that triangle.

Student 2

- Use the blue disc (S2 satellite).
- Place the centre of the disk on the S2 location (blue dot) on the map.

Student 1

- Using the blue dry-erase marker, trace around the disc to show all the possible places Francine could be based on her distance from the blue S2 satellite.

Notice that the two circles intersect in two places. You have now narrowed Francine's location down to two possibilities. Most of the time, if you use only two satellites, you'll get two possible locations. On the Map of Canada we are using, what are the names of the towns or cities nearest to where Francine might be?

______________________________ ____________________________________

You now need more information to find Francine. You'll need the data from the third satellite.

Student 1

- Use the green disc (S3 satellite).
- Place the centre of the disk on the S3 (green dot) location on the map.
- This circle represents all the places Francine could be based on her distance from the S3 satellite.

Student 2

- Using the green dry-erase marker, trace around the disc to find Francine's location.

Notice that now the three circles intersect at only one spot. In all cases you need three satellites to find a single spot on a flat surface.

In which of the two possible towns or cities is Francine with her GPS receiver?

____

The Earth is not flat; it is a three dimensional shape, almost a sphere. For the Earth then, except in very special circumstances, a minimum of four satellites are needed to find a single location.

If more satellites are available, the GPS receiver can average the measurements to calculate its location more accurately.

This activity assumes that the satellites were all stationary. In real life, the satellites are moving (orbiting the earth), so their positions are continuously changing. As a result, the GPS unit is constantly re-calculating its distance from each of the satellites it can "see" at that moment. For more information go to www.nasm.si.edu/gps/work.html.

Challenge:

Based on the positions of the three satellites, as indicated by the red, blue and green dots, what would the radii of the circles have been if Francine was in the following cities:

	Red Circle	Blue Circle	Green Circle
Yorkton, SK	______ mm	______ mm	______ mm
Calgary, AB	______ mm	______ mm	______ mm
Vancouver, BC	______ mm	______ mm	______ mm

Student Instructions – Mining the Store

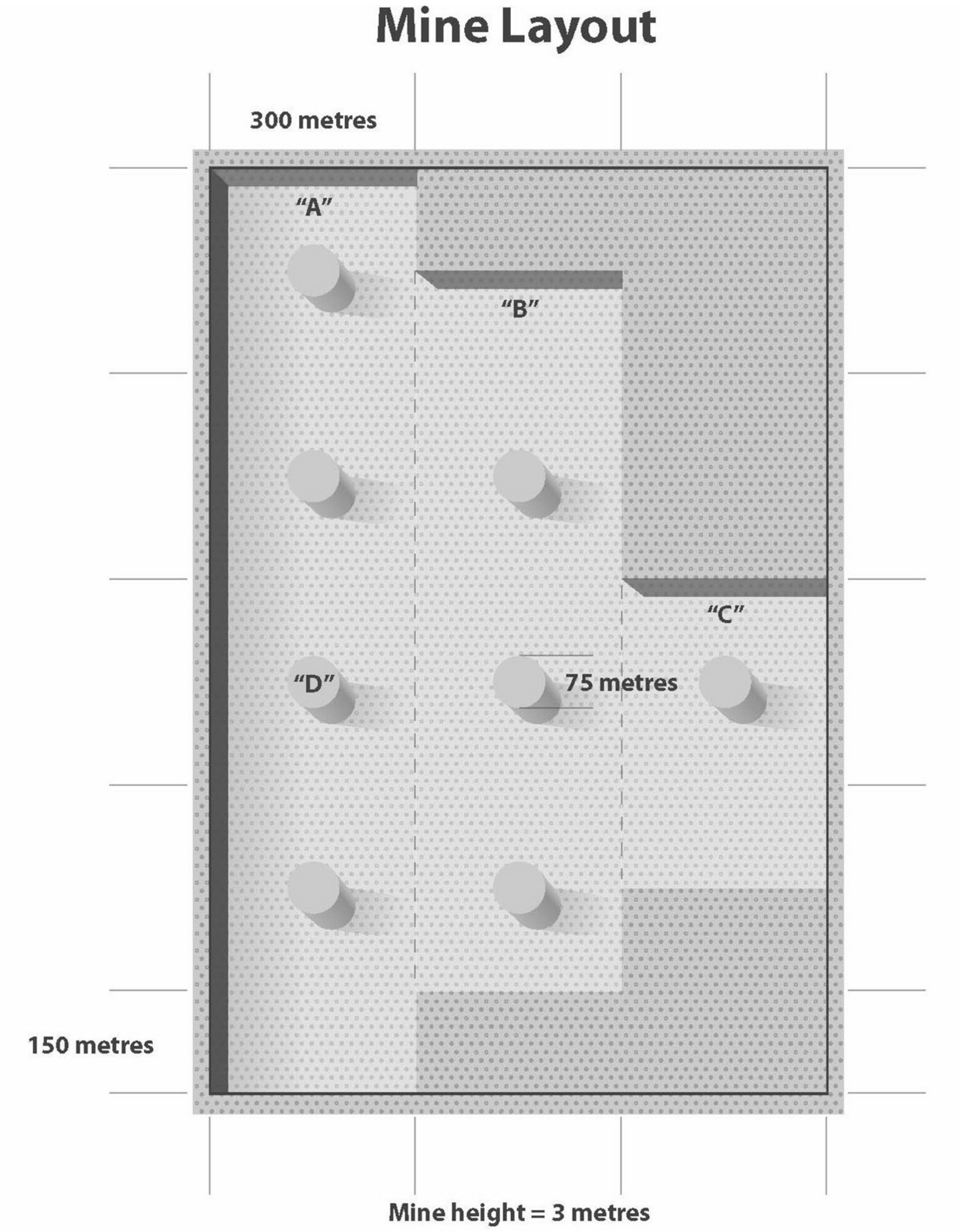
Surveyors are called upon to measure how much earth or other materials are needed to make embankments, over passes, berms or to measure how much material needs to be removed from construction sites such as underpasses or tunnels.

The Acme Potash Mine is being closed down. They have been ordered by the Environment Ministry to place the tailings pile (waste products from the mining process) back into the underground space as part of the clean up required.

Your surveying task in this activity is to help Acme Mining Company decide if they have enough room underground to store the tailings pile.

If the tailings pile is too large to fit back into the mine, you'll need to find out how deep the hole is needed to store the extra tailings.

Calculation Sheets are provided for you.



Top Down View

MINE LAYOUT VOLUME CALCUALTION SHEET

AREA "A" =

AREA "B" =

AREA "C" =

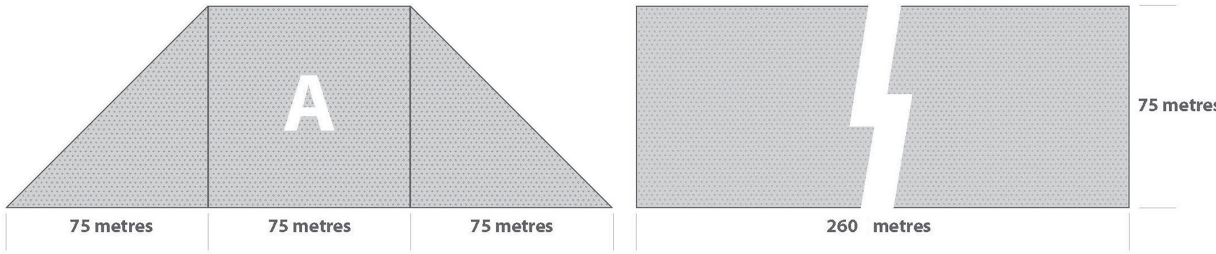
AREA "D" =

TOTAL AREA = AREA "A" + AREA "B" + AREA "C" - (8 x AREA"D")

TOTAL VOLUME = TOTAL AREA x HEIGHT

IS THIS MORE OR LESS THAN THE VOLUME OF THE TAILINGS?

____



Calculation of Tailings:

Area of the end of the Pile:
The two triangular ends of the pile when considered together make a square of 75 metres on a side. This is the same as the centre portion on the pile so that the area is:

To finish calculating the volume, muliply the area of the end of the pile by the length of the pile.

Comparison

Is the Tailings Pile larger than the Mine?

❑ Yes ❑ No

If the Tailings Pile is larger, how deep should a round hole 10 metres across be made to hold all of the excess tailings? (Hint: Remember how the calculation of the mine pillar was carried out.)

Student Instructions – Tessellating Cell Towers

Surveyors are often required to locate the position of cell phone towers based on how much coverage is needed.

Your Survey Contract:

Your surveying company has been contracted to find locations for the cell phone towers in a network.

The network must provide cellular service coverage to as much of the mapped area as possible.

You have three types of towers (tile shapes) to use:

- The basic tower gives coverage in all directions at a very limited range.
- The high power tower has more range than the basic tower in each direction.
- The specialty tower has increased reception / transmission in two direction but is limited in the others.

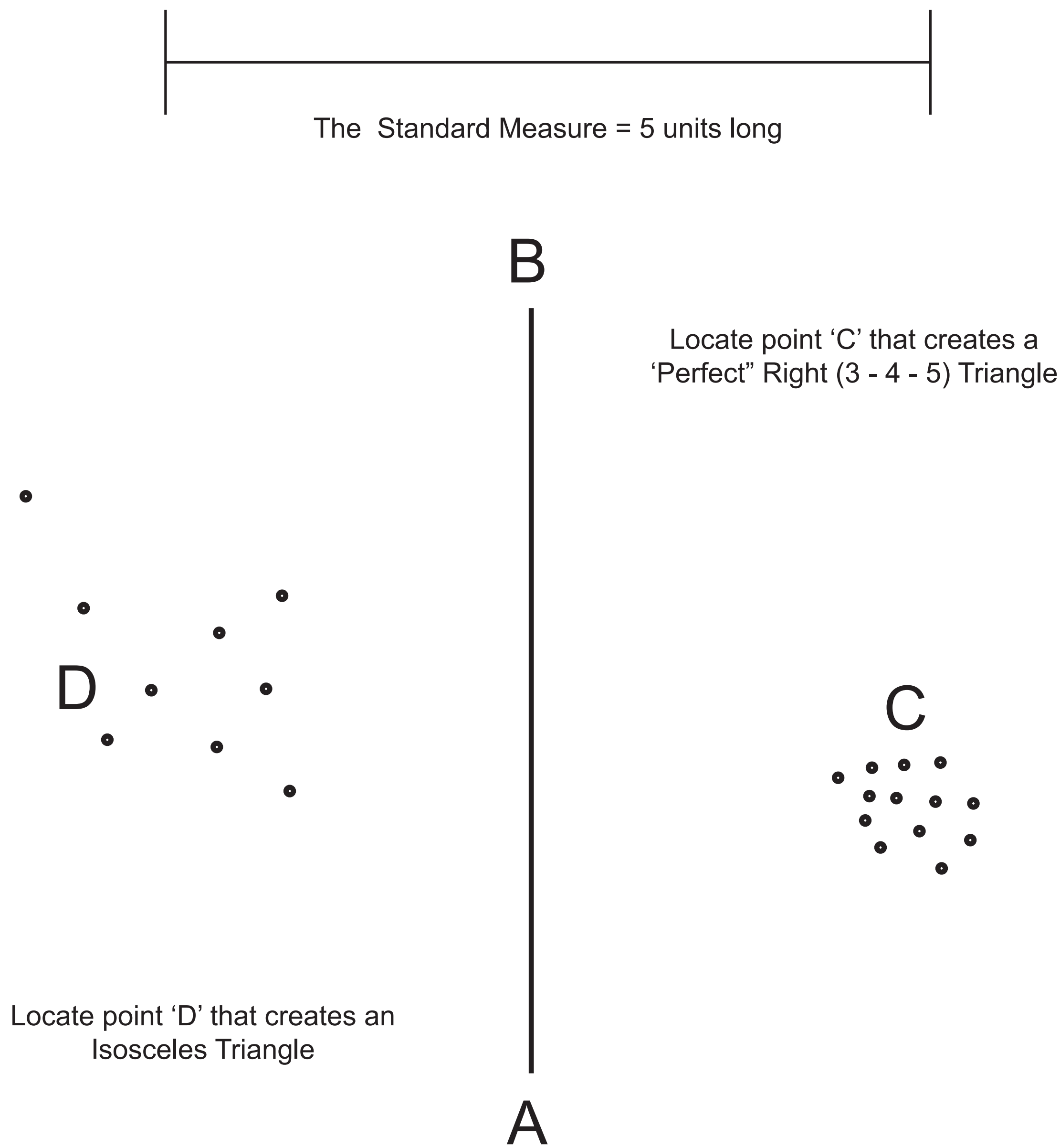
Task #1

Work with a partner and use the towers provided to find the repeating pattern that will cover the map completely with no spaces and no overlapping pieces.

Task #2

Now build the network with the fewest towers possible. Cell phone towers are expensive, so your contract requires you to get the most coverage with the least number of towers. Take away some of the shapes in the pattern to do this. Your towers cannot overlap but will need to touch each other so they can communicate with other towers. You also need to be sure that all residential areas (coloured yellow) and travel routes (coloured red) are covered.

Student Work Sheet for “In Search of the Lost Monument”



WHERE ARE YOU? Latitude and Longitude

Looking at the Globe or a Map of the World. (Map of the World)

1. Locate the Prime Meridian (Greenwich).	
a. Identify the three continents that the Prime Meridian passes through.	
	i
	ii
	iii
b. Identify four of the countries that the Prime Meridian passes through.	
	i
	ii
	iii
	iv

WHERE ARE YOU? Latitude and Longitude

Looking at a map of Canada

For Canada Identify the:	
Easternmost Longitude	
Westernmost Longitude	

Identify the:	
Northernmost Latitude	
Southernmost Latitude	

For Saskatchewan **Identify the:**	
Easternmost Longitude	
Westernmost Longitude	

Identify the:	
Northernmost Latitude	
Southernmost Latitude	

WHERE ARE YOU? Latitude and Longitude

Looking at a Map of Saskatchewan

Using the dot in the centre of the cities as their location, identify the latitude and longitude of

Saskatoon	Latitude:	52°08'N	Longitude:	106°40'W
Regina	Latitude:		Longitude:	
North Battleford	Latitude:		Longitude:	
Prince Albert	Latitude:		Longitude:	
Your town	Latitude:		Longitude:	

What is located at (approximately)

Latitude:	51°46'N	Longitude:	106°27' W	
Latitude:	49°31'N	Longitude:	108°49' W	
Latitude:	53°56' N	Longitude:	106°05' W	

Where are you? Dominion Land Survey

Looking at the Dominion Land Survey Map

Find the Land Owner of the following lands:

- Example One: NW-26-37-6-W3 ____________________
- Example Two: SW-34-38-8-W3 ____________________
- Example Three: NE-3-35-5-W3 ____________________

There are three red dots on the map. Describe the locations.

Dot 1	
Dot 2	
Dot 3	

Student Sheet - Mapping your Classroom

Student Name

Distance from A: m Scale Distance from A:

Distance from B: m Scale Distance from B:

Distance from C: m Scale Distance from C:

Student Name

Distance from A: m Scale Distance from A:

Distance from B: m Scale Distance from B:

Distance from C: m Scale Distance from C:

Student Name

Distance from A: m Scale Distance from A:

Distance from B: m Scale Distance from B:

Distance from C: m Scale Distance from C:

Row/ Column	1	2	3	4	5	6	7	8
A								
B								
C								
D								
E								
F								
G								
H								
I								
J								
K								
L								
M								
N								
O								
P								
Q								
R								
S								
T								
U								
V								

Graph Paper for I Spy

STUDENT WORKSHEET - WAYMARKING

LATITUDE ☐ LONGITUDE ☐

APPROXIMATE LOCATION (COUNTRY, PROVINCE, "NEAR TO ..."

☐

IS LOCATION ON GOOGLE EARTH? YES ☐ NO ☐

IS LANDMARK ON GOOGLE EARTH? YES ☐ NO ☐

SEARCH STRATEGY:

WEBSITES INVESTIGATED:

☐

E-MAIL CONTACT: ☐

OTHER STRATEGIES:

☐

Number	Cache Coordinates	Cache Contents	Symbol #	Symbol	Initials

Specifications and Graphics for Build A Railroad

The background map for Build a Railroad is 15.32 " x 20.47 " (38.9 cm x 52 cm). If you have access to a large format printer or plotter, you can print the entire map on a single sheet of paper. If not, the map has also been provided as four, 8.5" x 11" sections that can be printed on a standard printer and then trimmed and overlapped to form a single map.

The map should then be taped or glued to any ferrous background surface. The magnetic track and road pieces will then stay in place on the map.

The railway and roadway sections are provided on a single 8. 5" x 11" sheet. These can be printed with most standard printers using magnetic sheets such as Staples Item 386943.

Note: When printing any of these PDF files, make sure to turn off any scaled printing so the proportions of the graphics remains accurate.

As an extension to this activity, a three dimensional modal of the contour map can be built to help students visualize what is depicted by the two dimensional map. A graphic is provided for each layer on the map. These will need to be printed on a large format printer or plotter, or by scaling the image down to fit your printer and then scaling the drawing back up by hand using a grid (see www.ehow.com/how_12732_enlarge-drawing-using.html)

Using the graphics as templates, cut out the layers from 1/8" - 1/4" inch thick material such as cardboard or styrofoam. Each graphic includes two alignment markers. Using a large nail or a pencil, punch a hole through the material at the centre of each marker. When the layers are stacked on top of one another, the same nail or pencil can be used to properly align the layers before gluing them together.

Specifications For GPS Table Top

The map supplied with the crate is made of a vinyl material that can be drawn on using dry-erase markers. The GPS circles are of the proper scale to use with the satellite shadows as printed on the map. However, this entire activity can be carried out with any map of any scale as follows:

1. Make sure that the map you are using will work with dry-erase markers, perhaps by placing a clear acrylic overlay on it. Mark three points on the map representing the satellite shadows. It doesn't matter where the shadows are but it will work best if they are distributed around the locations where you want the students to find Francine.

2. Measure the distance from the centre of each satellite shadow to Francine's location. These distances become the radii of each of the three circles.

3. Cut out the circles and punch holes at their centres. These holes should correspond in size to the satellite shadows.

4. Cut out at least one, right triangle so that its base is the same dimension as the radius of one of the circles. This will help the students visualize the relationship between the circle and the GPS satellite since the hypotenuse of the triangle is the distance that Francine is from the satellite.

5. These steps can be repeated for any number of different locations for Francine.

Specifications and Graphics For Tessellating Telephone Towers

The background graphic is 8.5” x 11” and can be printed on a standard colour printer. The background map can be taped or glued to any ferrous material so the magnetic tower pieces will stay in place on the map.

The graphic for the different tower types can be printed on magnetic sheets such as Staples Item 386943. When cutting out the tower pieces, it is important that care be taken to cut precisely along the outlines so the pieces will fit together like a jig-saw puzzle.

Note: When printing any of these PDF files, make sure to turn off any scaled printing so the proportions of the graphics remains accurate.

Specifications and Graphics For “In Search of the Lost Monument”

The props for the extended activity consist of five lengths of chain. Any type of light-weight metal or plastic chain, such as you would find in most hardware stores, can be used. Attach a 1” diameter loose-leaf ring (such as Staples Item 16278) to the end of each chain. The finished lengths of the chains (measured to the centres of the rings) should be approximately:

- For the right triangle:
  - 5 units (1 metre units makes a good size triangle)
  - 4 units
  - 3 units
- For the Isosceles triangle:
  - Uses the 5 unit chain from the right triangle
  - 2 x 3.535 units

To use tape measures for this activity, use two, reel-type tape measures such as Princess Auto 100 foot Open Reel Tape, SKU 8051145.

Specifications For “Where Are You?”

The Rural Municipality map supplied with the crate comes from the rural municipality of Corman Park that surrounds the City of Saskatoon. However, the activity can readily be adapted to the map from any rural municipality in Saskatchewan. Rural municipality maps are readily available, at a nominal charge, from the local R.M. office. Each of the elements of the “Where Are You” activity can then be tailored to that particular R.M. map by picking specific quarter sections of land and having the students identify the property owner(s). As well, two locations on the map can be marked with red dots so the students can figure out the legal land description of those quarter-sections.

Using Google Earth - find Latitude and Longitude of where they live.

Specifications For “GPS Map Your Classroom”

The demonstration element of this activity can be carried out using three reel-type tape measures (such as Princess Auto 100 foot Open Reel Tape, SKU 8051145). Such tapes have an open tab on the zero end so they can be attached together using something like a 1” diameter loose-leaf ring (such as Staples Item 16278). The ring then represents the GPS receiver.