3.10 Land Use Mapping

City planners need to know which areas of a city are used for which purpose. Therefore, they produce a map of "land use", that identifies parts of a city and the major activities (land use) that happen there. Remote sensing imagery is very useful for this purpose, since you certainly don't want to spend many weeks or months walking or driving around a city to map its land use. But to use remote sensing imagery effectively, you have to be able to interpret it accurately.

The satellite image in this activity shows a part of downtown Montreal. It will be a bit harder to interpret this black and white image, because you don't have colour clues to rely on. But you can see quite a bit of spatial detail – even individual streets and large buildings.

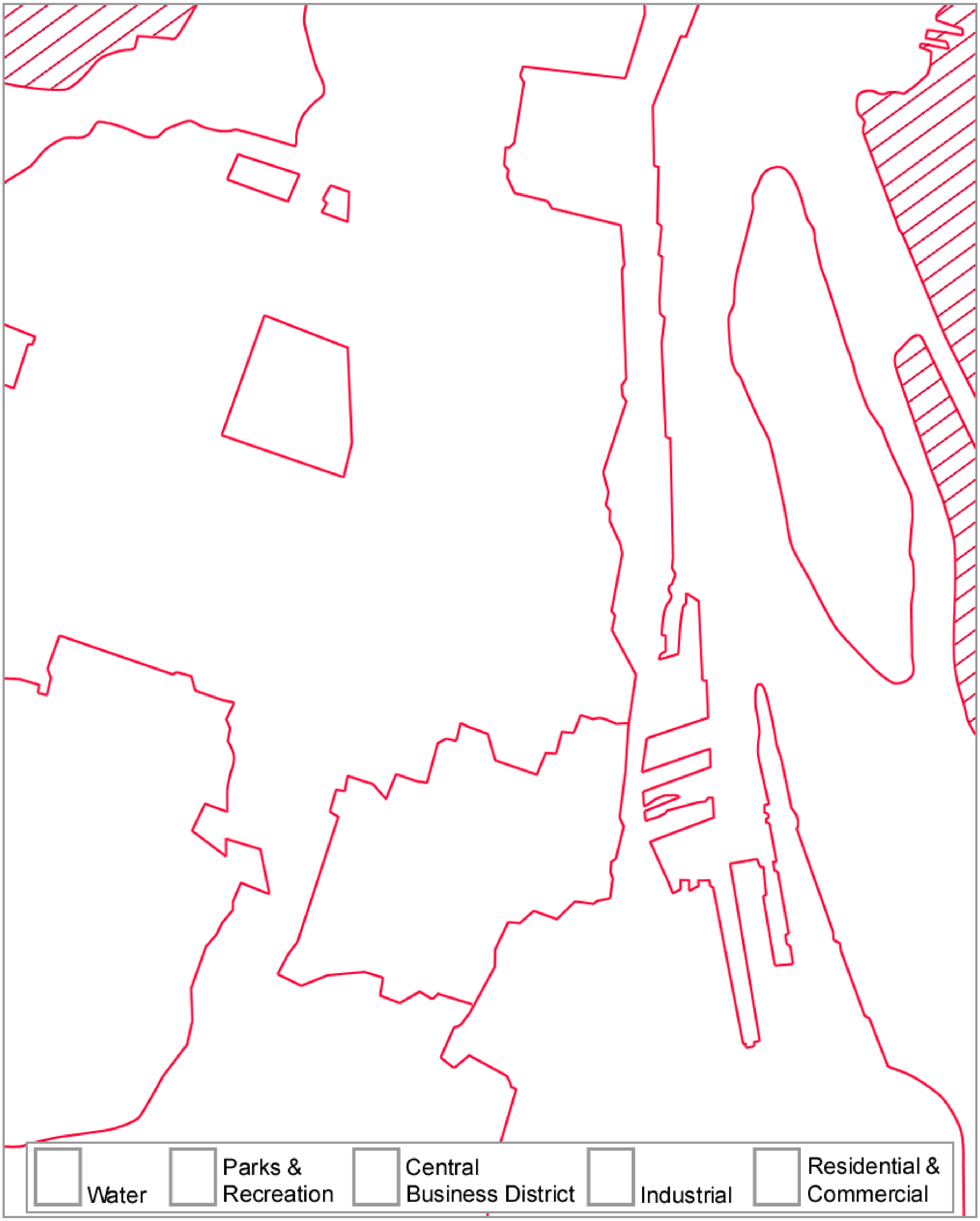
Task

There are five categories to map: water, industrial, central business district, parks & recreation, and residential & commercial. Choose a different colour for each of these categories and colour in the boxes in the index of the blank map. Then for each area outlined on the map, interpret the corresponding area on the image. Use the interpretation key below for clues. Once you figure out the land use for a particular area, colour in the map to match it.

Land Use Category	What does it mean?	Look for this in the image
water	rivers, lakes	smooth, dark areas with docks and bridges
industrial	large factories, railway yards, docks, storage yards	rail yards; large (wide) buildings; empty lots; bare ground; lack of rectangular street pattern
central business district	tall office buildings, hotels	closely packed, tall buildings casting large shadows
parks and recreation	parks, golf courses, race tracks, amusement parks, sports arenas	large grassed areas; winding paths; ponds; oval tracks; large, irregular buildings
residential and commercial	houses, apartment buildings, stores, shopping centres	rectangular street pattern, closely spaced houses and some larger buildings

Satellite Image – Downtown Montreal

Land Use Map – Downtown Montreal



3.11 At a Mine Site

There seems to be a lot of activity going on in this remote sensing image of a copper mine. We are using a sensor on an airplane here, so we have very fine detail of features. Also, the spectral band combinations are chosen to show healthy, dense vegetation as bright red. Less healthy and thinner vegetation will show less red and more brown colouring. Artificial materials like pavement and buildings will appear in different shades of pale blue.

Of course you can't see what is going on underground, but let's take a tour of what happens above ground:

"Ore" is taken from the ground and processed at a mill (A). This involves grinding it up and adding water. The parts of the mixture that are useful are called "concentrates" and passed to the smelter "B" for further processing, while the unwanted parts are called "tailings" and need to be disposed of.

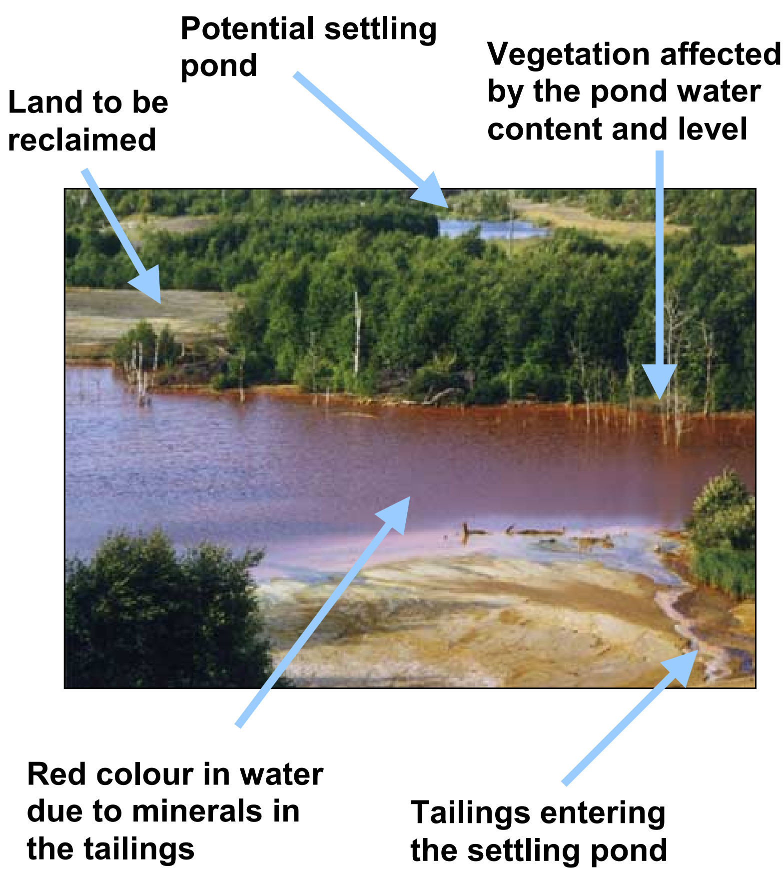
At the smelter, the concentrates go through several processes, including melting at very high temperatures, to isolate the metals that are the desired end products. The remaining materials are called "slag" and also need to be disposed of.

The copper that is produced here, becomes the water pipes and electrical wires in our houses, as well as many other useful products. The unwanted parts of the processes, are allowed to settle and mix with air and water in settling ponds. It takes special effort to overcome the environmental effect that the slag and tailings have on the soil, air, water and vegetation.

Question #1:

We can see in the satellite image, several stages of the environmental recovery that the mine has implemented.

At "C", a pipe is dumping the raw tailings (yellow colour) into a settling pond. What is another location where tailings are entering a settling pond (2.3, 2.6) or (4.7, 1.8) or (4.5, 2.7)?



Question #2:

The settling pond in the satellite image at "D" is almost completely filled in with tailings. Where can you find another almost-filled pond (0.5, 5.2) or (0.5, 3.0) or (2.0, 6.0)?

Settling pond being filled with tailings

Question #3:

Lime is added to the tailings to reduce its acidity. You can see in the satellite image, a big pile of lime stored at "F". Where is another lime pile (2.2, 7.5) or (6.5, 6.7) or (5.6, 1.0)?

Lime pile at the mine site

Grass and young trees growing on the tailings

Question #4:

At "G" in the satellite image, seeds have been planted and grass has started to grow on the tailings. A few young trees are also growing here. Where is another area like this (4.6, 3.2) or (0.4, 7.2) or (0.7, 3.4)?

Mature trees growing on land reclaimed from a tailings pile

Question #5:

Fully mature trees, growing on old tailings can be seen on the satellite image at “H”. Where is another similar area (6.5, 1.0) or (2.2, 0.9) or (3.7, 3.7)?

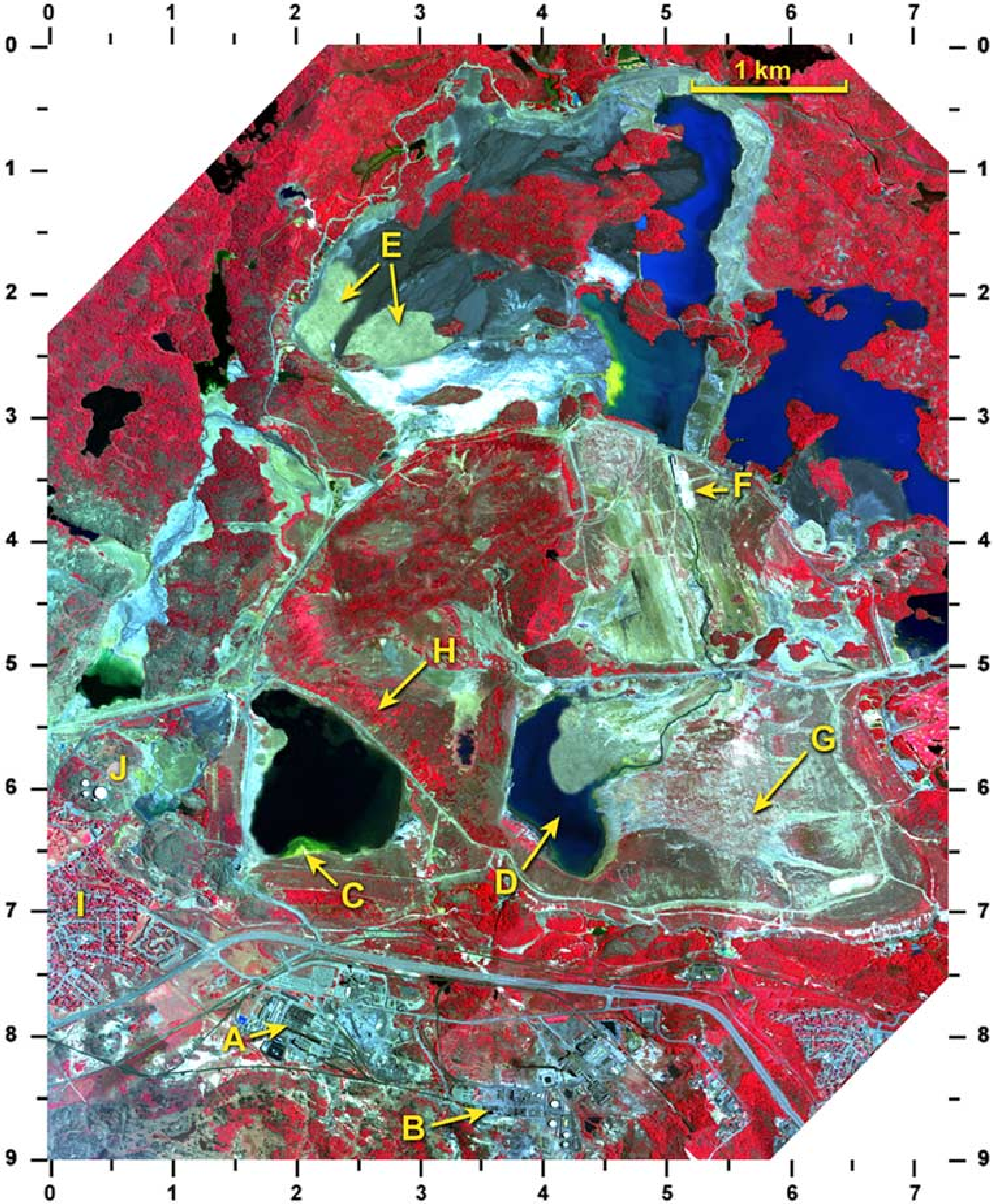
Question #6:

On the satellite image there is a housing development for mine workers, at “I”. Where is another such neighbourhood (0.2, 4.6) or (2.0, 2.0) or (6.5, 8.1)?

Question #7:

A cluster of large storage tanks can be seen on the satellite image at “J”. Where is a second group of storage tanks located (6.9, 7.1) or (3.7, 7.6) or (4.1, 8.8)?

Remote Sensing Image of a Mine



3.12 A Different Perspective

Looking at things from directly above is very different from the normal way that we see things. But when we use satellite imagery, we have to get used to how things look from space. Try the following activity to see this difference.

There are two sets of pictures of places in the city of Ottawa and vicinity. One set was taken from an airplane, looking at things from an angle (obliquely, that is) – which is a more familiar way to see things. The other set was taken from satellite, looking at things from directly above – which we are not used to.

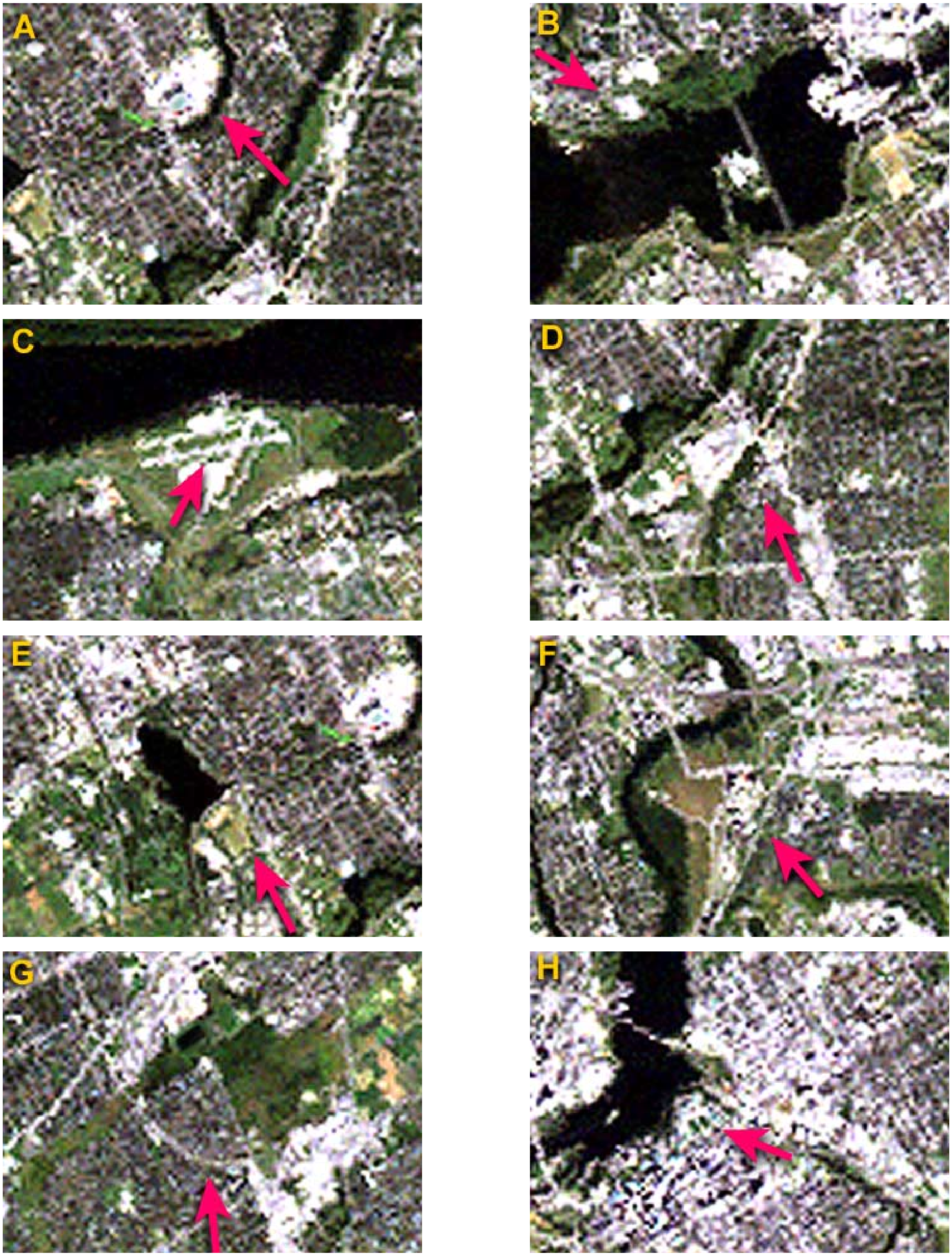
Task

Can you match each aerial photograph to its corresponding satellite image? To help you, we've shown on each satellite image, from where and in which direction the matching air photo was taken.

Aerial Photograph	Satellite Image
1	
2	
3	
4	
5	
6	
7	
8	

Aerial Photographs taken over Ottawa

Satellite Images of Ottawa



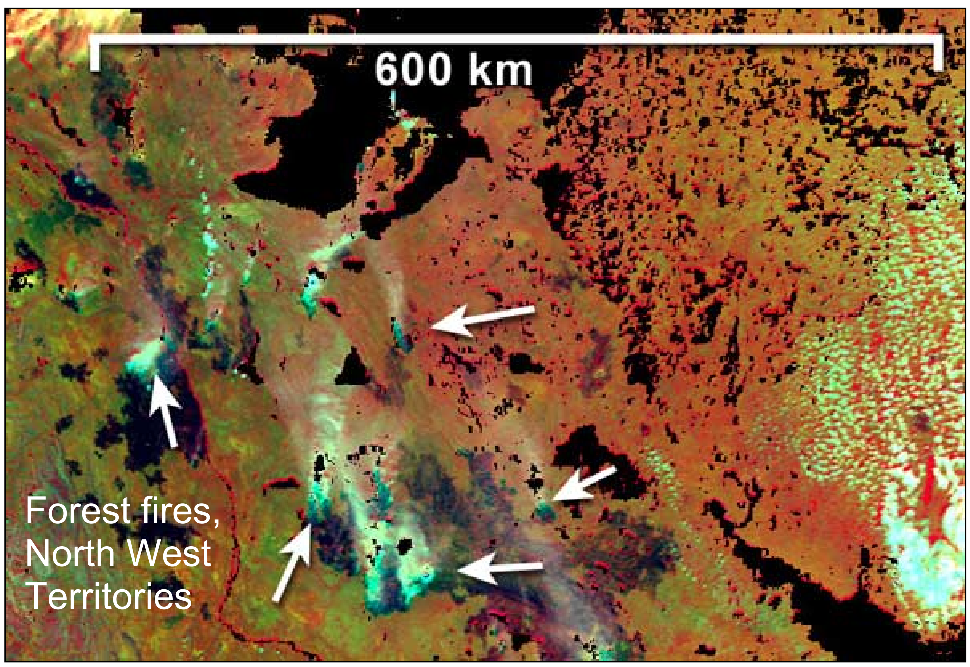
4.1 Why does Remote Sensing work so well?

Without Remote Sensing

Covering a large area on foot, by car, by boat or even by airplane is very expensive and can take a long time. By the time a large area is covered using these methods, things at the beginning of the survey could have changed.

With Remote Sensing

A satellite scans a very large area within seconds.

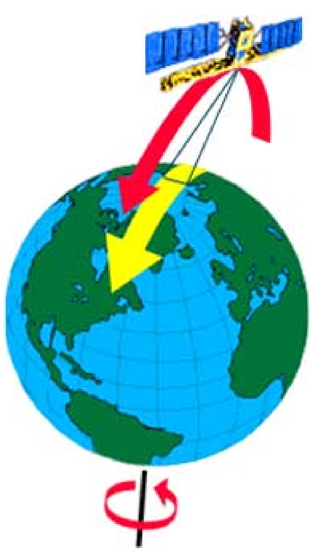


Without Remote Sensing

A survey of a large area of forest, agricultural land, cities or oceans could require paying a team of people and perhaps renting boats or airplanes, potentially making it very expensive for just one project.

With Remote Sensing

The cost of building, launching, and operating a satellite is shared by the many thousands of people who buy images for their own projects.



Without Remote Sensing

It is sometimes hard to see small changes and it is very difficult to count and record many small changes, especially if they occur over a large area. In order to make good decisions about how to help our environment, we need to know accurately, what is happening where and when.

With Remote Sensing

A satellite can acquire repeated views of the same area and computers can accurately show what has changed between acquisitions. When dealing with fast-changing disasters (forest fires, floods) or when looking at the slow change of crops, forests or city growth, remote sensing images can't be beaten.

Without Remote Sensing

There is always a lot of guesswork. Resource managers go to a site to take samples or make a count in only a small portion of the area to be studied. Using this information, predictions are made for the entire area. The same survey done twice could produce very different results.

With Remote Sensing

Remote sensing tells us exactly what is there, how many and where. It doesn't rely on a person's memory or experience. It gives us reliable and repeatable information with measurable accuracy.

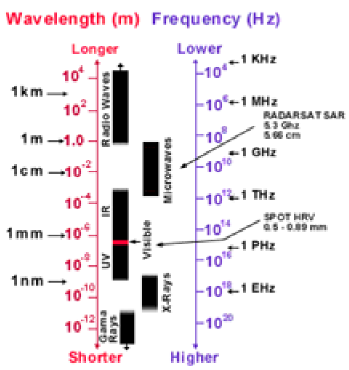
Without Remote Sensing

If information is described in writing or even in a drawing, it can be used only in a limited way. It is very difficult to make comparisons to other similar descriptions and it is even more difficult to analyze. It may not be possible to make good decisions based on this type of information.

With Remote Sensing

Remote sensing information is mostly digital and therefore can be analyzed by computer, compared, and statistics can be collected from it. Decisions can be made more accurately from this type of data.

4.2 Frequently Asked Questions



a) Is remote sensing always done using satellites?

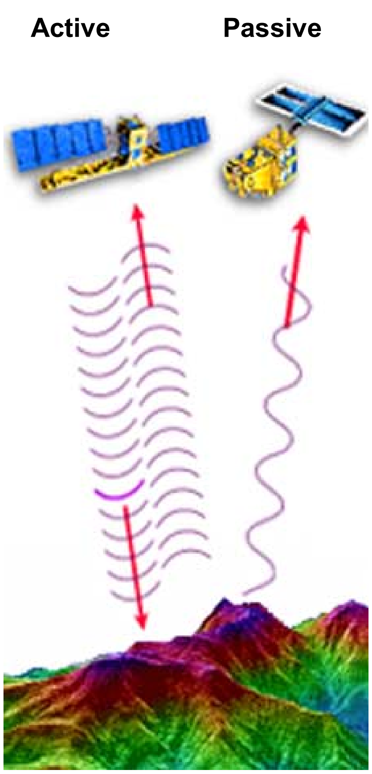
No.

Remote sensing is simply sensing things from a distance. You do "remote sensing" whenever you look, hear or smell. Remote sensing can be done for business and scientific research using helicopters, airplanes, rockets, or balloons. Even kites have been tried, but satellites are definitely the most popular platform for carrying remote sensing equipment.

b) Is there a difference between a Landsat satellite and a RADARSAT satellite?

Yes.

Landsat carries a "Thematic Mapper" scanner that uses the visible and infrared parts of the electromagnetic spectrum to make images. As humans, we can only see the visible light part of the spectrum (the colours of red, orange, yellow, green, blue and violet), but we can't see the infrared parts as Landsat can. RADARSAT, however, carries a radar instrument that uses the radar or microwave part of the spectrum to make images. We can't see that part of the spectrum either. These are the same microwaves that are used in many other ways such as in microwave ovens.



c) What is the difference between an ACTIVE and a PASSIVE sensor?

A camera provides an excellent example of both passive and active sensors. It is the film of the camera that is the sensor. It records the light that is reflected from the object that is being photographed.

If the illumination for the scene is coming not from the camera but from another source (say, the sun) then the camera is a **PASSIVE** sensor. On a cloudy day or inside a room or at night, there may not be enough light. When the camera also has to provide the illumination for the scene (using a flash) it becomes an **ACTIVE** sensor.

d) How does radar work?

A short pulse of energy is sent out by the radar antenna at an angle, towards the ground. The pulse bounces off targets on the ground (houses, trees, grass, telephone poles, etc.) and some of the energy is reflected back to the antenna. This is called "backscatter". The more energy a target backscatters, the brighter it will be shown on the radar image.

e) Is there one remote sensing satellite that is the best?

There is no "best". The best choice of satellite data depends upon the application.

Some satellites (and the sensors they carry) are designed for looking at fine detail so that small targets can be imaged. Other satellites specialize in covering very large areas all at once, or perhaps in revisiting the same area often. Radar-carrying satellites are chosen for use at night, for penetrating clouds or for mapping special targets like ice. Other satellites carry sensors that are particularly good at imaging in colour, to help in the "spectral" identification of targets.

f) How high up are these satellites?

The earth observation satellites such as Landsat and RADARSAT are about 900 km above the Earth. This is much higher than the international space station (about 200 km) but not as high as the communication satellites (in geostationary orbit) that are used for TV and telephone (about 32,000 km).

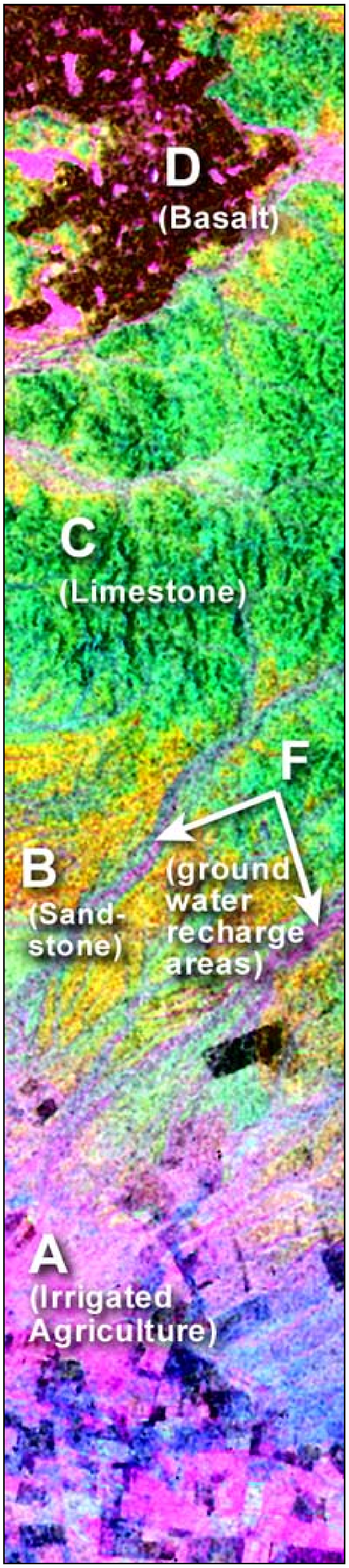
g) How many remote sensing satellites are there?

Lots.

RADARSAT is Canadian. Other satellites belong to different countries such as U.S., Europe, Japan, France and India. Private companies are now launching remote sensing satellites too, because they have realized that this technology is very useful and profitable.

h) How do the remote sensing satellites "cover" the Earth?

The Earth Observation satellites move in a "near polar" orbit. As the Earth spins west to east beneath them, they orbit from the North Pole down to the South Pole, back up to the North Pole, etc., each time passing close to, but not exactly over the poles. These two motions



(the satellite orbit and the rotation of the Earth) make it possible for them to see almost the entire surface of the Earth.

i) How long does it take for a satellite to "cover" the Earth?

One Landsat satellite, which looks straight down, takes 16 days to cover the whole of the Earth's surface. The NOAA satellite, which also looks straight down but covers a much wider area takes much less time. The RADARSAT and SPOT sensors, on the other hand, can be steered to point at a sideways angle at a target area from several neighbouring orbits. In this way, in a limited fashion, it is possible to get daily views of an area for several days.

j) How is the satellite data sent from way up there, down to us?

There are two receiving stations in Canada. One is in Gatineau, Quebec, the other in Prince Albert, Saskatchewan. Together these two receiving stations can pick up all the data transmitted by satellites passing over any part of Canada. Other ground stations have been set up around the world to similarly capture data from a variety of satellites when they are overhead.

Most of the time the satellites re-transmit the data that they receive directly to the ground station below them, using radio waves. At other times when the satellite is not within line-of-sight of a receiving station, it will store the data on board temporarily, and then transmit to the ground station when it passes overhead.

k) How long does it take the data to reach Earth?

The data is transmitted instantaneously (well . . . . to be accurate, it's transmitted at the speed of light).

l) Why are some satellite images in black and white and others in colour?

Some sensors record images from just one part of the electromagnetic spectrum, showing the image in shades (usually 256) of grey making what's called a "black and white" image. This is how RADARSAT works.

When an image is recorded simultaneously in several parts of the spectrum, then three of those spectral "bands" are shown as shades

of red and green and blue. Landsat and SPOT images are often displayed this way. From those three primary additive colours, one can make any of the other colours such as orange, brown, turquoise, etc. That is also how your TV and your computer monitor work – when the three images in red, green and blue are superimposed on the screen, a full range of colour results.

m) Why do we get such strange colours in many of these satellite images?

Remote sensing uses parts of the spectrum that people can't see by eye: infrared, ultraviolet, radar, etc. If we want to display (on a photo or a computer monitor) one or more of these bands, we must use one or more of the three primary colours that people can see: red, green and blue. Therefore, you could get some strange combinations, like: infrared information shown as blue, red information shown as green and green information shown as blue !! The resulting colours will be nothing like what we experience using just our eyes.

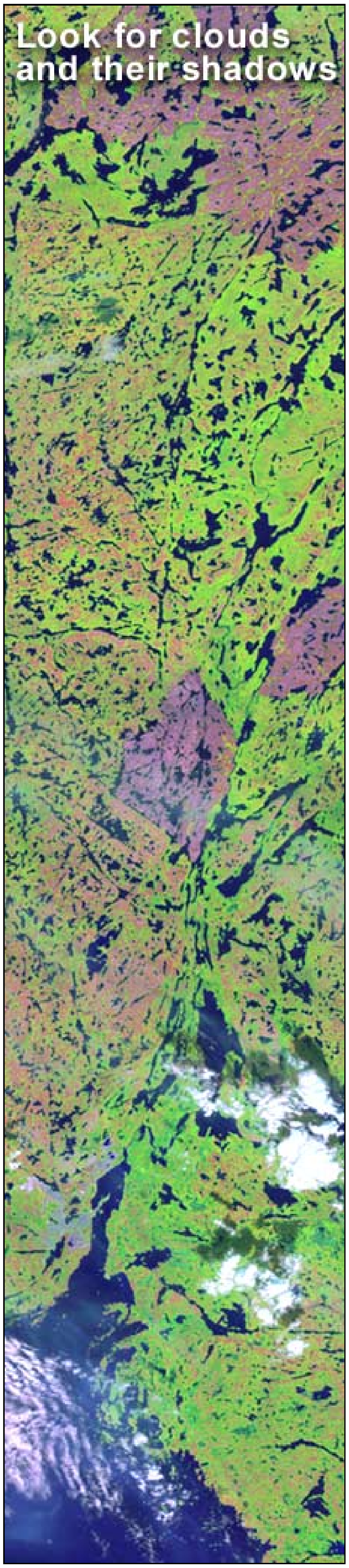
n) Can sensors "see" underground or underwater?

Under very special circumstances (using long wave radar over an area that is extremely dry) it is possible to see a few metres into the ground. In Canada, where usually the ground has lots of moisture, we are limited to seeing what's on the surface only.

Some of the visible wavelengths, like blue for instance, penetrate water quite well and if the water is clear, we can see down several metres.

o) What is a "spectral fingerprint"?

It's a way to try to identify objects in a satellite image. By using many parts of the spectrum, including the visible colours and perhaps parts of the infrared band, we try to find how an object reflects light. The way that an object reflects different parts of the spectrum is its "spectral fingerprint". There are different spectral fingerprints for different kinds of trees, crops, soil, etc.



4.3 Glossary of Remote Sensing Terms

AIRBORNE SENSING: Remote sensing from an airplane. *(Related words: airphoto, aerial)*

ANALOGUE: This is the opposite of DIGITAL. It refers to things that aren't made up of numbers. A photo taken with a film camera would be an analogue picture. A photo taken by a digital camera would be defined in terms of zeros and ones and would be considered digital. *(Related word: digital)*

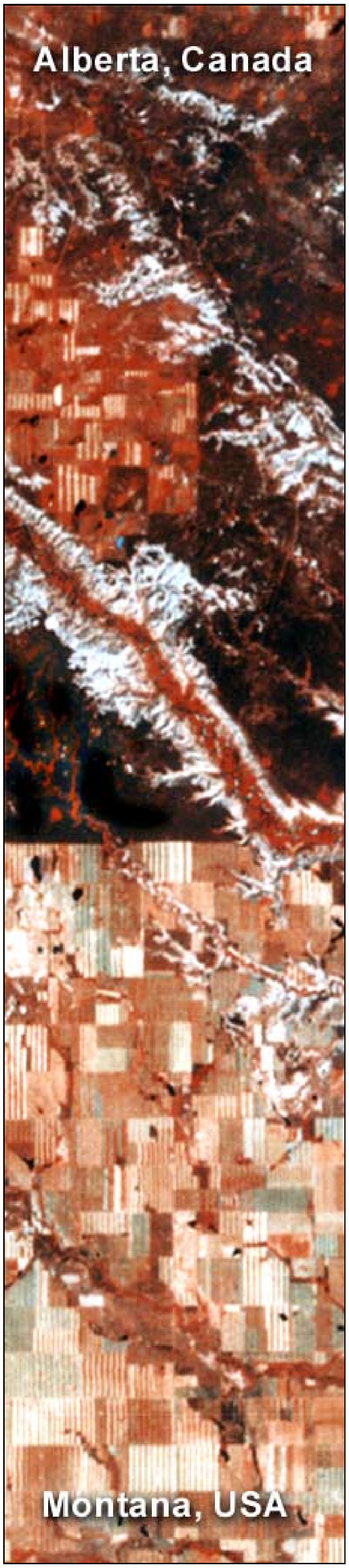
APPLICATION: The end purpose for which remote sensing is used. Most often remote sensing is used to measure, map or monitor features of our environment. (See "Student's Introduction to Remote Sensing" for examples of applications) *(Related word: apply)*

BACKSCATTERING: Energy, when hitting a target, can be scattered in many directions. The part of the energy that is scattered back in the exact direction where it came from, is "backscattered". *(Related word: reflection)*

CLOUD: If there are clouds in the area and an optical satellite like SPOT, IRS or Landsat passes overhead, the satellite image will show the cloud but the features below the cloud won't be seen. A cloud shadow, the same shape as the cloud, will be seen nearby. *(Related words: penetration, reflection, opaque)*

CLASSIFICATION: When image pixels are the same colour, or nearly the same colour, an image "classification" computer program can recognize this and group such pixels together. Such a grouping is called a "class" and the process of doing the grouping is called "classification". The remote sensing researcher then has the challenge of identifying just what each "class" represents in the real environment (pine trees? pavement? shallow water? dry grass?). *(Related word: classes)*

COMPOSITE IMAGE: We can make a "composite" image by selecting the most appropriate parts of other images. For instance, we could take only the cloud-free parts of



many images to make a "composite" image of all of Canada showing no clouds at all. It would not be a realistic scene, since we always have some clouds, but it would show all of Canada without allowing cloud cover to mask parts of it. *(Related words: combining, mosaic)*

DETECTION: If you are detecting something, you are trying to determine if it is there. This could be done using your senses or by using instruments. Once it is found, it has been detected. *(Related words: sensing, discovery, detect)*

DIGITAL DATA: Information that is made up of numbers is digital data. Telephone numbers are digital data, so are the percentage scores on your last test. So are digital images from satellites. The opposite of digital is ANALOGUE. *(Related words: digitized, analogue)*

DIGITAL ANALYSIS: If you have a digital satellite image, then it's useful to analyze it digitally. Special computer programs are available for this. Such programs can stretch and distort a digital image to make it fit a map, they can enhance it to make it show some features more clearly, they can classify the image into categories which contain similar features, and much more. *(Related words: image analysis, classification, enhancement)*

EARTH OBSERVATION: Looking down at the Earth from aircraft and satellites using various sensors which make images that are afterwards used to study what is happening on or near the Earth's surface. *(Related word: remote sensing)*

ELECTROMAGNETIC SPECTRUM: The range of energy which contains parts or "bands" such as the visible, infrared, ultraviolet, microwave (radar), gamma ray, x-ray, radio, and which travels at the speed of light. Different parts of the electromagnetic spectrum have different wavelengths and frequencies. *(Related words: spectrum, radiation, spectral band)*

EMIT: This word means the same as "sent out" or "given off". The sun emits radiation, some of which we can feel as heat and some of which we can see as light. The radar sensor in RADARSAT emits a radar beam. *(Related words: transmit, radiation)*

ENHANCEMENT: Anything that you do to an image to

make it simpler, faster or more accurate to analyze and interpret by eye is a form of “enhancement”. Special enhancement techniques can improve colour, brightness, contrast, sharpness, etc. *(Related words: visual interpretation)*

GROUND STATION: See RECEIVING STATION

GROUND TRUTHING: Remote sensing analysts must be sure that their image analysis is accurate. This is done by field where they go out to the actual places shown in the images and confirm that what they think they see on the image is actually true. *(Related words: verification, calibration)*

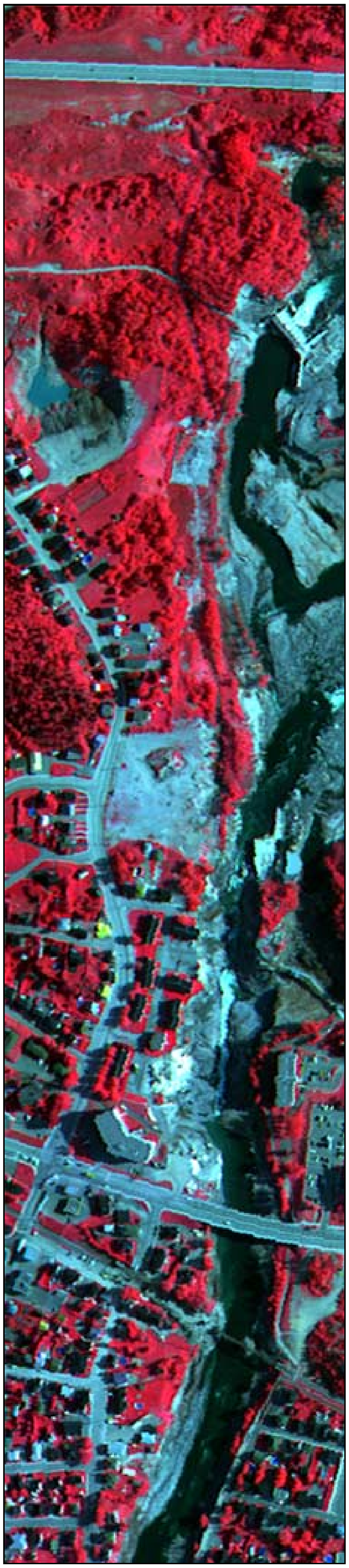
IMAGE: The picture that is a result of the sensing process. A remote sensing image can be displayed on a computer monitor or it can be made into a printed copy. *(Related word: imagery)*

IMAGE ANALYSIS: This is the process of studying an image in order to explain, measure, map, count or monitor what is on the Earth’s surface. *(Related words: interpretation, classification)*

LANDSAT: Owned and launched by the United States, this is a series of remote sensing satellites that use the visible and infrared parts of the spectrum to record images of the Earth’s surface. *(Related words: SPOT, IRS, RADARSAT, NOAA, satellite)*

LINE-OF-SIGHT: When two objects (such as a satellite and a receiving station) have nothing in between them, then they are in “line-of-sight” of each other. When a satellite is on the other side of the Earth from a receiving station, the Earth is in between them, so the satellite and the receiving station are not in “line-of sight” of each other. *(Related words: visibility, data reception)*

MONITORING: Keeping track of how things change over time. For example, with remote sensing, using several images taken over time, you can monitor the result of logging in a forest or how much of an oil slick in the ocean has been cleaned up or how well crops are growing or how much a glacier has melted or how far a plume of sediment travels in a lake, etc. *(Related words: change detection, multi-temporal analysis)*



MOSAIC: A big image made by combining smaller images. For example, to get an image of a whole province in Canada, we must combine many images. This is tricky because the images were probably taken at different times and possibly in different seasons so they could look different in colour or brightness.

ORBIT: The path traced by a satellite as it passes around a planet. *(Related words: path, satellite, near polar, geostationary)*

PIXEL: The smallest unit in a digital image. A satellite image is made up of a matrix of many pixels, each having its own digital value. *(Related words: image, digital analysis)*

PLATFORM: This is what carries a sensor – usually a satellite or an airplane. But a remote sensing platform could also be a hot-air balloon, a tall tower, etc. *(related words: satellite, aircraft, sensor)*

RADAR SHADOW: Just as with a flashlight, a radar sensor “illuminates” a scene, and if an object blocks the beam, a shadow area develops behind it. Such shadows can be seen in a radar image. Radar shadows are pure black – they contain absolutely no information. *(Related word: radar beam)*

RADARSAT: This is the first Canadian remote sensing satellite. It uses radar technology to capture images of the earth’s surface. *(Related words: satellite, radar)*

RECEIVING STATION: At a receiving station, antennas collect the signals sent by an orbiting satellite. Electronic devices process the signals and the data are stored. Usually the station also converts the data into usable digital and printed images. *(Related words: satellite, reception, downlink)*

REFLECTION: Reflection occurs when radiation (light, radar signals, etc.) bounces off a target. It is very important in remote sensing how that reflection happens, how much is reflected and how the radiation is changed in the process of reflection, because it tells us much about the target that caused the reflection.

REMOTE SENSING: Remote sensing is the action of collecting images or other forms of data about the surface of the Earth, from measurements made at some distance above the Earth, processing these data and analyzing them. *(Related words: earth observation, environmental monitoring)*

RESOLUTION: Spatial resolution describes how clearly you can see detail in a picture. Consider the focussing done by a camera. If the picture is blurry and you can't see small objects, the resolution is poor (low resolution). If the picture is sharp and you can see small objects, the resolution is good (high resolution). Resolution is also used in describing colour detail (how similar colours are) and even time detail (how close in time things happen). *(Related words: detail, image analysis)*

SATELLITE: A satellite is a natural or man–made object continuously orbiting above the Earth or another planet or star. A remote sensing satellite carries one or more instruments for recording images of the Earth, which are transmitted to a receiving station using radio waves. *(Related words: platform, receiving station, orbit)*

SCANNER: While a camera would take a picture of an area all at once, a scanner is a device that examines an area point by point until the entire area has been imaged. These points become the pixels in a digital remote sensing image.

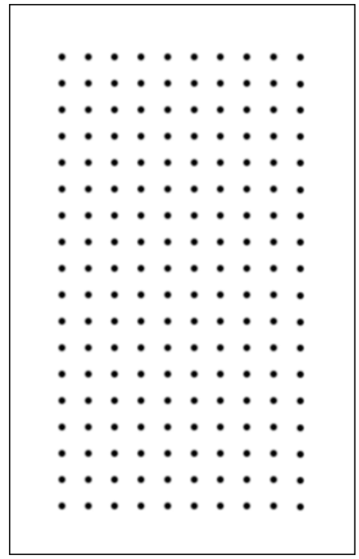
SENSOR: A sensor is the device that records a remote sensing image, much like a camera. *(Related words: scanner, platform)*

SPECTRUM: See ELECTROMAGNETIC SPECTRUM

TARGET: Targets are the features being studied in a remote sensing image. *(Related words: backscatter, reflection)*

TRANSMIT: Energy that passes through an object or material is "transmitted". This is in contrast to energy that may be reflected or absorbed. A window (which is not too dirty) allows light to transmit through and thus we are able to see through glass. *(Related words: reflect, absorb, backscatter)*

Appendix A: Using a Dot Grid (to Measure Area)



Using the dot grid technique:

1. Trace the dot grid onto a piece of acetate film.
2. Place the acetate with the dot grid, over the area that you want to measure. It doesn't matter how the acetate fits over the image, as long as all of the area to be measured is covered by the dots.
3. Count the dots that fall within the area to be measured. Once you start counting, don't move the acetate. If a dot is on the edge of the area, count it if it's more than one half inside the area, and don't count it if it's less than one half inside the area.
4. The number of dots that represent 1 square kilometre will be specified in each activity. Divide the total dot count that you made by that number to arrive at the final area in square kilometres.

Appendix B: Using a Compass

A "compass rose" is an illustration such as the one on this page, showing the points of the compass.

The main directions: north, south, east, west are called the "cardinal points" of the compass.

Always look for the compass rose, or perhaps a "north arrow", to see in which direction an image is oriented. North isn't always to the top, although that is a popular convention.

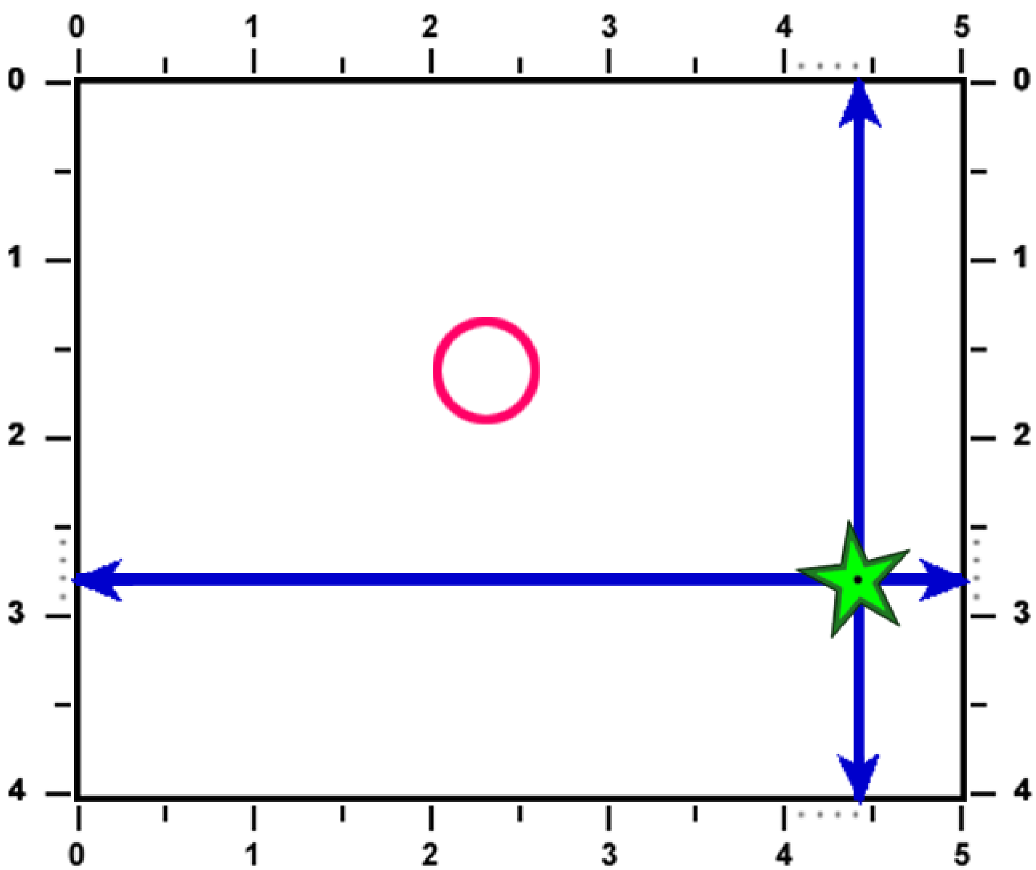
Appendix C: Using Coordinates

One convenient and precise way to point to a certain spot on a picture (or a map) is by the Cartesian Coordinate method. A series of numbers (or sometimes letters) on the edge of the picture lets you identify a spot without having to put some reference mark inside the picture.

If we want to talk about a feature such as a lake, road or field in a satellite image and we don't want to mark up the image itself, then we can use two numbers to identify the spot. The first number is always the horizontal distance and the second number is always the vertical distance.

In the example here, the star has a horizontal coordinate of 4.4 and a vertical coordinate of 2.8, and they are often written as: (4.4, 2.8). Use a straight edge like a ruler or a piece of paper to line up the numbers. Make sure the straight edge is exactly parallel to the edge of the image. This can be done by connecting the same number (4.4 in this example) on both the top and the bottom scale. Do the same for the second number by lining up the same number (2.8 in this example) on both the left and right scales.

To see if you can do this, try to find the coordinates of the centre of the circle in the diagram. They are: (____, _____)



Appendix D: Answers to the Activities

3.1 Which is Which ?

a) 2	h) 10
b) 7	i) 4
c) 12	j) 11
d) 9	k) 3
e) 8	l) 6
f) 10	m) 1
g) 5	

3.2 Find It

1) C: (7.7, 6.1)	5) D: (5.7, 8.0)
2) A: (5.2, 2.6)	6) B: (5.5, 6.4)
3) B: (4.8, 6.7)	7) D: (5.3, 5.0)
4) A: (8.2, 4.2)	

3.3a Measure This (northern Saskatchewan)

1) D: (2.0, 0.5)
2) A: light pink
3) C: less than 1km long
4) A: 17 km
5) B: less than 1 square km
6) D: 10 km

3.3b Measure This (Halifax area)

1) D: (1.4, 0.7)
2) A: south
3) C: (1.0, 1.2)
4) B: 16 km

3.4 Clearcutting in the Forest

D) (0.7, 5.0) (2.4, 3.0) (6.5, 9.2)
E) approximately 7.4 square km

3.5 Oil Spill Danger

A) Ormond
B) Canto
C) June 18 (in 5 days)
D) Approximately 67 barriers

3.6 Crops Types

Task #1
Town: (1.4, 1.6)
Village: (4.1, 5.3)
River exits at: (6.0, 2.8)
Railway exits at: (0.0, 5.5)

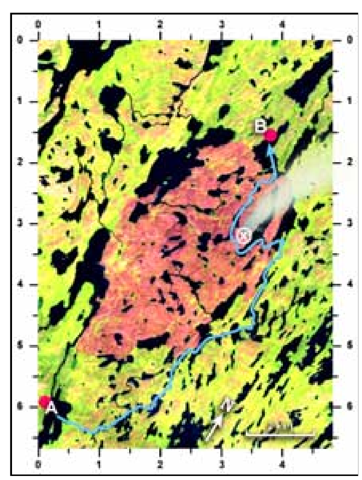
Task #2	
a) beans	e) corn
b) beans	f) grains
c) alfalfa	g) grains
d) corn	

Task #3
a) trees and shrubs
b) approximately 32 fields

3.7 Forest Fire

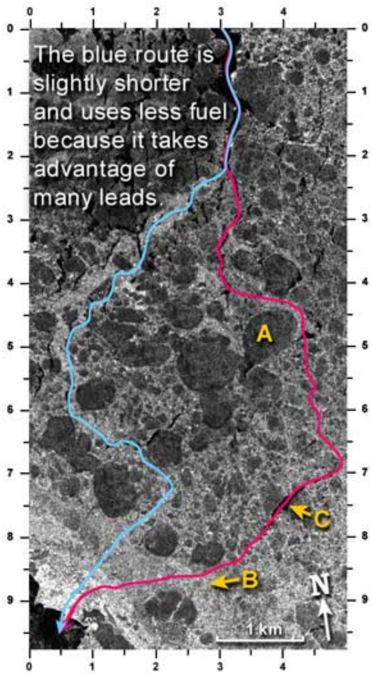
Task #1
Approximately 16 km

Task #2
Closest Lake is at: (2.1, 2.1)
Next closest lake is at: (0.7, 3.7)



3.8 Navigating a Ship Through Ice

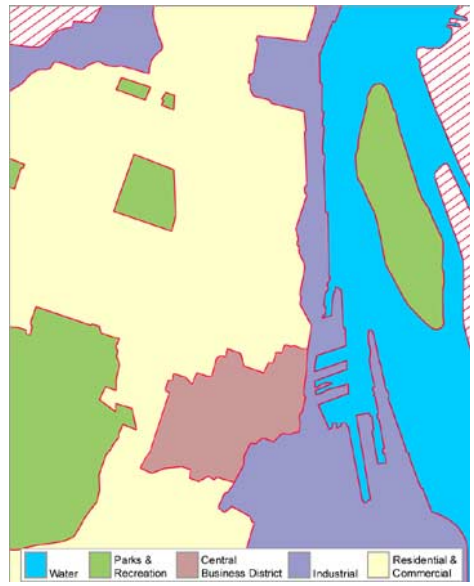
Task
Distance: 8.5 km (blue route)
The more difficult route is >9 km (red route)



3.9 You Figure it Out !

Sandspit	Queen Charlotte City
A) 3 B) 4 C) 1 D) 2 E) 4 F) 4	A, B) 2 C) 3 D) 4

3.10 Land Use Mapping



3.11 At a Mine Site

1) (4.5, 2.7) 2) (2.0, 6.0) 3) (6.5, 6.7) 4) (4.6, 3.2)	5) (3.7, 3.7) 6) (6.5, 8.1) 7) (4.1, 8.8)

3.12 A Different Perspective

1) H
2) D
3) F
4) A
5) C
6) G
7) B
8) E