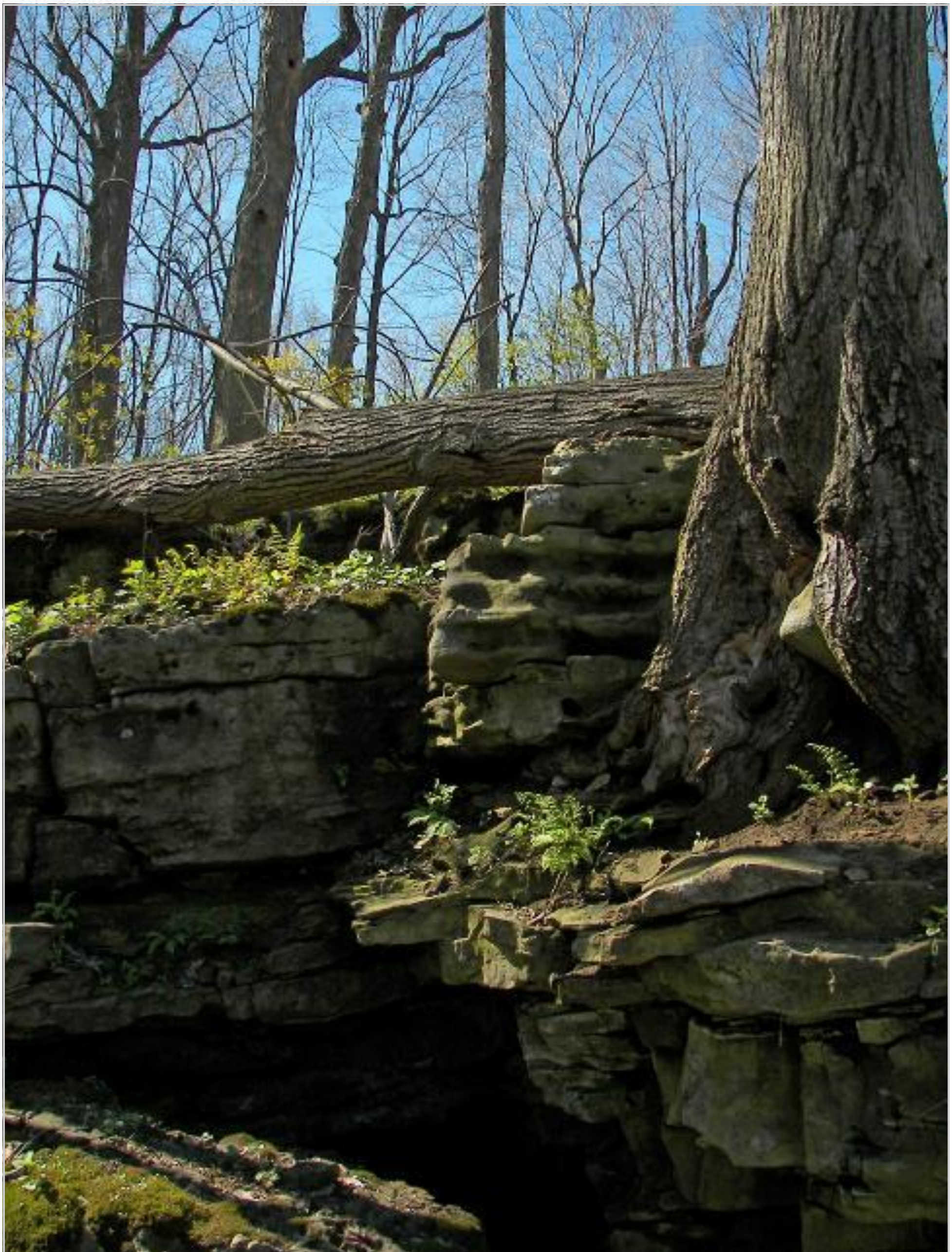
Teacher Field Guide



A High School Teacher's Guide to Leading a Field Trip at the Eramosa Karst Conservation Area

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Introduction to These Resources

This Field Guide is accompanied by a USB drive. Together, these resources present a complete unit on Karst formation and management. You should review the documents on the USB drive and decide which resources will be the most useful for your students.

Contents of the USB drive:

1. Unit Overview

   A detailed description of everything on the USB drive, Unit Objectives, Curriculum Connections, and background to the Karst.

2. Pre-trip Activities

   These activities will provide a background to Karst and Karst formation, making the field trip go more smoothly.

   A. ''What is Karst?' Slide Show
   B. Cyber Hunt
   C. Models: Build models to see how Karst forms and how water moves in Karst
   D. 'Karst Around the World' Slide Show

3. Field Trip Guides

   A. Interpretive Hike: Water on the Rocks. You are holding the teachers guide in your hands. You will find 3 student handouts and an answer key on the USB drive.

   B. Geo-technology Hike: This hike uses GPS co-ordinates, aerial photos, and topographic maps to allow students to explore the Eramosa Karst. The teacher's guide is included in this booklet. You will find 2 student handouts, a topographic map, and an aerial photo on the USB Guide.

4. Cumulative Activities

   These activities will synthesize the information learned on the Karst Field Trip. Both require students to debate what should be done with the Eramosa Karst's Feeder Lot.

   A. Town Hall Meeting. You will find instructions, Character Cards, Student Handout, an Aerial Photo, and a Topographic Map on the Flash Drive.

   B. The Great Feeder Lot Debate. You will find instructions, 2 handouts, Character Cards, and an Assement Matrix on the USB Drive.

Field Guide Overview

This field guide includes information for 2 programs.

Program 1, an Interpretive Hike called What is Karst; Water on the Rocks, is in 2 parts. Part 1 takes you out into the karst while exploring karst formation and identifying key features. Part 2 leads you back to the parking lot by following a sinking stream as it flows through the Karst.

Program 2, Karst Hydrogeologic Inventory, is a separate field trip that uses geotechnology to allow students to explore the Karst. It does repeat some of the activities in Program 1, so use your discretion when deciding which activities to do.

Both programs can be done in one day, or you may choose to do only one. Program 1 is described here. See page 40 for Program 2

Directions

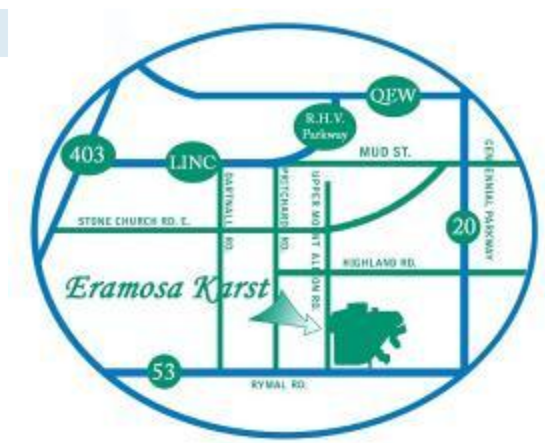
How to get to the Eramosa Karst:

From the Lincoln Alexander Parkway, exit Stone Church Road East

Turn Left onto Stone Church Rd. E.

Turn Right onto Upper Mount Albion Road

Eramosa Karst will be on your left hand side after the 4-way stop.



Program 1: Interpretive Hike. What is Karst? Water on the Rocks.

This guide contains background information and directions to each point of interest. You may choose to share all or part of it with students and can read it or re-phrase it as you feel comfortable.

The USB Drive that accompanies this guide contains worksheets for students to fill out as you tour the Karst. Students should be divided into groups of 3 to 5 to work together.

Objectives

Students will be able to:

1. Explain what karst is
2. Identify key karst features
3. Explain how key features formed
4. Discuss the challenges of karst aquifers for water management
5. Track the flow of water in a karst

Key Points

1. Karst forms in areas where carbonic bedrock (limestone, dolostone) reacts with slightly acidic ground water (carbonic acid).
2. Karst is characterized by 6 key features; underground drainage, springs, sinkholes, caves, karren, and sinking streams.
3. The same processes of chemical weathering performed by water on the surface are performed by ground water below the surface. Looking at these surface features help us understand what is going on below ground.
4. Water travels through karst landscapes very quickly and with very little filtration. This can cause water quality problems .

Materials

Teacher:	
Must Have	Optional
Trail Map Compass	GPS Unit Aerial Photos (From USB Drive) Bottle of Spring Water (for demonstration) Rubber Boots
Students:	
Must Have (1 per Group)	Optional
Clipboard Worksheet Ruler or Measuring tape Floating Object (film canisters work well)	Rubber Boots Water (to drink) Snack

Directions

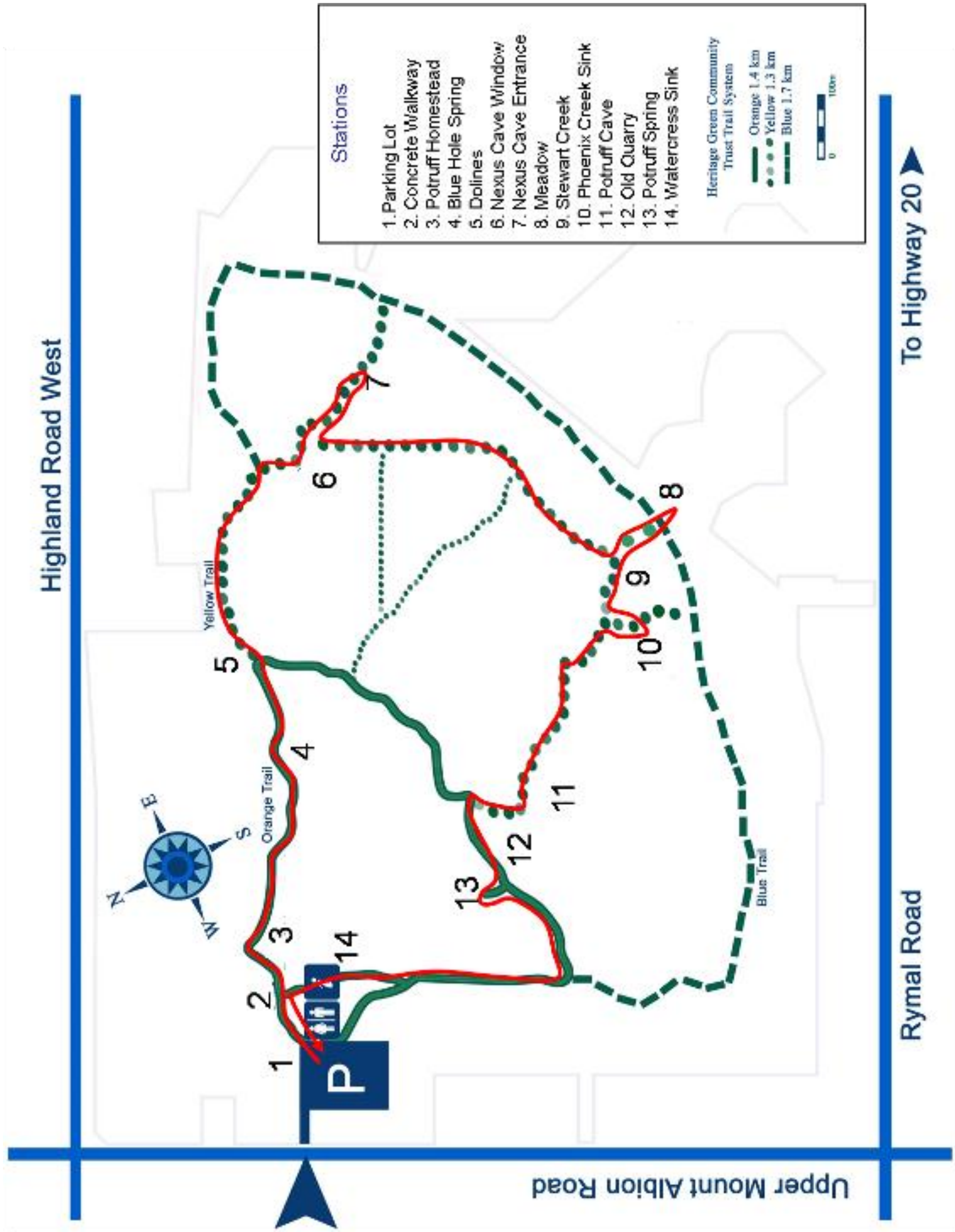
How to find your way around the Eramosa Karst:

This trail guide contains directions to each station. There is also a map making each station on the next page. If you have access to a GPS unit, you can also use that to help you locate stations using the coordinates below.

Approximate GPS Co-ordinates of Stations and Points of Interest.

Station	Station Name	UTM
1	Parking lot	596558E 4782263N
2	Bridge	N/A
3	Pottruff Homestead	596763E 4782299N
4	Blue Hole Spring	596922E 4782209N
5	Sinkhole 3	(along trail)
6	Nexus Cave Window	597265E 4782097N
7	Nexus Cave Entrance	597393E 4781990N
8	Feeder Lot	597227E 4781780N
9	Stewart Creek	597036E 4781777N
	Stewart Creek Sink	597009E 4781785N
10	Phoenix Creek Sink	596970E 4781779N
11	Pottruff Cave	596808E 4781965N
12	Old Quarry	596756E 4782023N
13	Pottruff Spring	596733E 4782033N
	Poison Ivy Patch	596611E 4781998N
	Eramosa Escarpment	596620E 4782007N
14	Watercress Sink	596659E 4782248N

Unless otherwise indicated, continue straight on gravel paths, ignoring any unmarked forks or grass paths.


Highland Road West
Upper Mount Albion Road
Rymal Road
To Highway 20
Stations
1.Parking Lot
2. Concrete Walkway
3. Potruff Homestead
4. Blue Hole Spring
5. Dolines
6. Nexus Cave Window
7. Nexus Cave Entrance
8. Meadow
9. Stewart Creek
10. Phoenix Creek Sink
11. Potruff Cave
12. Old Quarry
13. Potruff Spring
14. Watercress Sink
Heritage Green Community
Trust Trail System
Orange 1.4 km
Yellow 1.3 km
Blue 1.7 km
Yellow Trail
Orange Trail
Blue Trail
P
N
E
S
W

Station 1: Information Centre at the Parking Lot

Overview: Karst is a landscape where the distinction between ground water and surface water fades

Information Points:

Water is present in two parts of every landscape; on the surface and in the ground. In a typical landscape, surface water and ground water are distinctly different. Surface water flows in streams and ground water sits in droplets underground, filling the spaces between sediments. Sometimes ground water is stored in an aquifer, a gap in the bedrock or soil sediments.

In a karst landscape, the distinction between ground water and surface water fades. Water sinks underground and springs up again, quickly switching from surface to ground water. Ground water also acts like surface water, flowing through underground channels in the bedrock, the same way surface water flows through stream beds on the surface.

So how does this happen? What does a karst look like? Where do these bedrock channels come from?

The information centre is designed to resemble a karst landscape.

Imagine yourself standing underground in a cave. The roof is the cave ceiling, the skylight is a karst window, and the boulders are the cave floor. The grated channel represents an underground stream.

During a rain fall, rain collects on the roof and runs through the skylight into the channel, the same way water flows in karst systems.

Try looking at the information centre again after you have seen the Karst and see if you can identify the Karst features here.

Directions:

From the Information Centre, walk past the washrooms on the left and head towards the large Spruce tree and the display board.

Take the Orange Trail into the meadow.

Stop on the concrete walkway for station 2.

Travel Time: 2 minutes

Station 2: Bridge

Overview: Carbonic acid is the main actor in karst formation.

The concrete bridge on a high-water flow day. The combination of melting snow and a recent rainfall has filled the normally dry creek bed. On a low-flow day, you will see dry bedrock here.

Information Points:

1. Karst is a landscape formed when carbonic acid dissolves carbonate bedrock.

2. Carbonic acid (H_2C0_3) is the main actor in karst formation.

3. Carbonic acid is made when rain water mixes with carbon dioxide, described by the formula: $H_20 + CO_2 \longrightarrow H_2C0_3$

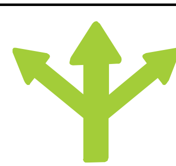
Have students look around for CO_2 sources. There are two obvious sources but one can be easily overlooked.

1. The air: Humans and animals breathe, burn fossil fuels, etc.
2. The soil: Soil dwelling worms, insects, micro-organisms, and decaying plant matter all produce biological CO_2 that is stored in the soil.

As rain water falls through the air and percolates through the soil, it picks up surrounding CO_2 and becomes carbonic acid.

Question: Is there more karst activity in the spring or in the winter?

Answer: The spring. There is more biological activity in the soil, producing more biological CO_2. This results in stronger carbonic acid that can dissolve more bedrock.



Directions:
Continue along the Orange Trail, heading towards the woodlot.
Stop at the sign post for Pottruff Homestead.

Station 3: Pottruff Homestead

Overview: Carbonate Bedrock underlies all karst areas. The Eramosa Karst lies on dolostone.

Information Points:

Remember from the previous station that karst is a landscape formed when carbonic acid dissolves carbonate bedrock.

There are two very common carbonate rocks in this area.   Dolostone (Magnesium Carbonate) is the most common and limestone (Calcium Carbonate) is the second most common.

Limestone and dolostone were formed thousands of years ago when this area was covered by the Silurian Sea. The coral reefs that thrived there have since become the limestone and dolostone that make up the Lockport Formation and the Eramosa Member.

The Lockport Formation is the limestone slab that makes the Niagara Escarpment. (The Niagrara Escarpment is the edge of the Lockport Formation.) The Eramosa Member is a slab of dolostone that sits on top of the Lockport Formation. Its edge is Eramosa Escarpment, a cliff about 10 feet high you will see later on in the program.

Activity

Have students explore the area and looking for dolostone. They should find the ruins of the Pottruff barn and house.

The Pottruff family quarried this dolostone from the Eramosa Escarpment in the 1800s.

These rocks show signs of being dissolved by carbonic acid. Some of them have very rough surfaces that look like swiss cheese. These bumps and holes are called karren. They were created over thousands of years when carbonic acid dissolved the rock.

When we see karren on surface rocks, we can assume the carbonic acid is also dissolving the underground bedrock.

Karren on a rock at the Eramosa Escarpment. You will see this Escarpment later on in the program.

Directions:

Continue along the Orange Trail.
Keep right at the East Mountain Trail Loop intersection and remain on the Orange Trail
Stop on the boardwalk. This is Blue Hole Spring.

Time: 10 minutes

Station 4: Blue Hole Spring

Overview: You cannot see the spring at Blue Hole Spring but it has a big impact on the ecosystem here.

Information Points:

There are several key identifying features of karst. Sinkholes, caves, sinking streams, and springs are all indicators of karst areas where underground drainage is common. Blue Hole Valley is so named because there is a spring to the South West.

While this area may look dry today, it does occasionally flood. There is water flowing underground here, through channels in the bedrock.

The acidic groundwater (carbonic acid) slowly dissolved the dolostone, creating underground water channels. Normally, water sinks down into those channels and flows underground.

After a heavy rain fall, those channels can overflow. The excess water flows through Blue

Hole Spring and floods this valley. Springs are areas where ground water surfaces, literally springing from the ground.

The occasional flooding affects which kinds of plants can survive here. You'll notice there are very few trees here, but a lot of quick-growing herbaceous plants, as well as water-tolerant plants.

Optional Activity: Plant Identification.

Using the handout on the USB drive (appendix 1), this activity has students look for a variety of plants in the valley, including common wildflowers, shrubs, and trees.   They should not be able to find any of the trees.

Students should not leave the bridge to do this activity. This wetland habitat is sensitive, not to mention muddy...

Lead the students in a discussion of how water influences ecosystems. The periodic abundance of water makes this unsuitable habitat for tree seedlings. As long as it continues to flood, this area will not go through the usual stages of succession and will remain a meadow.

Directions:
Continue along the Orange Trail.
At the signpost for the Orange and Yellow Trail, stop for Station 5

Time: 5 minutes

Station 5: Dolines or SInkholes

Overview: Dolines form when surface sediments sink into underground cavities in the bedrock.

Information Points:

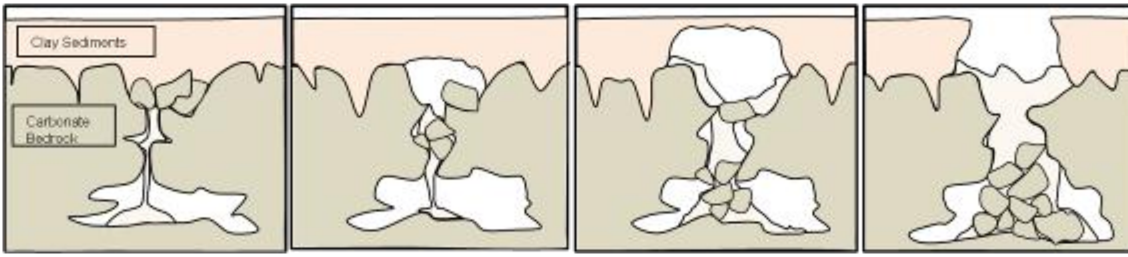
Dolines are more commonly known by their American name, sinkholes.

Sinkholes are another key feature of karsts. There are two types of sinkholes in the Eramosa Karst: Collapse Sinkholes and Suffusion Sinkholes.

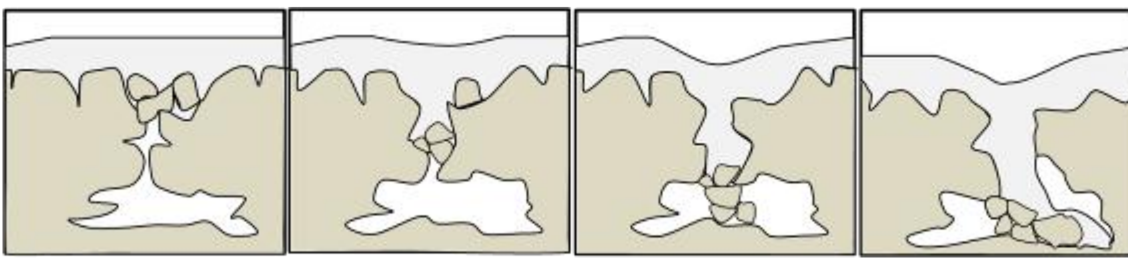
Most people are familiar with the dramatic side of collapse sinkholes. Perhaps you have heard news stories about the ground suddenly giving way, swallowing whole city blocks.

Collapse sinkholes usually form in clay sediments. The underground clay sediments fall into a cavity in the bedrock, leaving an empty pocket between the bedrock and surface sediments. Eventually, the pocket loses stability and the surface sediments collapse. There are at least two collapse sinkholes in the Eramosa Karst (you'll see them later).
Collapse Sinkhole

The less dramatic suffusion sinkholes are formed in sandy or loamy soils. The loose



sediments slip into a cavity the way sand slips through an hourglass. The resulting sinkholes have sloped sides, resembling a bowl. Most of the sinkholes in the Eramosa Karst are suffusion sinkholes.



Have students look into the forest and locate a sinkhole. Once everyone has found one, have students fill out the worksheet. As you walk to the next station, you can have students observe the terrain around them and keep a tally of the sinkholes they see.

Directions:

Keep Left and follow the Yellow Trail
Continue on the Yellow Trail for about 10 minutes.
At the signpost for the Yellow and Blue Trails, keep right on the Yellow Trail.
In about 30 meters, stop at Nexus Cave Window

Time: 10 minutes

Station 6: Nexus Cave Window

Overview: Caves form when carbonic acid dissolves the underground bedrock. Water flows through these caves quickly without natural filtration, allowing pollutants to spread quickly.

Information Points:

Up to now, we've been referring to 'channels' in the bedrock. These channels are more commonly known as caves.

Karst scientists define caves as 'Natural cavities dissolved into bedrock by water large enough for human passage.' If a cavity is not big enough for humans to fit though, it is called a 'channel' rather than a cave.

Nexus Cave is a narrow crawl space that runs for approximately 350 meters underground. The arrow indicates the direction.

Caves like this one are another key feature of karsts. At this window, a portion of the cave's ceiling has collapsed leaving us with a view into a section of the cave.

Nexus Cave Window is the access point to Nexus Cave. At 350 meters long, Nexus Cave is the tenth longest known cave in Ontario. It is also the most accessible dolostone cave in Ontario.

While many cavers take advantage of this area, you are not advised to enter the caves with your students. The spaces are extremely small and difficult to maneuver. Injuries are common even among trained cavers. Instead, have your students look down into the cave to look for traces of water and possible water contaminants.

Activity and Discussion

Question: Why might a cave window pose a threat to water quality?

Melted snow drips into Nexus Cave Window. Surface water can flow directly into the cave with no filtration.

The Cave on a low flow day. There is very little resistance to water flow in these open spaces, allowing water to flow quickly.

The Cave on a high flow day. This fast moving water can move contaminants quickly. In a matter of hours, downstream drinking water could be contaminated by pollutants from the Cave Window.

Directions:

Continue allow the Yellow Trail to Station 7, Nexus Cave Entrance.
At the signpost, keep to the left and continue along the Yellow Trail.
Nexus Cave Entrance is at the edge of the woodlot, around a slight bend

Time: 5 minutes

Station 7: Nexus Cave Entrance

Overview: Caves form through a combination of chemical weathering (dissolution) and physical weathering (erosion).

Information Points:

Aside from being the beginning of Nexus Cave, there are several examples of chemical weathering here. (Chemical weathering=dissolution).

1. The entrance consists of several suspended slabs of dolostone. These slabs were originally one rock. Thin cracks in the rock were gradually enlarged as water flowed into them and dissolved the surrounding rock.

These 'grikes' eventually reached all the way through the bedrock, in effect cutting the rock into individual suspended slabs.

The stream bed overflowing with Spring rainfall.

2. Upstream (to the south east), Nexus Creek emerges from the fields. The dissolution of bedrock is clearly seen in the channel the flowing water has carved into the bedrock. This stream overflows at times and can be quite powerful. When the water is moving quickly, it also physically erodes the stream bed.

3. There are also many surface karren on these rocks. Karren form on soluble rocks as carbonic acid flows or pools on the surface. The carbonic

acid slowly dissolves the rocks, creating small pits and depressions. The results look somewhat like Swiss cheese.

This rock is filled with karren.

These same processes of dissolution and chemical weathering also happen underground.

In underground systems, water slips through natural cracks in rock, dissolving the areas beside the cracks. (The same way it made grikes at the surface). Eventually, the cracks become wide enough for large amounts of water to slip through. This faster moving water can physically erode the rock, speeding up cave formation.

Scientists are fairly positive that Nexus Cave was formed through a combination of chemical and physical weathering.

Activity and Discussion

Students will measure the size of a karren, a grike, and/or the stream bed to determine how much of the rock has been dissolved and how long dissolution has been occurring.

Have students work in their groups and send them out to locate a karren feature, a grike, and the stream bed (to the south east). Skip the stream bed measurements if there is water flowing through it.

Measure the distance from the highest point of the feature to the lowest point.

Have students calculate how long it took to dissolve these features assuming that dolostone dissolves at a rate of 0.0001 m/year, or 1m every 10 000 years. (see discussion on the following page).

Station 7: Nexus Cave Entrance Continued

Questions for Discussion

1. How much of the bedrock has been dissolved?

   (Responses will vary)

2. How long did this take?

   (Responses will vary as different sized karren will give different results)

3. How old is this karst?

   (The biggest grike or karren will probably be the oldest. We can assume the karst is at least as old as that feature, although it may be older. No one should get an answer greater than 13 000 years).

Decantation Runnels. These karren were created by water trickling over the rock like a miniature waterfall

4. What major geological event happened here approximately 13 000 years ago?

   (The glaciers retreated from Southern Ontario at the end of the last ice age).

5. What does that tell you about karst?

   (It only forms when it is warm. Students should remember that biological activity is needed to produce CO_2 in the soil and make carbonic acid. During the last ice age, it was too cold for life to be active in the soil. There was little carbon dioxide and little carbonic acid.).

The outer wall of Nexus Cave in winter. Very little dissolution happens when it is cold.

Part 2: Tracking a Sinking Stream

At this point, the focus of the trip shifts. The first half was about understanding karst landscapes and karst formation. This half is about tracking a stream as it flows through the karst, sinking and springing up again.

Directions:

Turn back along the Yellow Trail and trace your steps back into the woodlot.
At the signpost, keep left to go down the Yellow Trail (do not pass Nexus Cave Window).

Continue to follow the Yellow Trail through the woodlot and through the meadow.

When you reach the T intersection (A gully and a line of trees will block your way), keep left and follow the unmarked grassy trail to the South East.
This trail will bring you into the Feeder Lot.

Once you have passed the line of trees, stop. This is Station 8.
The open meadow the South East is the Feeder Lot.

Time: 15 minutes

While you're walking: Keep your eyes open for animal signs.

-Coyote tracks and scat are very similar to those of a dog, but dogs usually travel with humans. So if you see dog-like tracks with no human tracks, you might actually be looking at coyote tracks.
-Wild turkey tracks look like very large bird tracks. Turkeys often travel in groups, so look for clusters of large bird tracks.

Station 8: Feeder Lot

Overview: Meadows and fields are important for maintaining good water quality.

Information Points:

Standing with your back to the woodlot, facing the road, you see the Eramosa Karst's Feeder Lot. This area contains the surface portion of the streams that run through the karst conservation area. For many years, the city planned to develop this land and build houses here.

A citizen's group called Friends of the Eramosa Karst campaigned to preserve this land. They argued that developing it would damage the streams that run into the Karst and negatively impact the protected Conservation Area. Thanks to their efforts, this land was designated as protected green space in Feburary 2011. It is not part of the Conservation Area but will not be developed.

Questions for Discussion

1. Why is "Feeder Lot" an appropriate name for this area?
   (The streams that flow through here 'feed' the karst.)

2. What value does this land have? (There are multiple opinions; value as a water source, wildlife habitat, as a good place to build houses, as a recreation area, etc.).

3. Do you agree this land should be preserved? Why or why not?

4. Take a look at the aerial photos of the Eramosa Karst. Where are the streams? How do they connect to the karst features you have seen? Does looking at the aerial photo help you orient yourself to the site?

Note: If you plan to complete “The Great Feeder Lot Debate” or “Town Hall Meeting” activities, emphasize that this is the lot in question.

Directions:
Retrace your steps back along the Yellow Trail.
Keep North and pass back through the line of trees.

At the T intersection, you were at before, keep left, maintaining your North bearing.

Keep Stewart Creek on your left.
Stop at a break in the vegetation where you can see the creek.

Time: 5 minutes

Station 9: Stewart Creek

Overview: This is the surface portion of the stream we will be following through the Karst.

Information Points:

Stewart Creek runs through the feeder lot as a surface stream. When it enters the Karst it sinks and springs up again in several locations.

Phoenix Creek also runs along the surface through the feeder lot. These two streams merge at their sink point, just up ahead.

The blue lines are the creeks. The green line is the Karst boundary


Stewart Creek in winter.

Optional Topics

Have students look at the creek and observe its shape.

Streams are naturally curvy. They only run in straight lines if humans have made them. The curves are important for creating habitats for different aquatic plants and animals.

Curved streams are essential to aquatic life. The curves break up the water's current, providing calm pools where plants can gain a hold and aquatic insects and fish can find shelter.

A hydrologist adds biodegradable red dye to Stewart Creek just before its sink point. He will then monitor the downstream springs to see where this stream resurfaces. Tracking the flow of water through a karst is important to maintain high water quality. If there is a problem at a sink point, we need to know which downstream springs will be affected.

Directions:

Continue along the Yellow Trail to the Phoenix Creek signpost.
Keep left and stop on the boardwalk at Phoenix Creek Sink.

Time: 2 minutes

Station 10: Phoenix Creek Sink

Overview: Phoenix Creek has dissolved an underground channel in the bedrock and sinks underground here.

Information Points:

Phoenix Creek used to flow over land in the now dry creek bed you see to the North West. Over time, Phoenix Creek has dissolved a channel through the bedrock, creating an underground passage. Normal water volume flows underground at this sink point and continues to flow through channels in the bedrock.

The dry creek bed still flows with water sometimes. When there is excessive rain and the underground channel is completely filled, the excess water runs through the old creek. This dry creek bed is a ‘blind valley’ that contains water only after there has been a large rainfall or snow melt.

Stewart Creek sinks underground a few meters to the East. At some point underground, Phoenix Creek and Stewart Creek merge together and form one stream; Pottruff Creek.

Activity: Measuring Discharge

Discharge is the volume of water flowing through a stream.

See the student handout in appendix 1 on the USB drive for instructions on how to measure discharge. You will demonstrate the technique for your students. Having them observe the process here will be useful when they have to measure the discharge at Pottruff Spring, the spring at the end of this sink (Station 13).

Use the narrow portion of the stream upstream from the sink point. Do not attempt to measure the discharge at the area shown in the picture below. The sink point will disrupt your measurements.

Phoenix Creek on a high flow day. Discharge was high.

The hydrologist is adding a biodegradable yellow dye to this creek. He later found both red and yellow dye at a downstream spring. Where would the red dye have come from (see page 27)? Why would both dyes appear at the same spring (see page 28)?

Directions:
Turn around and return to the main Yellow Trail.
Keep to the left.
Observe the Blind Valley to the left.
Continue along the Yellow Trail, passing through the meadow.
You will be walking towards a woodlot.
Station 11, Pottruff Cave, is just within the woodlot.

Station 11: Pottruff Cave

Overview: Pottruff Cave is a collapse sinkhole, formed when water slowly dissolved the bedrock from above and below ground.

Information Points:

Pottruff Cave as we see it today is a collapse sinkhole.

The cave was created as Pheonix Creek and Stewart Creek gradually dissolved the underground bedrock. Originally it was entirely underground, separated from the surface by a dolostone ceiling and a thin layer of soil.

Water from the surface trickled down through the soil, picking up CO_2 from organic matter there. As it picked up the CO_2, it became more acidic, forming carbonic acid.

When this carbonic acid came in contact with the ceiling, it seeped through the cracks in the dolostone, gradually widening them through dissolution.

When the cracks were too wide, the cave ceiling lost stability and collapsed, leaving this scar of bedrock.

Questions for Discussion

Before sharing the information points with your students, you can lead them in a discussion using the questions below. They should help your students understand what has happened here.

1. Was there ever water flowing through here?
   (Yes: We can see evidence of water in the Karren and the collapsed bedrock.)

2. Where might the ground water have originally flown?
   (The collapsed bedrock to the right of the cave gives us a clue. The collapsed bedrock seems to follow the shape of a stream, curving the way surface streams do. It is easy to imagine a stream flowing through this channel.)

3. Which direction did the stream flow? How can you tell?
   (It probably flowed South to North, the same direction all the water in the karst flows. We saw the stream sink to the south and can imagine that water continuing to flow to the north.)

4. What other area does cave remind you of?
   (Nexus Cave Entrance; Pottruff cave may have looked something like that before it collapsed. Nexus Cave Window; Pottruff cave is also a collapse sinkhole).

Pottruff Creek (the combination of Stewart Creek and Phoenix Creek) still flows through this area. It has sunk even deeper underground but can usually been seen at the bottom of the cave. If it has been very dry recently, there may be no water flowing.

Water levels change significantly depending on the time of year and the amount of rainfall. These pictures show how much the Karst can change after a rain storm.

Pottruff Cave in early winter when water levels are low.

Pottruff Cave in spring after an unusually large rainfall.

Directions:

Continue along the Yellow Trail.
At the signpost for the Yellow and Orange Trails, turn left onto the Orange Trail.

As you round the corner, you will see dolostone boulders to your left and a slope to your right. This is the Eramosa Escarpment.

Stop on the boardwalk.

Time: 3 minutes

Optional Topics: Garlic Mustard

Garlic Mustard is an invasive plant. It was brought to Canada by European settlers who used it to flavor food. It escaped from their herb gardens and now covers much of Ontario's forest floor.

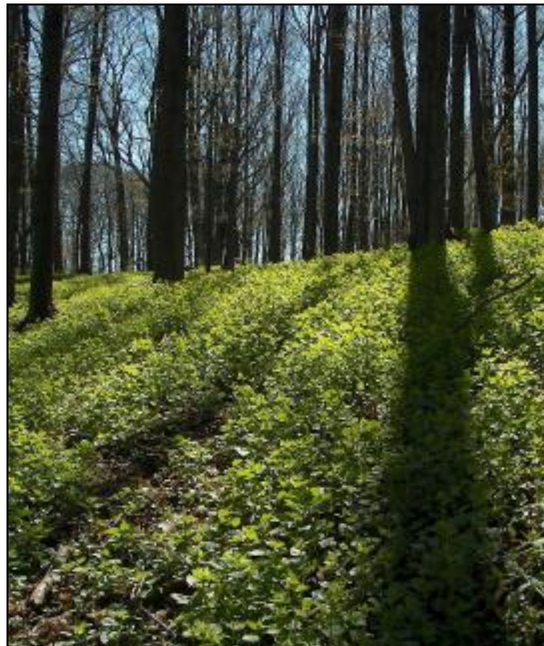
Conservationists are worried about Garlic Mustard because it spreads so quickly. As a result, it threatens Ontario's native forest plants like Trilliums.

Have your students look for this plant. It is very easy to find in the area around Pottruff Cave.

In late spring, look for knee-high plants with light green leaves and small white flowers.

In the fall, look for ground-level plants with a few deep green leaves.

If you are not sure you have found the right plant, try smelling it. Garlic Mustard smells exactly like its name suggests.



Garlic Mustard near Pottruff Cave. It is easy to find at the Eramosa Karst because it grows everywhere.

Trilliums compete with Garlic Mustard for space to grow

May-apples seem to be able to out-compete Garlic Mustard. Look for these short plants.

Station 12: Old Quarry

Overview: Water flows underground here. We can see evidence of occasional flooding.

Information Points:

At the beginning of the tour, you were told to keep your eyes open for the Eramosa Escarpment. This is it. You are standing in the middle of the Escarpment. It raises about 2 meters up on one side and drops about 5 meters down on the other.

The Eramosa Escarpment is at the edge of a dolostone slab called the Eramosa Member. It sits on top of the Lockport Formation. (The edge of the Lockport Formation is the Niagara Escarpment.)

Around 200 years ago, the Pottruff Family quarried rocks from here and used them to build the foundation of their house and barn. You already saw the ruins of these at the Pottruff Homestead. You can see evidence of the quarry activities that happened here. Some of the rocks have straight sides and pointed edges. These rocks were most likely quarried.

Questions for Discussion

1. How do you know karst activity has been happening here?
   (Karren in the rock.)

2. Review Question: How did these karren form?
   (Carbonic acid pooled or dripped on the carbonate bedrock and slowly dissolved it creating pits or depressions.)

3. What evidence of water do you see in this area?
   (There is a bridge here, indicating that water flows through here sometimes.
   The bedrock is exposed, like in a stream channel.
   There are few plants (especially large plants) in the area.

4. This indicates that is area floods occasionally, most likely after heavy rains or snow melt create a large volume of water. Where does the water flow when there is a low volume?
   (Undergound. Pottruff Creek continues to flow underground here. We only see it when the underground channels fill and the excess water flows along the surface.)

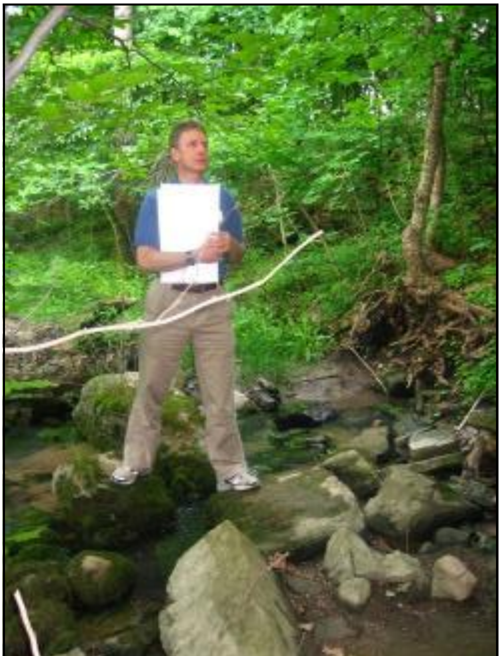
Directions:

From the boardwalk, continue along the Orange Trail.
At the Pottruff Spring signpost, take the side trial down the hill to the right.
Stop at the bottom.
This is Pottruff Spring.

Time: 2 minutes

Station 13: Pottruff Spring

Overview: This stream is the combined flow of Stewart Creek and Phoenix Creek. The two streams merged underground and now spring up here.



The spring in Summer: low flow

The spring in early Spring: high flow

Information Points:

We have seen this stream before at Stewart Creek, Phoenix Creek Sink, Pottruff Cave, and at the Old Quarry. It flowed underground for most of the way but now surfaces again.

Questions for Discussion

From this point on, this creek is called Pottruff Creek.

1. Would you drink this water? Why or why not?

Ask students to think about advertisements they have seen for bottled spring water. Any students who have a disposable water bottle with them can take a look at that. The bottles usually say something about 'fresh spring water'.

We usually think of 'fresh spring water' as being the purest and cleanest kind of water.

But is the water from karst springs the same?

2. Would you drink the surface water from the creeks we saw on our tour? Why?
3. How is that surface water connected to this spring water here?
   (This is the exact same water)

In karst aquifers, 'spring water' is pretty much the same as surface water.

The water flows through caves the same way as water flows through a pipe; quickly and with very little filtration. If you wouldn't drink the surface water in karsts , you shouldn't drink the spring water either.

Activity: Measuring Discharge.

If water levels are too high to work safely, skip this activity, or demonstrate it for the class. Use the instructions on the student handout (appendix 1) top measure discharge of the stream. Students should work in groups.

In all likelihood, each group will calculate a different discharge, even though the same volume of water is flowing through all points of this stream. Take a moment to emphasize how difficult it is to measure discharge accurately.

The volume should also be considerably more then at Phoenix Creek Sink because 2 streams have converged underground and emerge here.

Directions:

Retrace your steps up the hill. At the signpost, keep right and follow the Orange Trail. At the signpost for the Orange and Blue Trail, keep right to stay on the Orange Trail.

At the signpost for the 2 Orange Trails, keep right again and follow the Orange Trail into the meadow. Stop at the signpost for Watercress Sink

Time: 10 minutes

Station 14: Watercress Sink

Overview: Watercress Sink is the last sink point for Pottruff Creek in the Eramosa Karst.

Information Points:

Overflow runs into the meadow

Pottruff Creek has flowed above ground from Pottruff Spring to this sink.

From here, it flows underground to another spring, located in the suburbs you see to the north. After a few meters, It sinks again. Eventually it makes its way down the Niagara Escparpment and flows into Hamilton Harbour.

Watercress Sink occasionally overflows, sending the excess water down a bedrock path in the meadow. If you are here on a high flow day , you will see the overflow stream. If you are here on a low flow day, look around for exposed bedrock in the meadow. This is the dry stream bed.

Directions:

Continue along the Orange Trail.
At the signpost for the Orange Trail, turn left and return to the parking lot.

You may choose to have students complete the Parking Lot Scavenger Hunt before you leave, to summarize the information one more time. (appendix 3).

Questions for Discussion

1. What two things are needed to make karst?
   (Carbonic acid and carbonate bedrock.)

2. What are the key features of karst?
   (Karren, Spings, Sinks, Caves, Dolines)

3. How do caves form?
   (Water slowly dissolves bedrock underground. When the channels are big enough for water to move quickly, it also physically erodes the bedrock. Eventually, the water creates channels big enough for humans to fit through and the channel is officially called a cave.)

4. What are some of the challenges of water quality management in karst areas?
   (There is no filtration of ground water. Ground water easily becomes contaminated by whatever we have put on the surface (Garbage, chemicals, etc). Pollutants can also travel great distances very quickly as their flow is uninterrupted.)

Program 2: Karst Hydrogeologic Inventory

Students will work in groups to take a Hydrogeologic inventory. Using GPS coordinates, students will locate different karst features, mark the position on an aerial photo or topographic map and fill out a work sheet for each site. Work sheet activities include using a dichotomous key to identify karst features, taking measurements to determine the rate of dolostone dissolution, and measuring stream discharge. After completing the field activities, students will map the water course through the karst, inferring the underground water courses.

Objectives

Students will be able to:

1. Identify key karst features
2. Explain basic karst hydrology
3. Use GPS co-ordinates to locate karst features
4. Orient aerial photos or topographic map o their surroundings
5. Take simple measurements to determine the rate of dissolution in the karst
6. Measure discharge of a karst stream
7. Use a compass to determine direction

Materials

- Clip board, pencil, worksheets
- List of Co-ordinates,
- GPS unit.
- Aerial photo and/or topographic map.
- Camera (optional)
- Thermometer
- Compass
- Measuring Tape
- Meter Stick
- Small Float (film canisters work well)
- Rubber boots (at least 1 pair per group)

Notes

GPS co-ordinates are given in UTMs and were obtained using Magnetic North and WGS 84. Co-ordinates will not be exact locations and students may have to scout around for the karst feature they are looking for.

Divide students into groups of 3-5 members. Each group should be assigned coordinates in a different order so that they will not overlap. Stations do not need to be completed in alphabetical order.

Stations are located on or near the marked trail. Students will use the GPS coordinates to determine which direction to go but should stay on the trail as much as possible.

Although all groups will see the same types of features, not all groups will see the same specific features. Remind students to find their own stations, as their co-ordinates may be different from those of other groups

If you want to practice tracking co-ordinates with the whole class, you can walk as a class to co-ordinates 596598E 4781987N (Orange/Blue Trail Split) and spilt up from there. The stations are all located along the same trail and the class can easily be kept track of.

Glossary

Discharge: The volume of water in a stream. Units: m^3/sec. Measured as the amount of water moving through a fixed point in a fixed amount of time.

Topographic Map: a map using contour lines to indicate elevation

Carbonic Acid: a very weak acid responsible for the dissolution of carbonate bedrock in karst. Formed when rain water reacts with carbon dioxide (CO_2) in the air and soil.

Calcium Carbonate: chemical compound, $CaCO_3$, a principle component of limestone. In karst, this is what dissolves in water.

Conductance: A measure of the electrical conductivity of water, indicating the amount of calcium carbonate ions dissolved in the water. A high conductance means that many ions are dissolved in the water, indicating that more rock has been dissolved.

pH: measure of the Hydrogen ions in a solution, indicating if the solution is an acid or a base. In karst areas, the more acidic the water, the more rock it dissolves.

Prerequisite Knowledge and Skills

Before coming on this trip, students should

1. View the 'What is Karst?' slide show.
2. Understand how to measure discharge (go through the worksheet with them)
3. Be familiar with:
    - finding GPS co-ordinates
    - using compasses
    - reading maps
    - aerial photos and orienting them to their surroundings

Procedure

1. Divide students into groups of 3-5, as you feel comfortable. Make sure every group has the handouts and maps they need, a GPS unit, and the discharge measuring equipment.

2. Give each group list of co-ordinates in a different order (Appendix 5), a topographic map (Appendix 4), and an aerial photos (Appendix 3)

Each co-ordinate list should end with station H: the parking lot. Students will wait here when they have completed the tour. You can have them fill out the parking lot scavenger hunt while they are waiting (appendix 2).

3. Send groups out to locate sites.

4. When students locate a site they will:

    Identify the Karst Feature (dichotomous key).
    Take a photo (optional).
    Fill out the worksheet.
    Label the aerial photo correctly (the photo has a UTM grid overlay to help with locating sites.
    Label the map correctly

5. Remind students that they also have the chance to collect Bonus Points:

Extra points for providing the GPS co-ordinates and a photo of the following:

1. A different sinkhole than the one they were given co-ordinates for.
2. An example of karren.
3. Any 'urban' or human built feature that changes the way water flows in the karst.

6. When finished, students return to Station H, parking lot. Students will wait here until everyone has returned.

If any groups finish early, consider sending them to these additional sites.

Sinkhole 4	597033E 4782116N
Blue Hole Valley	596922E 4782209N
Pottruff Homestead	596763E 4782299N
Feeder Lot	597094E 4781792N
Nexus Cave Entrance	597393E 4781990N
Nexus Cave Window	597265E 4782097N

Post Trip Wrap Up

Back in the classroom, lead your students in the following activities and discussion.

1. Using your filled in worksheet, topographic maps, labeled maps, and labeled aerial photos, determine the direction of water flow in the Eramosa Karst. Sketch the water course on your map, including your best guess at underground water courses. (HINT: Sinkholes are good indication of caves below the surface).

1. (ANSWER: streams run from the South East to the North West; starting at Stewart Creek and Phoenix Creek, (students will only see Stewart Creek). The two streams join underground at Phoenix Creek Sink and flow underground to Pottruff Spring. The stream makes a brief appearance at Pottruff Cave, and we can infer that it flows un-

derground at the Old Quarry. From Pottruff Spring, the stream flows above ground to Watercress sink, where it sinks underground once again).

2. Compare stream temperatures before and after flowing underground. Are there any differences? What does this tell you about water flowing underground?

(ANSWER: in the summer, water will be cooler after coming from underground, as the water has been blocked from the sun and cooled by the colder ground temperatures. In the winter, the water will be water after coming from underground, as the water has been shielded from the colder air temperatures)

3. What 'urban' features did you see? How will they impact the water in the karst? Why is water quality important in the karst?

(ANSWER: Students may have seen roads, houses, dirt-biking paths, superstores, etc. Water will be contaminated with road salt, petrol-chemicals, household waste. Water may also be diverted from the karst by sewer systems. Water quality is important to maintain healthy aquatic and terrestrial ecosystems and to maintain the karst features themselves. Changes in water quality or volume can change the dissolution rate of bedrock, changing the way the karst functions).

More information:
http://www.dyetracing.com/khi.html

Appendices included on the USB Drive:

Appendix 1: Student Handout

Appendix 2: Parking Lot Scavenger Hunt

Appendix 3: Eramosa Karst Educational Photo (Aerial Photo)

Appendix 4: Topographic Map

Appendix 5: GPS Coordinates