GEOLOGICAL SURVEY OF CANADA

OPEN FILE 5810

GeoTour guide for Kamloops, British Columbia

R.J.W. Turner, R.G. Anderson, R. Franklin, M. Cathro, B. Madu, C. Huscroft, E. Frey, and K. Favrholdt

2008

Natural Resources Canada Ressources naturelles Canada

GEOLOGICAL SURVEY OF CANADA

OPEN FILE 5810

GeoTour guide for Kamloops, British Columbia

R.J.W. Turner, R.G. Anderson, R. Franklin, M. Cathro, B. Madu, C. Huscroft, E. Frey, K. Favrholdt

2008

Available from
Geological Survey of Canada
601 Booth Street
Ottawa, Ontario K1A 0E8

R.J.W. Turner, R.G. Anderson, R. Franklin, M. Cathro, B. Madu, C. Huscroft, E. Frey, K. Favrholdt
2008: GeoTour guide for Kamloops, British Columbia, Geological Survey of Canada, Open File 5810, 34 p.

Open files are products that have not gone through the GSC formal publication process.

GeoTour guide for Kamloops, British Columbia

Our land, our community

Geological Survey of Canada Open File 5810
British Columbia Geological Survey Geofile 2008 - 6

R.J.W. Turner and R.G. Anderson, Geological Survey of Canada; R. Franklin, North Saanich; M. Cathro, Consulting Geologist; B. Madu, British Columbia Ministry of Energy, Mines, and Petroleum Resources; C. Huscroft, E. Frey, and K. Favrholdt, Thompson Rivers University

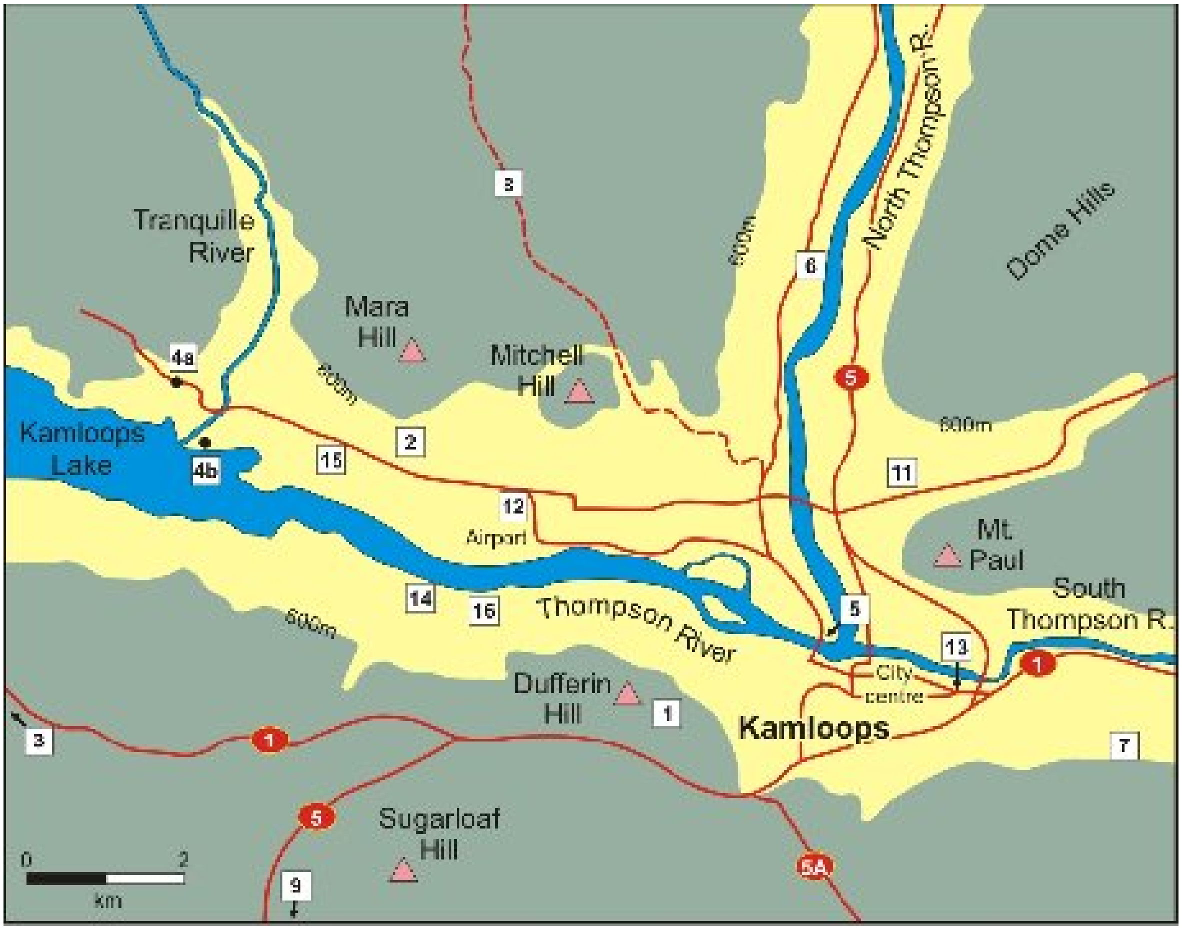


Figure 1. *A map of GeoTour stops in the Kamloops area*

GeoTour guide stops

1. **Mount Dufferin**, **Kenna Cartwright Park**, – a view of the Kamloops area.
2. Cinnamon Ridge, **Tranquille Road** – ancient volcanic rocks.
3. McAbee Fossil Site, Highway 1 near Cache Creek – ancient life in the Kamloops area.
4. **Red Lake Road viewpoint and Tranquille –** the Thompson River delta and Tranquille River delta.
5. Overlander Park, North Shore – a tale of two rivers.
6. Oak Hills, **Westsyde** - living with floods and dykes.
7. Kamloops Bike Ranch, **eastern Kamloops –** origins and challenges of ancient glacial lake silt benches.
8. Lac du Bois Grasslands Protected Area, Lac du Bois Road – hills, kettle lakes, and glacial debris.
9. Highland Valley copper mine, **Logan Lake –** a giant ore body and mine.
10. Lafarge limestone and cement plant, **Highway 1 east of Kamloops –** vital resource and greenhouse gas challenge.
11. Cement and asphalt plant, **Paul Lake Road** - key building materials for Kamloops.
12. Petro-Canada petroleum depot, **Tranquille Road** - fueling Kamloops and greenhouse gas challenge.
13. City of Kamloops Centre for Water Quality, **downtown Kamloops** - our water supply.
14. City of Kamloops waste water treatment plant, **Mission Flats Road –** where our waste water goes.
15. City of Kamloops compost facility, Tranquille Road - recycling our yard waste.
16. City of Kamloops landfill, **Mission Flats Road** - garbage and recycling.

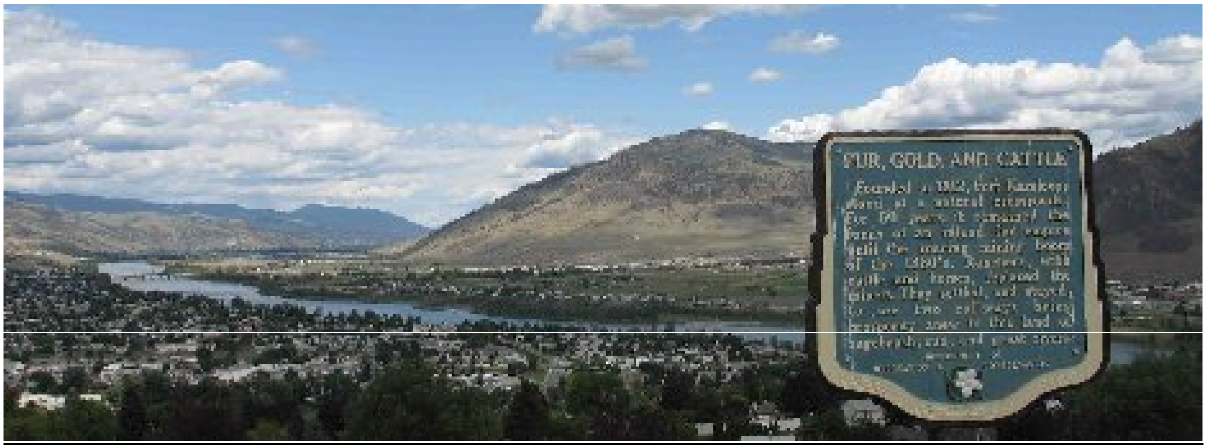


Figure 2. *View to the north of Kamloops and the North Thompson River valley from the City of Kamloops scenic lookout on Columbia Street. (Photo by R. Turner)*

Kamloops, Meeting of the Waters

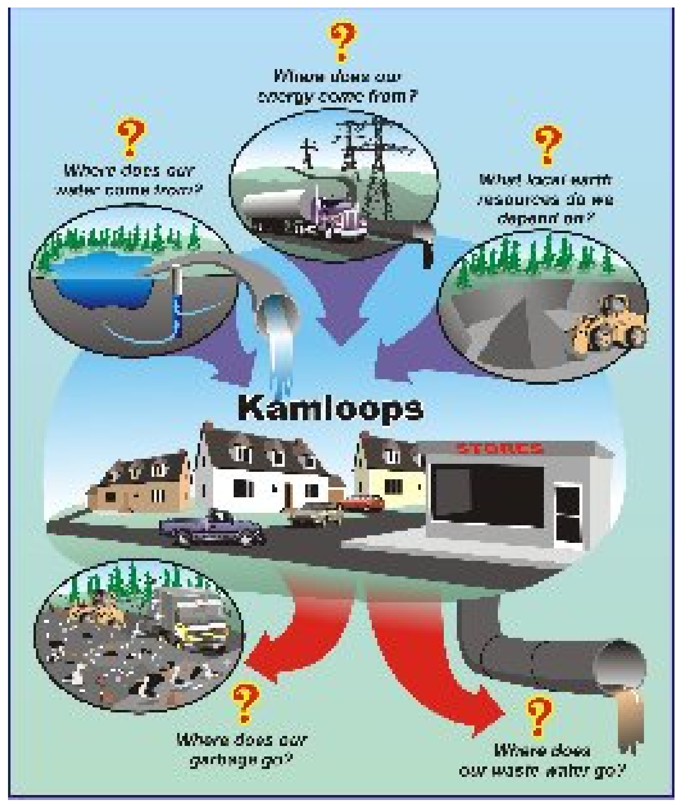


Figure 3. *Kamloops depends on the Earth to provide resources that flow into the city, and to assimilate wastes that flow out.*

We live within the great Interior Plateau of British Columbia where the two major tributaries of the Thompson River join and flow together into Kamloops Lake. To the Secwepemc or Shuswap people, this place is "Tk'emlups", meaning 'meeting of the waters'. Two major highways and railways follow these river valleys and converge here, making it a transportation crossroads. Kamloops is a meeting place in other ways. Grasslands and forests, the two major ecosystems of southern BC are found here. The boundary between the gently rolling Interior Plateau and more rugged Shuswap Highlands lies just east of the city. And as we will discuss in this guide, this landscape boundary follows a geological boundary between ancient North America and "exotic" Pacific islands that make up the landmass of western British Columbia.

Kamloops, like any other community, is dependent on the Earth for water, food, materials, and energy. Not only does the Earth provide resources, but it accepts our wastes. This *GeoTour* field guide explores how the community of Kamloops lives on, lives from, and lives with, the land. What earth materials underlie this landscape and how do they influence our use of the land? What nearby mineral resources do we depend on? What earth hazards do we need to accommodate or avoid? Where does our water supply come from? Where does our waste water go? Where does our garbage go? Where does the energy that fuels our lives come from? The answers to these questions illustrate how our landscape sustains our lives.

This guide takes us on a tour of the geological landscape of Kamloops. Many *GeoTour* locations may be familiar to you, but this guide hopes to provide you with new way of looking at the land, with what we might call "landscape eyes".

First, let's talk geology

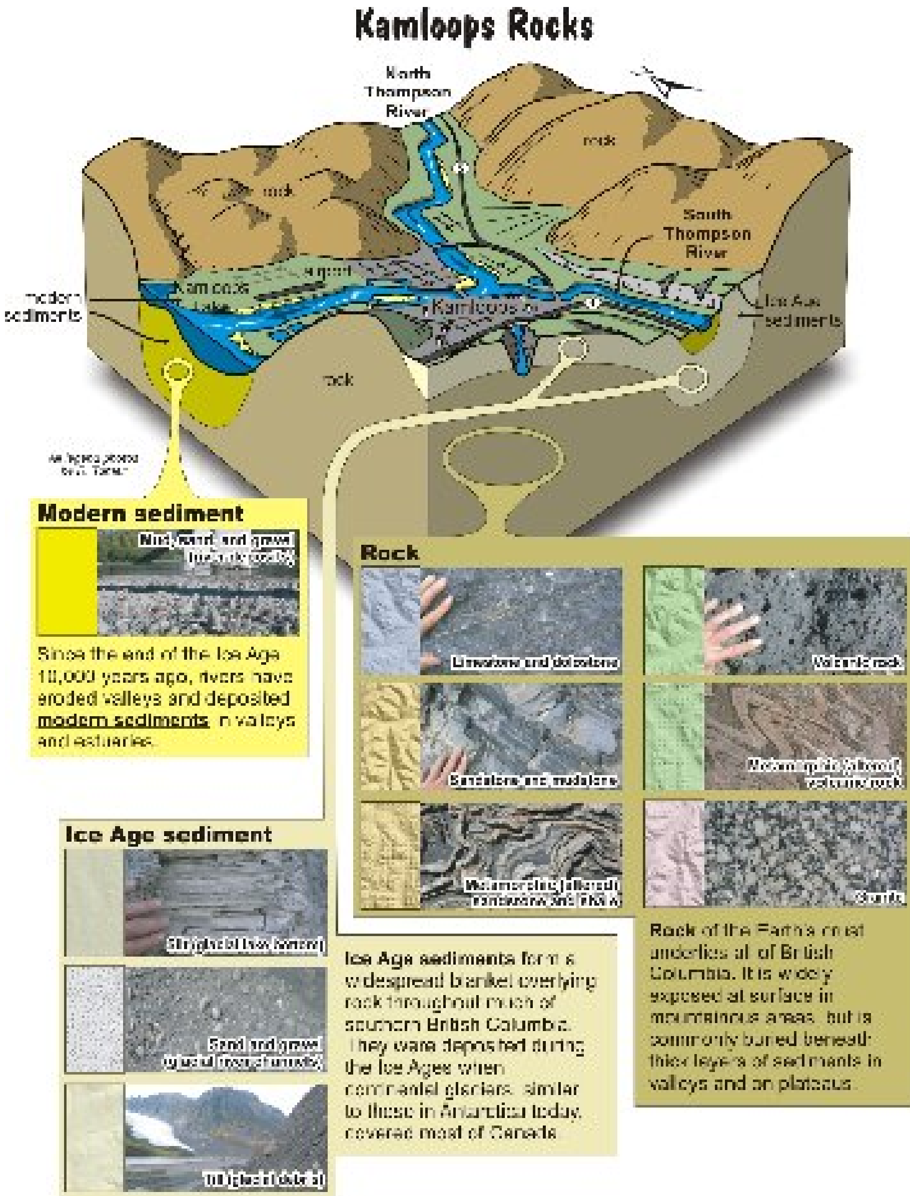


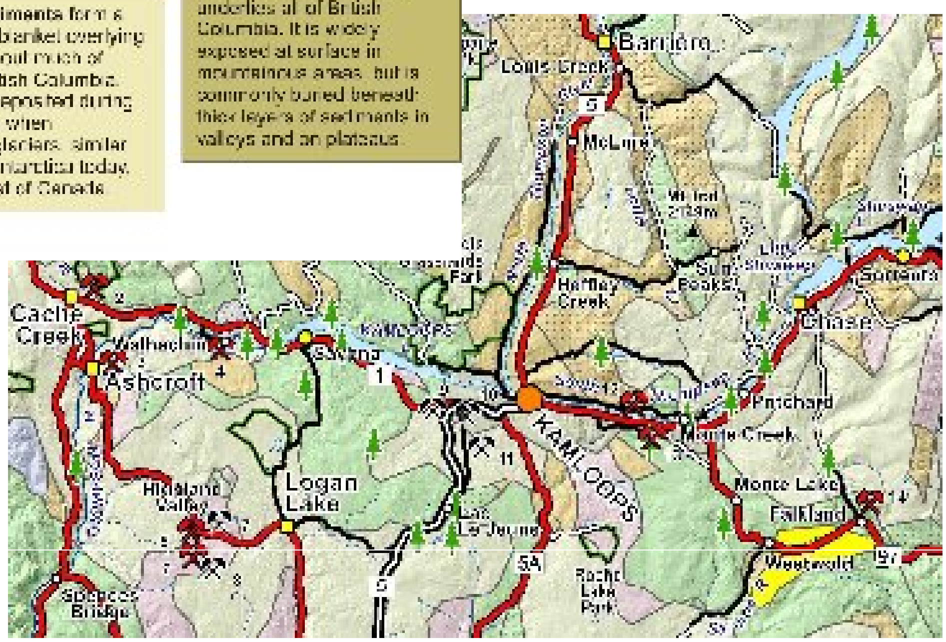
Figure 4. *A geologist's cut-away diagram and legend (to the left) illustrates the distribution of the three main geological materials that comprise the landscape and underground in the Kamloops area. The geological map below shows the broader distribution of these different rocks and sediments.*

Geological Materials – what are they?

The geological materials that underlie British Columbia fall into three basic types. 1) **Rocks** of the Earth's crust underlie the entire province and are commonly exposed at the surface in mountainous areas. 2) **Glacial sediments** deposited during the Ice Ages are widespread and often form a blanket over underlying rock on plateaus and in valleys.
3) In the 10,000 years since the end of the last Ice Age, rivers have eroded Ice Age sediments that filled valleys and deposited sand and gravel as **river plains or deltas**.

Mines displayed on map

__**Active mines** (red crossed hammers)__
1 New Afton (copper-gold)
2 Gravel pits, Barnhartvale Road
3 Z-2 (zeolite - absorbent mineral)
4 Walhachin (basalt rock for rail beds)
5-6 Highland Valley (copper-molybdenum)
12 Harper Ranch (limestone for cement)
13 Buse Lake (alumina-silica for cement)
14 Falkland (gypsum for cement)
__**Former mines** (black crossed hammers)__
7-8 Bethlehem pits, Highland Valley
9-11 Ajax, Afton and Iron Mask (copper-gold)



How did all these geological materials form? A quick tour through geologic time.

How old is Kamloops? Well, European settlement of the Kamloops area goes back to the mid 1800s. However, First Nations settlement in the region is much older and likely goes back several thousand years. But the land itself is much, much, much older. What follows is a brief summary of the geological history that geologists have pieced together for the Kamloops region.

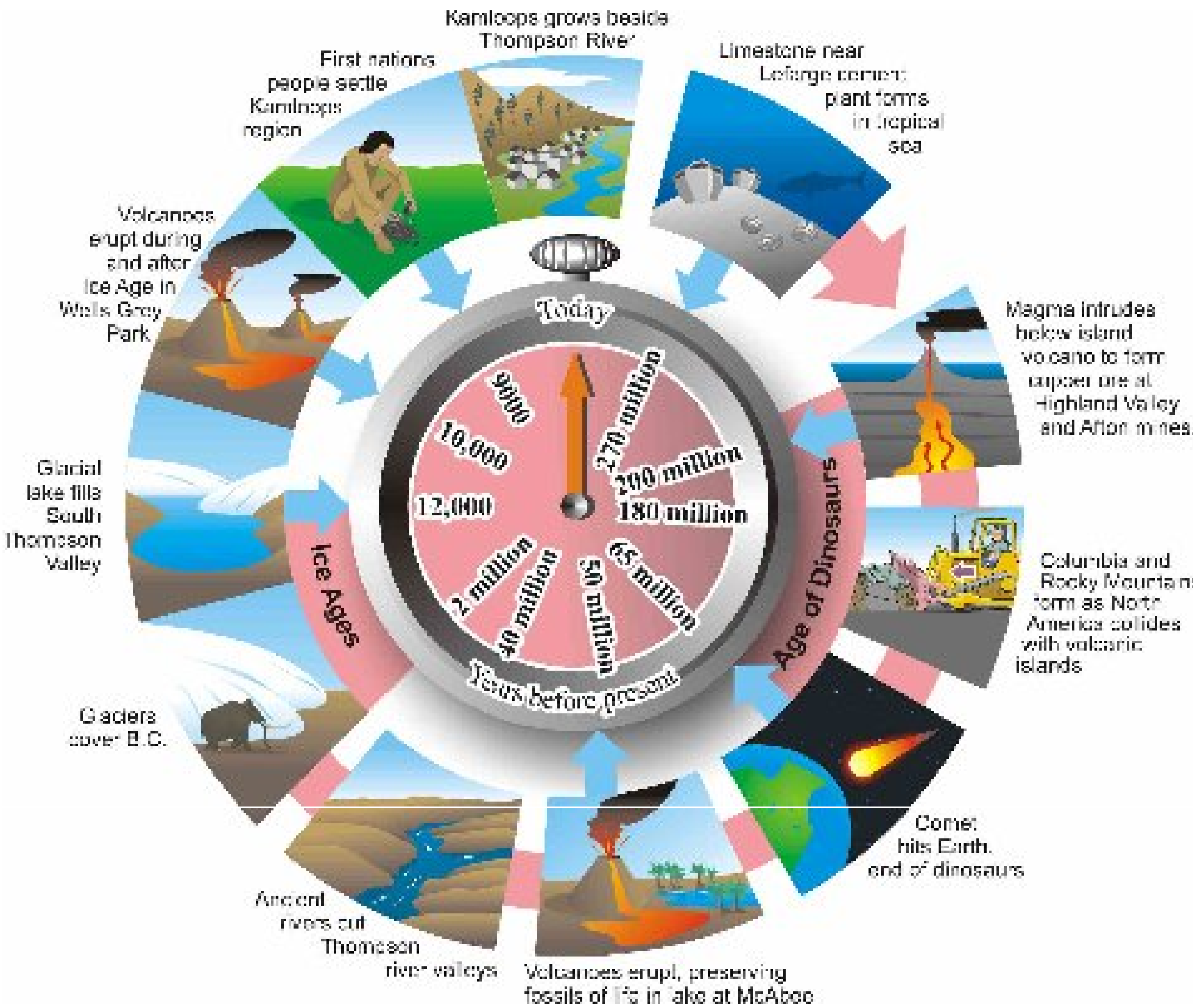


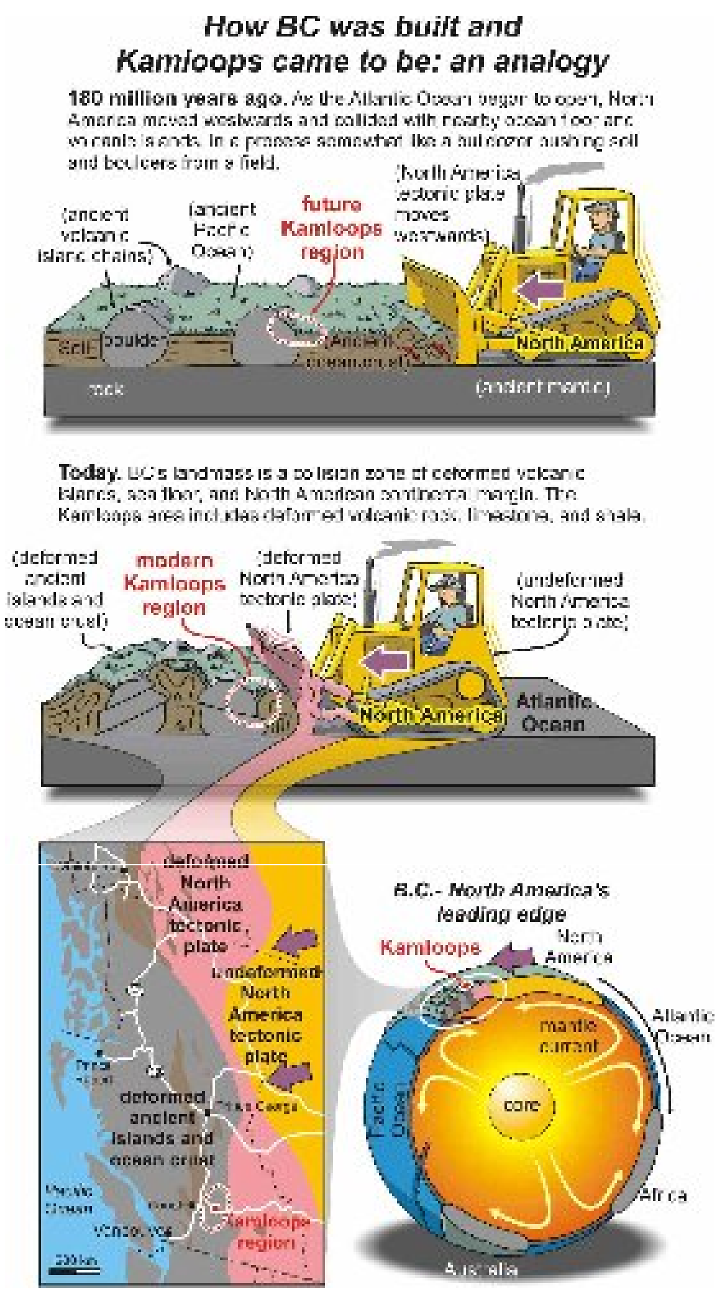
Figure 5*. The geological history of the Kamloops region is presented as a clock. Each ancient geological event is recorded in a geological material and the fossils that it contains. Much ancient history has been destroyed by erosion of the geological materials over geological time, leaving many gaps in the history.*

A book with most pages missing

Imagine the analogy of viewing the Earth as a story book, or more accurately, a library of books. In its many pages are recorded, in rock and fossil, the Earth's history. Each volcanic eruption, each flood deposit, each slow burial of mud and animal and plant remains on the seafloor is another page. Each region on Earth is a separate book, recording the history of that place. However, when geologists try to read the story we find that most of the pages are missing. Only a few pages remain. Why? Erosion is the answer. Erosion is continually removing geological materials and the records they contain. Few geological materials escape erosion. Today, most of British Columbia is eroding, bit by bit, by river scour, glacier grind, rock fall, and land slide. We lose "pages" every year. Geologists work with the remaining scraps of the story to piece together the geological history of a place such as Kamloops.

The Kamloops geological story

The Kamloops area is built on a mosaic of different geological materials, each with a unique age and story. One of the oldest materials is 270 million year old limestone that once was ancient seafloor (**Stop 10)**. Fifty million years later, mudstone and volcanic rock that underlies much of Kamloops today was seafloor mud or volcanic islands in the ancestral Pacific Ocean. During this same period, melted rock rose rose beneath volcanoes to form the copper deposits at Afton and Highland Valley (**Stop 9**). This seafloor and volcanic islands collided with the western edge of North America 180 million years ago (Jurassic age), as the Atlantic Ocean started to open and North America moved westwards against the seafloor and volcanic islands. This collision welded the mudstone and volcanic lavas to North America, adding to its landmass and causing its coastline to jump westwards. The collision caused mountains to rise as the lava and limestone was deformed into folds and broken by faults. For millions of years erosion carved the mountains. Fifty million years ago, volcanoes erupted and blankets of volcanic ash and lava covered the land, forming the plateau country northwest of Kamloops (**Stops 2 and 3**). Forests and lakes filled the lowlands between volcanoes and their record is preserved at the McAbee fossil beds (**Stop 3**). Ancient rivers carved this landscape, forming the modern valleys of the Thompson Rivers. The ice sheets of the Ice Ages further carved these valleys, and rounded the plateau and mountains in the Kamloops region. Volcanoes in the Wells Gray Provincial Park area were active during and after the last Ice Age. As the glaciers melted, lakes formed where glaciers dammed valleys (**Stop 7**). Plants and animals re-colonized the land as the glaciers retreated, and First Nations peoples followed, hunting game, foraging plants, and fishing for salmon. Euro-Canadian settlers came later, first as fur traders and prospectors, and later as farmers and ranchers, building the city that has become Kamloops.



The BIG PICTURE: How British Columbia was built

***Figure 6**. An analogy describes an early part of Kamloops' geological history. Imagine that a tractor, plowing a stoney field represents the British Columbia 180 million years ago. The tractor represents the ancient continent of North America, the soil ahead of the tractor is mudstone and limestone on the ancient ocean floor, and that boulders in the field are ancient volcanic islands. As the tractor moves forward, its blade pushes together soil and boulder, deforming the soil and breaking boulders. But damage is done to the tractor blade too.*

The Earth is 4.5 billion years old but the oldest rocks in the Kamloops region are only 270 million years old. Why is that? Until 270 million years ago, the Kamloops region was part of the ocean floor. The only remnants of that ancient ocean are ancient limestone, mudstone and volcanic rocks that were seafloor and volcanic islands that formed between 270 and 200 million years ago. About 180 million years ago, the Atlantic Ocean started to open by seafloor spreading, causing North America to move westward and collide with adjacent ocean floor and offshore volcanic islands. The resulting collisions welded the ocean floor and volcanic island rock to the western edge of North America, and caused the Columbia and Rocky Mountains to rise as the edge of North America was folded and faulted into a great mountain chain. Since that time, various geological events, from volcanic eruptions to erosion by rivers and glaciers, have continued to change the Kamloops region.

Let's start the GeoTour of Kamloops

There are 16 GeoTour stops in and around Kamloops, as shown on the figure below. The tour starts with a view over of the city (1), and a look at the local volcanic rock and fossils (2and 3). Stops 4 to 6 inspect the Thompson Rivers: their delta in Kamloops Lake (4), their different characters (5), and the hazard of floods (6). Stops 7 and 8 take a look at relicts of the Ice Age: glacial lake silts (7), and glacial deposits and grasslands (8). Stops 9 to 12 profile Earth resources: local giant copper mines (9), limestone quarry and cement plant (10), sand/gravel, concrete, and asphalt (11), and petroleum storage (12). The last 4 stops are municipal facilities for the City of Kamloops that manage our water supply (13), waste water (14), organic solid wastes (15), and solid waste and recycling (16).

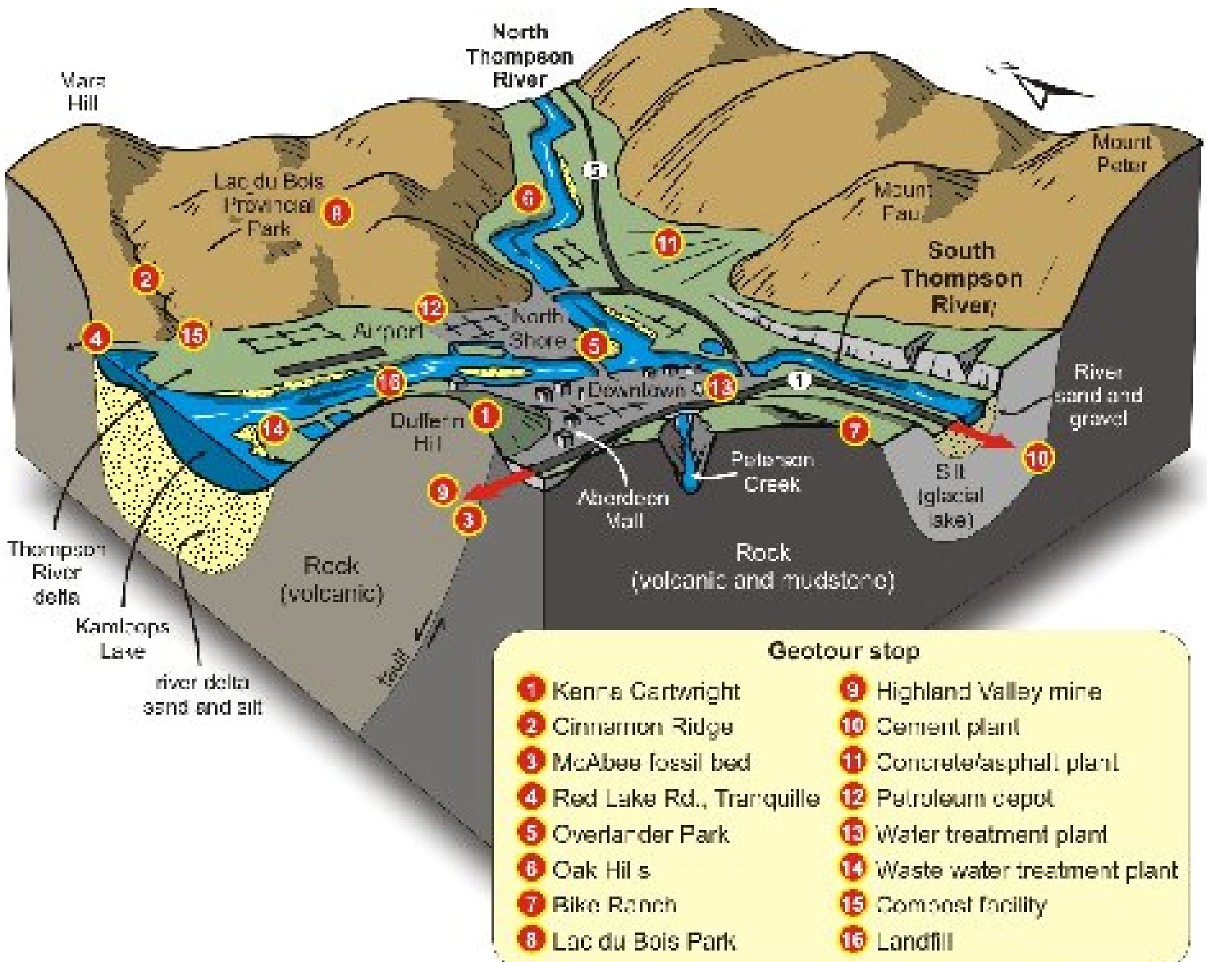


Figure 7. *Stops in the Kamloops GeoTour guide are on a geological cut-away view of Kamloops. Three major types of geological materials underlie the Kamloops Region.* ***Rock*** *is the oldest material and it underlies the entire region and is dominantly volcanic rock and mudstones.* ***Ice Age sediments*** *form a widespread blanket over the plateau, and thick silt benches in the South Thompson River valley. Since the end of the last Ice Age, 10,000 years ago, the Thompson Rivers and their tributaries have eroded through the Ice Age sediments, and deposited* ***modern sediments*** *of sand, gravel, and silt in river plains, deltas, and lakes.*

(Stop 1) Mount Dufferin: the big view of Kamloops

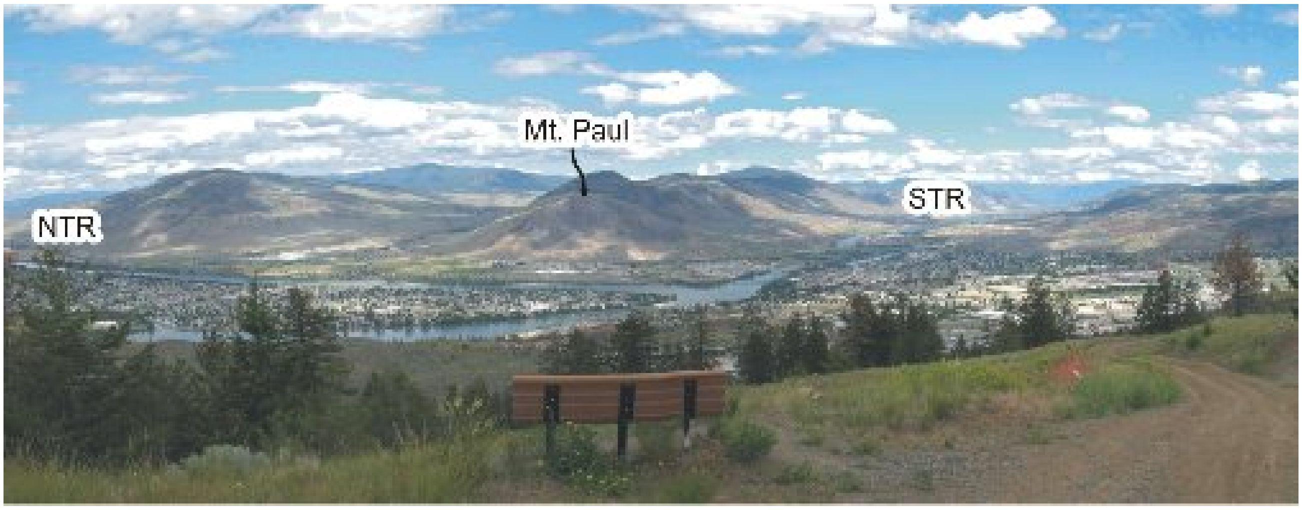
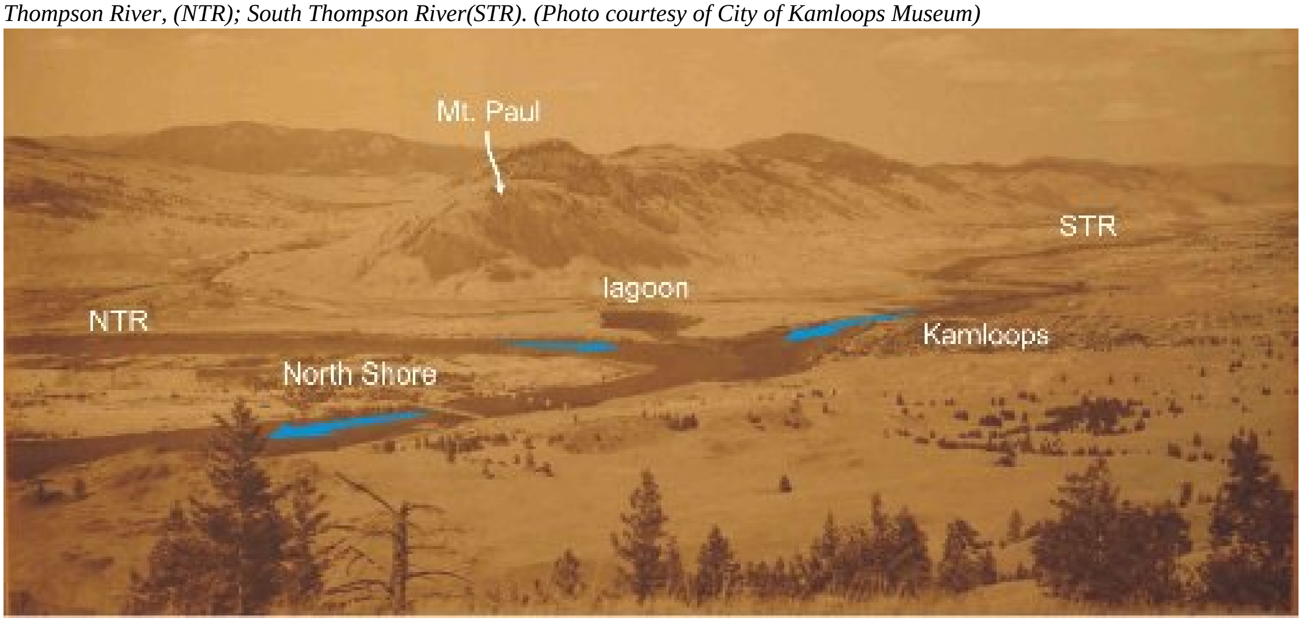


Figure 8*. View from the Highlander viewpoint near the telecommunications towers on Mount Dufferin in Kenna Cartwright Park, looking northeast across the valleys of the Thompson Rivers and the rolling Interior Plateau. Kamloops surrounds the confluence of the North Thompson (NTR) and South Thompson (STR) rivers, and extends from river plain up the valley sides to the plateau. (Photo by R. Turner)*

Highlander viewpoint, Mount Dufferin, Kenna Cartwright Park.

We need to have a look at the city and its setting in our quest to learn how Kamloops lives on its landscape. The view in Kenna Cartwright Park from the Highlander viewpoint on Mount Dufferin provides this big picture. Kamloops lies at the junction of two great valleys. These valleys are flanked by low mountains to the east and plateau to the west. On a clear day, high mountains are visible far to the north in the headwaters of the North Thompson River. Some landscape features that are visible include river meanders, river floodplain, river bar, talus (scree) slopes, and alluvial fan. As you ponder the view, here are some questions to ponder that are addressed later in the guide. What type of rock makes up the local mountains? What areas of Kamloops were settled first? Why? What areas of the city are prone to floods? Where is the water supply for the city? Where does the gravel and sand come from for all the concrete and asphalt required by city development? Where does the city's solid waste and waste water go?

Figure 9. What's changed over time? *Compare this photograph taken the lookout in October 1924 to today's view in Figure 7. North Thompson River, (NTR); South Thompson River(STR). (Photo courtesy of City of Kamloops Museum)*



How would a geographer describe Kamloops?

Kamloops lies at the junction of two major rivers, as do the communities of Prince George, Quesnel, Lytton, and Grand Forks. Kamloops is also built in part on a river delta, similar to Vancouver's suburbs of Richmond and Delta. Kamloops has spread from the shores of the Thompson Rivers up the valley slopes to the plateau to the south, a vertical distance of about 500 metres. This elevation gain may be the greatest of any other Canadian city. Nelson, West Vancouver, and North Vancouver are other contenders for that title. This elevation difference creates tremendous climatic variation within the city limits. Snow lasts about two months longer in the uplands than downtown in the valley. However, inversions during the winter can trap a cold heavy fog in the valley while the uplands can remain bright and warm. It may also be the hottest city in Canada, at least in the valley bottom. Because of that elevation difference, there are three biogeoclimatic zones (bunchgrass, ponderosa pine, and interior Douglas fir) within the city limits. You pass through all three zones on the trail up to the Highlander lookout. This elevation difference also makes water supply expensive – water from the South Thompson River has to be pumped as much as 500 metres uphill to reach all parts of the city.

Climate Change impacts: dying forests and spreading grasslands
Climate scientists predict that grasslands in southern BC will expand farther north and to higher elevations as our climate warms and summer temperatures rise. Pest infestation and forest fires are two of the mechanisms by which this change will take place. Extensive areas of dead pine forests due to mountain pine beetle infestation are visible from the lookout. Drought-tolerant grasslands better suited to the changing climate may permanently replace these forests.

How to get to Kenna Cartwright Park. Drive west from downtown on Highway 1. Exit on to Copperhead Drive (Exit 366). Turn left on Hillside Drive; Kenna Cartwright Park entrance is about 200 metres to the west. From the parking lot, take the Tower Trail up Mount Dufferin to the lookout near the telecommunication towers. It is a pleasant half hour climb up through grasslands (south-facing slopes), Ponderosa pine parklands (higher south facing slopes), and Douglas fir forests (in the valley and north-facing slopes) – note that topography controls vegetation.
Alternate stop: City of Kamloops Scenic Lookout, Columbia Street. The City of Kamloops scenic lookout on the Columbia Street also provides an excellent view of the Kamloops landscape. The access road the overlook is on the north side of Columbia, just uphill from the junction of Columbia and Grandview Terrace.

(Stop 2) Cinnamon Ridge: a canyon walk through ancient volcanoes

Figure 10. *A view of Cinnamon Ridge from the City of Kamloops Compost Facility. Cinnamon Ridge protrudes into the Thompson River valley just west of the airport. The weathering of volcanic rocks releases iron that has stained the rock a cinnamon brown colour, giving the ridge its name. The GeoTour hike follows the canyon that cuts into the ridge on the right side of the photograph. The flat-lying volcanic layers are the eroded remains of an ancient volcano that erupted 50 million years ago. (Photo by R. Turner)*

Kamloops is volcano country! Or, to be more accurate, it is ancient volcano country. The Coquihalla Highway (Highway 5) from Kamloops to Merritt cuts through green-grey volcanic rocks that are about 200 million year old. Dufferin Hill (**Stop 1**), Cinnamon Ridge (this stop), and the plateau to the northwest and west to Cache Creek, including the area of the McAbee fossil beds, are all volcanic rocks that erupted about 50 million years ago. Wells Gray Provincial Park to the north protects some remarkable volcanoes that formed during the last several million years and that may erupt again.

Figure 11. *(left) View looking south, down the canyon in Cinnamon Ridge. Pillars of volcanic rock (hoodoos) have been eroded by the stream as it cut the canyon. In the background are flat agricultural lands of the Thompson River delta, and the Thompson River. (Photo by R. Turner)*

The most interesting place to look at volcanic rocks in the immediate Kamloops area is just west of the airport. A variety of interesting volcanic features are exposed on the slopes of Cinnamon Ridge and one of its canyons. The narrow slot-like character of the canyon and hoodoo spires that rise above the canyon are fascinating features of the hike.

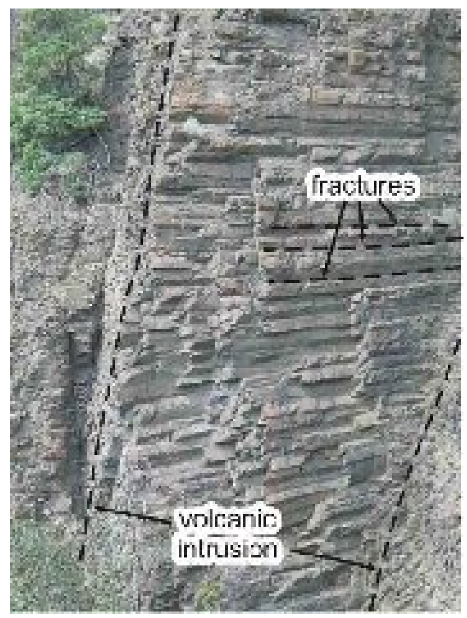


Figure 12. *(Left) The stream has cut a deep and narrow canyon in the soft volcanic rock. The canyon walls expose a volcanic rock composed of rock fragments. (Above, right) Curious fractures that create column-like shapes in volcanic rock formed by the cooling and contraction of the molten lava. The molten lava intruded along a steep fracture in the ancient volcano, then cooled to form volcanic rock.*
(Above, left) Close up of fragmental volcanic rock exposed in canyon walls. The rock formed by explosive volcanic eruptions of rock fragments and ash 50 million years ago. (Photos by R. Turner)

<u>How to get to Cinnamon Ridge</u>. Drive west on Tranquille Rd. past the airport for about 2.5 km. Turn right onto Ord Rd. and cross the railway tracks. (Please drive slowly after this point; the road is dusty and there are houses close to it.) Staying left, follow Ord Rd. to the end. Park somewhere along the loop at the end of the road. GPS co-ordinates 50.7188717, -120.4735067, on the north side of the loop, mark the trailhead. At the trail junction stay left to go to the canyon; the right trail climbs the ridge with wonderful views of the valley and Cinnamon Ridge. At the canyon mouth, the trail starts to climb up the ridge to the east; look for an opportunity to drop down to the dry canyon floor (beware of flash floods!) The canyon narrows as you approach the hoodoos. Beyond the hoodoos there are places where you can climb out of the canyon for a view back across the valley and the delta of the Thompson River.

(Stop 3) McAbee Fossil Beds – Let's meet some older Kamloops area residents

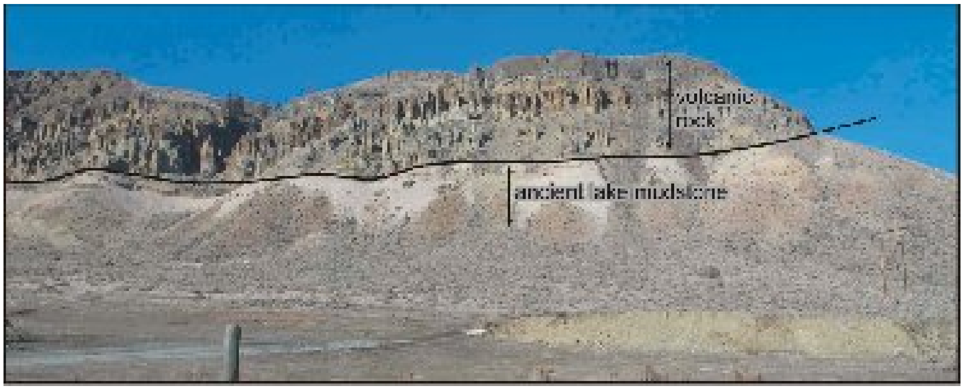


***Figure 13**. The view of the McAbee fossil beds from the TransCanada Highway. The cliffs at McAbee expose an upper layer of volcanic rock above a pale grey layer of mudstone that contains the fossil beds. Geologists interpret the mudstone layer to have formed on the floor of an ancient lake. The overlying volcanic rock layer is eroded into pinnacles or hoodoos, similar to Cinnamon Ridge. Above the cliffs but hidden from view is a slope that rises to the top of the plateau. This slope exposes many layers of volcanic rock that are similar to those at Cinnamon Ridge (**Stop 2**). The Thompson River has cut a valley into the plateau and through these volcanic rocks to expose the buried lake layer and its fossils. (Photo by R. Turner)*

***Figure 14**. (Right) Layers of white volcanic ash and brown fossil-bearing mudstone form the McAbee fossil beds. The brown layers break into paper-like layers. The surfaces of these layers contain an abundance of fossil life. (Photo by R. Turner). (Below) A 50 million year old fish fossil (right) and leaves (left) contained in mudstone from the McAbee fossil beds. Fossil photos courtesy of Dave Langevin and http://dll-fossils.com*

Who are the oldest residents of Kamloops? Geologists would say fossilized remains of ocean plankton, 270 million years old, preserved in limestones east of Kamloops deserve that title (see **Stop 10**). But those fossils are so tiny they are hard to recognize. However other ancient residents, found at the McAbee fossil beds east of Kamloops, are easier to get to know. Fossils of fish, plant leaves, insects, flowers and even birds tell tales of an ancient and rich community of life. These fossils are found in mudstone layers 50 million years old that geologists interpret to be formed in an ancient lake amid erupting volcanoes! Many volcanic ash beds are interlayered with the fossil-bearing mudstone layers. Special conditions in the ancient lake preserved these fossils in remarkable abundance; scientists believe the absence of oxygen in the water at the bottom of the lake prevented scavenging animals from eating the plant and animal remains, allowing them to become fossils after burial. The lake was finally overwhelmed by eruptions of volcanic ash and rock fragments that now form the cliffs above the McAbee shale beds. By reviewing all the fossil evidence, paleontologists interpret that the ancient lake was surrounded by a forest of deciduous and conifer trees similar to those found today in the eastern United States.

Figure 15. *Layers of dark mudstone and white volcanic ash in the McAbee fossil beds overlook a broad panorama of the Thompson River valley and adjacent highlands and plateaux. (Photo by R. Turner)*

How to get to the McAbee fossil beds. The fossil beds are privately operated (*http://dll-fossils.com)*. Tours are available daily in July and August. During the shoulder seasons of May-June and September-October tours need to be arranged in advance. The fossil beds are on the TransCanada Highway 65 km west of Kamloops or 13 km east of Cache Creek. Driving west, look for a sign on the north side of the highway 5 km east of Juniper Beach Provincial Park.

(Stop 4) Red Lake Road and Tranquille: a view of the growing delta of the Thompson River and shrinking Kamloops Lake

Are you ready to test your imagination? Geologists interpret that at one time, several thousand years ago, the city centre of modern Kamloops sat on the shores of a larger Kamloops Lake. However, the North Thompson River acts as a great conveyor belt carrying sand and silt. Over the years the river continued to dump its load of sediment at its delta where it flowed into Kamloops Lake. Year after year, the lake shoreline moved westwards as the eastern end of the lake filled. This process continues today, with the delta front migrating westwards about 13 metres each year. Geologists estimate that if the modern rate of advance continues, Kamloops Lake will fill completely in 4000 years. Kamloops Lake will become Kamloops valley!

The legacy of this westward advance is a flat delta plain that extends from Kamloops to Kamloops Lake. The land is flat because the sand and silt are deposited in the channel of the Thompson River or on the adjacent plain during spring floods. During these floods, the delta plain is inundated with a slow-moving lake of muddy water that leaves behind a layer of sand and silt (just ask anyone who has had their house flooded). This sand and silt is rich agricultural soil and much of the delta is farmland.

The drive up Red Lake Road past Tranquille to a roadside pullout at **Stop 4a** offers panoramic view of Kamloops Lake and the Thompson River delta. The access road and walk along the Lake Trail at Tranquille (**Stop 4b**) provides close up views of the delta lands, sand bars, and wetlands of the Thompson River delta. It also provides a look at the much smaller gravel delta of the Tranquille River.

***Figure 16**. A winter time view of the mouth of the Thompson River where it enters Kamloops Lake, from the Red Lake Road near **Stop 4a**. This is the delta of the Thompson River, built of sand and mud deposited by the Thompson River as its waters slow upon entering Kamloops Lake. Features in the photograph are described from left to right: a cliff of volcanic rock; flat agricultural lands, forests, and wetlands on the delta plain of the Thompson River; broad sand bars exposed in the channel of the Thompson River during the low water conditions typical of the winter period; forests and sewage lagoons (**Stop 14**) on the delta plain south of the river; and the gullied southern slopes of the Thompson River valley. (Photo by R. Turner)*

***Figure 17**. A view to the south and west across the Thompson River delta and estuary from the Cinnamon Ridge trail at **Stop 2**. The delta plain is the flat top of a thick sequence of sand and silt deposited into Kamloops Lake by the Thompson River. The estuary is rich wetland habitat for wildlife and fish where river waters mix with lake waters. The City of Kamloops compost facility (**Stop 15**) is the dark brown rectangle in the lower right. (Photo by R. Turner)*

***Figure 18**. A view from the end of Tranquille Road of pasture and river-side shrubs on the flat delta plain adjacent to the mouth of the Thompson River (**Stop 4b**). The access lane to the parking lot for the Lake Walk provides excellent views of the delta plain and shorelines of the Thompson River. Extensive sand bars are exposed during the winter when river and lake levels are low. (Photo by R. Turner)*

Figure 19. *A view of the mouth of the Tranquille River, Kamloops Lake, and Battle Bluff (right shoreline) (**Stop 4b**). The gravel has been carried by the Tranquille River to the lake shore where it forms a delta that protrudes into the lake. Upstream, the Tranquille River flows across extensive areas of volcanic rock and therefore much of the gravel is of volcanic origin. Look for sponge-like volcanic pebbles with holes that were gas bubbles trapped as the lava as it cooled to rock. Other volcanic pebbles are a distinctive brick red, coloured by the release of iron by weathering to form rust. Photo by E.Frey.*

Getting to Red Lake Road viewpoint (Stop 4a) and Tranquille Lake Trail (Stop 4b): Head west from Kamloops airport on Tranquille Road. Turn right onto Red Lake Road (Tranquille-Criss Creek Road). Follow the road across the train tracks, over Tranquille Creek bridge, and up the side of the valley. Half way up the grade is a pullout (**Stop 4a**) on the left with a commanding view to the east of the delta of the Thompson River and Kamloops Lake. Retrace your route to Tranquille Road. Turn right and drive to the end of the road. Follow the lane and sign "Lake Trail" to the parking lot on the lake shore (**Stop 4b**). A trail descends to the lake shore. Follow the shore upstream (to the east) to the sandy shores of the Thompson River delta. Follow the shore downstream to the west to the gravel beaches of the Tranquille River delta.

(Stop 5) Overlander Park and Thompson River: a tale of two rivers

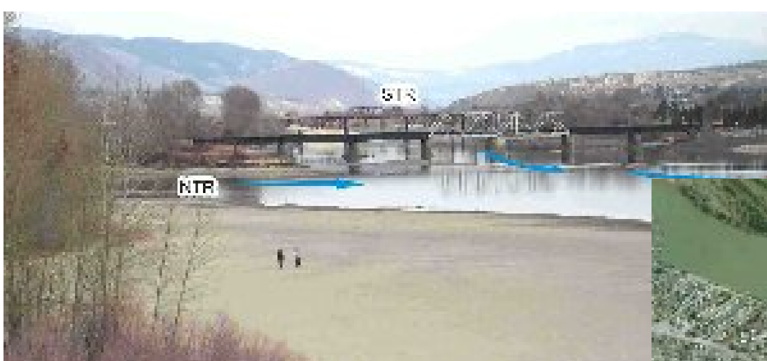


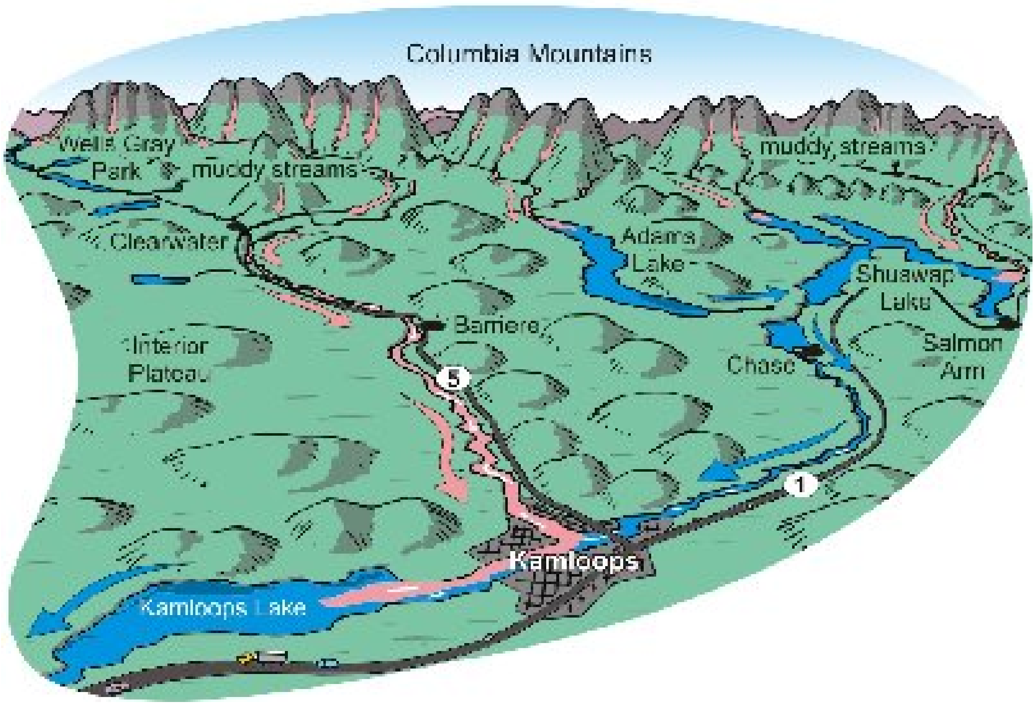
***Figure 20**. (left) View of sand and gravel bar at Overlander Park from Overlander Bridge, looking east (upstream) at the junction of the North Thompson (NTR) and South Thompson (STR) rivers which form the Thompson River (right). (Photo by R. Turner)*

Figure 21. *A satellite image of the confluence of the silty grey North Thompson River (upper left) and clear blue-green South Thompson River (right) to form the Thompson River (lower left). The Overlander Park sand and gravel bar is visible at the confluence. Photo courtesy of Google Earth.*

Overlander Park is located on the north side of the Overlander Bridge. The park borders a broad sand and gravel bar that is exposed during autumn and winter periods of low water on the Thompson Rivers. This bar is a great place to see the confluence of the two rivers, and to take a look at the sand and gravel that these rivers are moving downstream. Rivers are conveyor belts, moving silt, sand, and gravel eroded from upstream lands. The final resting place of the sand and gravel is the floor of Kamloops Lake (see **Stop 4**). Some fine clay floats through Kamloops Lake and flows into the Thompson River west of Savona, to continue its downstream journey to the Pacific Ocean at Richmond.

The two major tributaries of the Thompson River, the North and South Thompson rivers, meet at Kamloops. But in spite of their similar names, they are very different rivers! From spring to early fall, the North Thompson River is a cold grey opaque colour, while the South Thompson is an inviting and warmer clear blue-green colour. What's going on? As a geographer would tell you – look upstream in each river basin for clues.

Tale of two rivers: how lakes filter one but not the other



Tracing the North and South Thompson Rivers back to their headwaters reveals that both rivers drain the rugged Columbia Mountains and its many glaciers. Streams that flow from these glaciers are very muddy because they carry a load of glacial silt (finely ground rock). Both the North and South Thompson drainages flow through many large lakes. In this way, both river systems are similar. However, the lakes of the North Thompson River occur only in the Wells Gray Park area, drained by the Clearwater River. Note the name "Clearwater River". Rivers that flow into lakes enter a giant settling pond – mud and silt carried along by energetic river flow settles in the still water to the lake bottom. However, a large part of the North Thompson River does not flow through large lakes and therefore it carries the mud and silt eroded from mountain glaciers all the way to Kamloops Lake. In contrast, the headwater streams of the South Thompson River all flow into the giant Shuswap Lake system, filtering their waters. The South Thompson River flows out of Shuswap Lake as clear and warm as the Shuswap lakes. The only way for mud to get into the South Thompson River is through tributaries that enter the river downstream from Shuswap Lake. Chase Creek is one such stream and floods on Chase Creek can occasionally create muddy water in the South Thompson River. Such turbidity is important to Kamloops because the City draws its domestic water from the South Thompson River, and for many years turbidity created problems for water treatment (see **Stop 13**).

Figure 22. *A schematic view of the drainage basins of the North and South Thompson rivers. Muddy glacial waters are shown in pink, while clear lake and river water is shown in blue.*

Getting to Overlander Park: Cross the Overlander Bridge to the North Shore from the Victoria Street and the City Centre. Turn right on Fort Avenue and then again on Schubert Drive. At the end of Schubert, turn right on Beach Avenue and then left on Kitchener Crescent. There is a parking lot at the park. Cross to the River Walk trail along the dyke above the river bank. Look for stairs to the sand and gravel beach and bar below.

(Stop 6) Oak Hills on the North Thompson River: living with floods

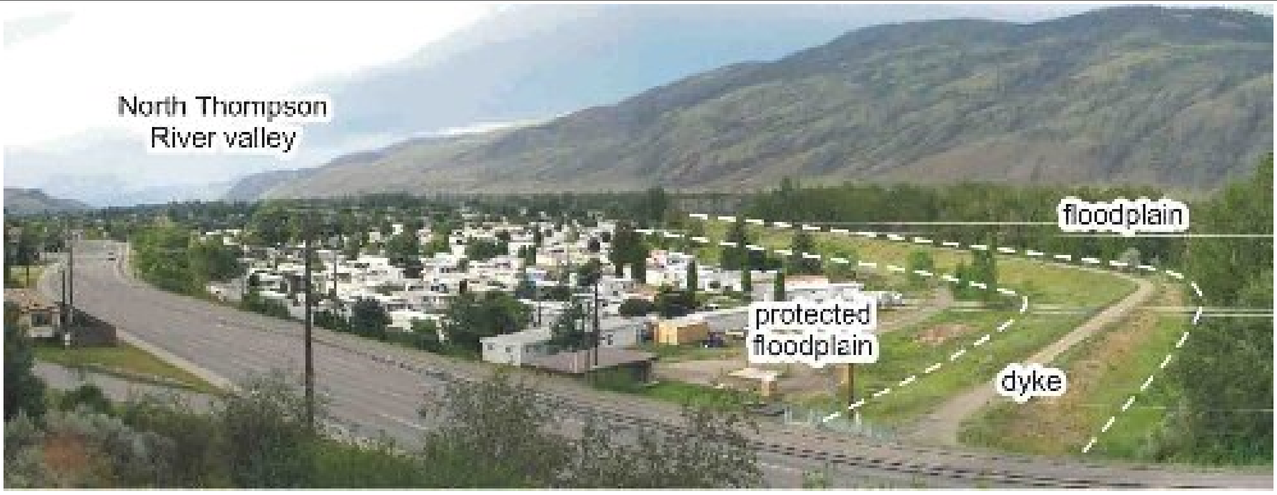
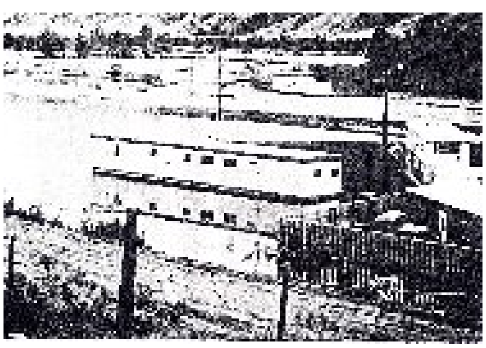


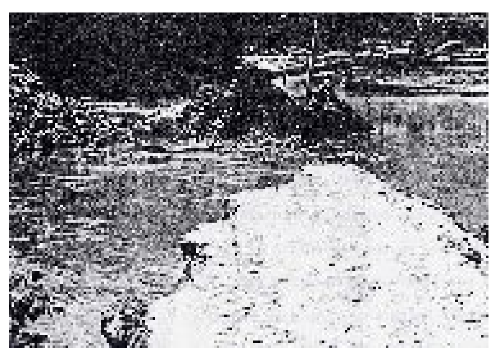
Figure 23. *A view looking to the northeast across the Oak Hills neighbourhood, its protective dyke, and the forested floodplain of the North Thompson River from Westsyde Road in northern Kamloops. A gravel road follows the top of the dyke. Beyond the dyke are trees along the shore of the North Thompson River. (Photo by R.Turner)*

Living with floods.

Important parts of Kamloops are built on plains of the Thompson rivers. Prior to European settlement, these plains were flooded every several years by the rivers during peak spring flows as the mountain snows melted. In 1894, a great flood inundated these plains, damaging many homesteads and barns. Following this and subsequent floods, ridges of earth and rock (dykes) were built to protect homes and barns from flood waters. In 1972, a major flood breached the dykes that protected the Oak Hills subdivision, causing extensive damage.A monument in Riverside Park, near downtown Kamloops, indicates the height of four major historic floods (Figure 23). As a result of the 1972 flood disaster on the North Thompson and other British Columbia rivers, the Province embarked on a program to map the flood plains of many rivers throughout the province. This work led to the construction of a number of major dykes built to protect lands from large floods. The Oak Hills subdivision in northern Kamloops lies behind one such major dyke.

Figure 24. (Left) *Oak Hills subdivision during the flood of 1972.* ***(Right)*** *Breached dyke at the Oak Hills subdivision during the flood of 1972. Photos courtesy of R. Buchanan and B. Gerath.*





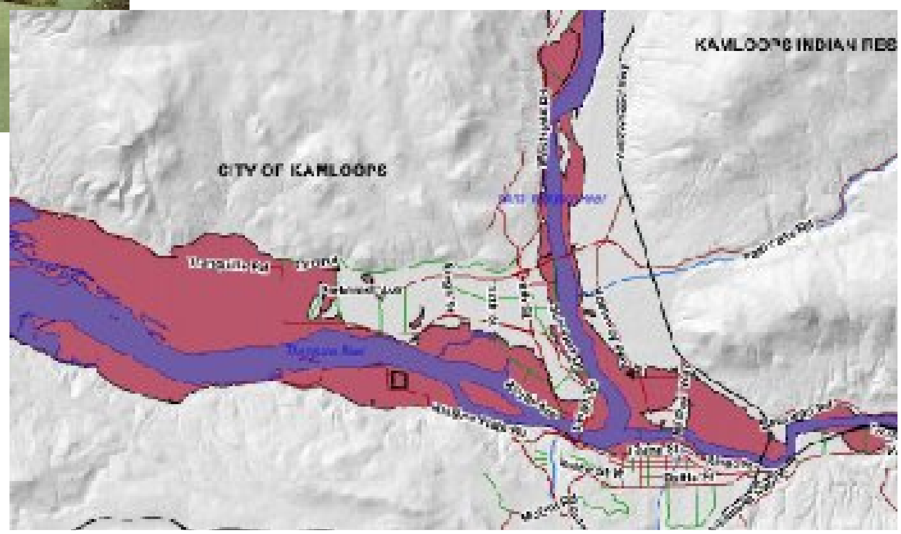
<u>How to get to Oak Hills</u>. From the North Shore, drive north on 8th and then Westsyde Road to Franklin Road. Turn right and drive to the parking lot of Westsyde Centennial Park. Climb up the grassy slope to the trail that follows the top of the dyke for about two kilometres. The dyke separates the banks of the North Thompson River from the Oak Hills subdivision. The dyke is a BC Ministry of the Environment "standard dyke", built to protect against a 200 year flood.

__Figure 25.__ A monument in Riverside Park beside Kamloops city centre to the major historic floods in Kamloops. Marks on the monument identify the height of each floods. From top to bottom they are: 1894, 1972, 1948, and 1999. (Photo by E. Frey)

What is the recipe for a really big flood?

Floods on big rivers like the Thompson always occur in the spring during the annual snowmelt. The biggest floods require the rare combination of a heavy snow pack (>130% of normal), a cool spring that delays the melting of the snow, and the onset of at least two weeks of hot weather that melts the snow quickly, that is then followed by heavy rains.

__Figure 26.__ (Below) Map of floodplains (pink) and rivers (purple) within the City of Kamloops. (http://www.kamloops.ca/maps/floodplaininfo.shtml)



How good are Kamloops' dykes?

The dykes along the North, South, and Thompson Rivers vary significantly in their ability to protect land from flooding. Dykes have been built for more than a hundred years - by individuals, local groups, and the Province - all at different standards. Many dykes were built during flood emergencies in great haste to protect property. The dykes that offer the greatest protection are referred to by the BC Ministry of the Environment as "standard dykes" and built to withstand a 200 year flood.The Oak Hills dyke is a standard dyke. Many of Kamloops dykes are high enough to protect against a 1 in 50 year flood. Some dykes are smaller. The ability of a dyke to hold back flood waters depends in part on how well it is maintained. Good dyke maintenance involves removing trees and other vegetation from dykes, and protecting dykes from burrowing animals. However, maintenance of the dykes by the dyking authority can be complicated the dyke is on private property and the land owners oppose the tree cutting.

__Figure 27__. The integrity of this dyke on the North Shore along the Thompson River may be compromised by the trees that grow on it. Trees can weaken a dyke; when tree roots die, they leave behind small tunnels that can allow water to flow through the dyke during a flood. Such small water flows can lead to larger failure of the dyke. (Photo by R.Turner)

What about the changing climate and future floods on the Thompson rivers?

Scientists predict warmer winters and summers in the future for Kamloops. Warmer winter temperatures will cause the snow elevation level to climb, decreasing the area of snow pack. This reduces the amount of snow in the mountains and therefore the amount of stored water. This may also lead to more frequent extreme low flows in area creeks and rivers during summer and fall, and possibly reduce flood risk in the spring.

There is some good news. The outlet of Kamloops Lake into the Thompson River at Savona is slowly eroding its channel, causing a slow long-term drop in the levels of Kamloops Lake. This in turn allows the Thompson River upstream of Kamloops Lake to cut downwards. This creates more storage capacity for floodwaters, and slightly reduces the flood risk over time.

(Stop 7) Silt benches of Kamloops Bike Ranch: ancient glacial lake deposits create modern development challenges

White to pale grey silt bluffs are a striking and distinctive feature of the South Thompson River valley in eastern Kamloops and further east along Highway 1. These bluffs form a striking backdrop to housing and agricultural lands along the South Thompson River. Less obvious is the ancient origin of these silts, and the difficulties they pose to modern development.

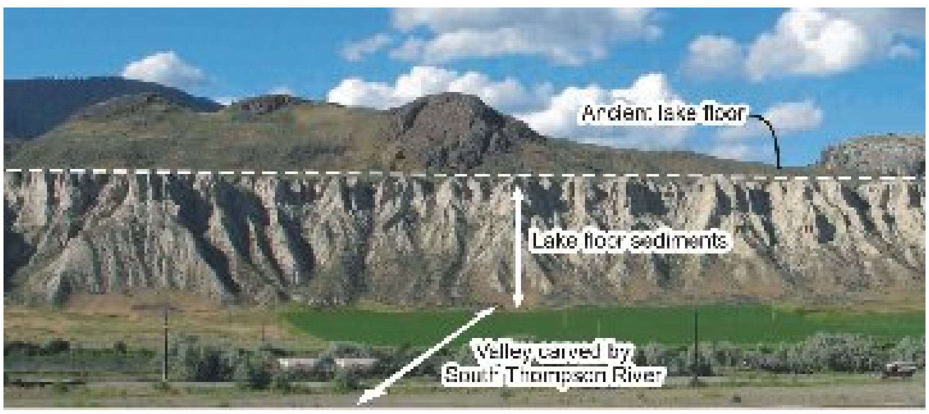


Figure 28. *Highway 1 east of Kamloops provides great views of silt bluffs along the South Thompson River. The river has cut a valley into the silt benches, exposing the silt bluffs. The silt benches are the floor of an ancient glacial lake. (Photo by R.Turner)*

Figure 29. *A view of the silt benchlands from the Kamloops Bike Ranch on Highland Avenue. The silt benches are cut by gullies that lead to the Valleyview Arena and Recreation Centre. Sinkholes occur throughout the benchlands.* ***(Right)***

An ancient glacial lake

From the Kamloops Bike Ranch high above Valleyview, you have a sweeping view across the gullied benchlands of the Bike Ranch to the South Thompson River and beyond to the silt bluffs and gullied benchlands north of the river. Prior to the gullies, and the valley cut by the South Thompson River, the benchlands were one continuous valley floor. How did this come to be?

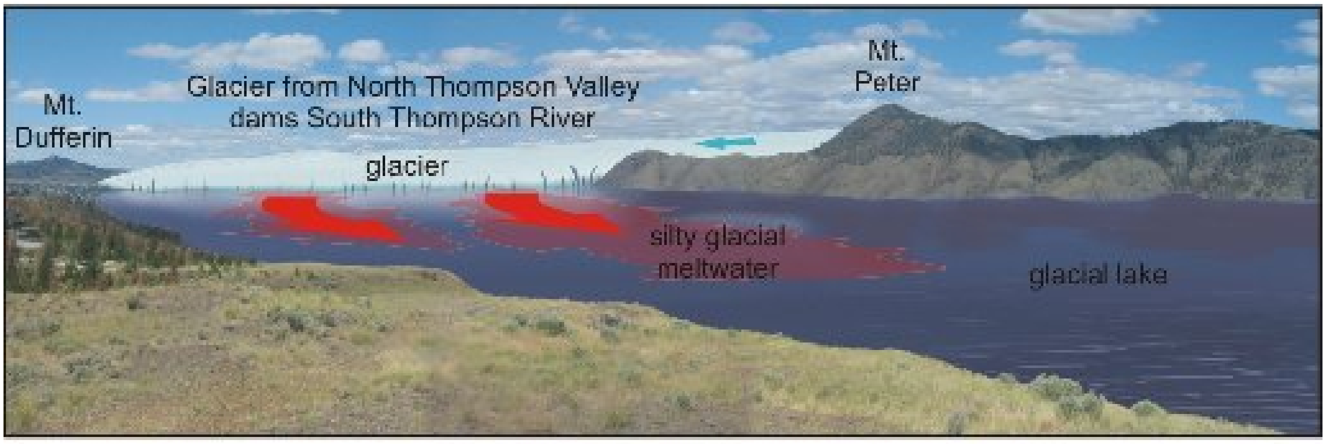
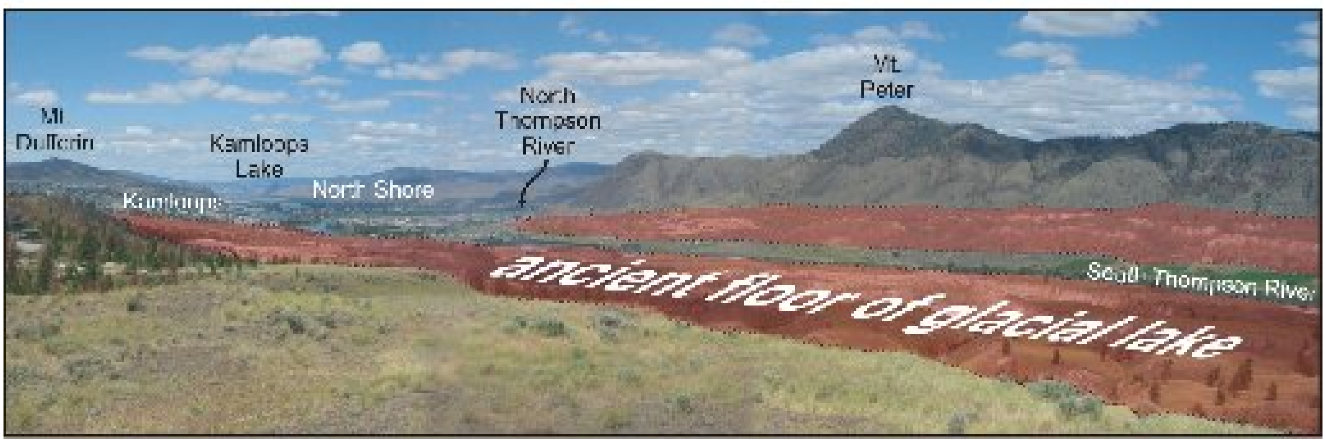


Figure 30. *(Above) An artistic rendering of the glacier and glacial lake that filled the Thompson rivers valleys at the end of the Ice Age. (Below) The benchlands are relicts of the glacial lake floor, divided by the valley cut by the South Thompson River.*



At the end of the Ice Age, the great ice sheet that covered the interior of British Columbia decayed. Large glacial lakes form in the present Thompson rivers valleys, their waters blocked by remaining ice. At one stage, glacier ice filled the North Thompson and Thompson valleys, and waters were temporarily dammed in the South Thompson valley, forming a glacial lake. Silt-rich glacial melt water flowed into the lake. The silt, derived from glacier grinding of rock, settled to the lake floor and over time tens of metres of sediment accumulated. Eventually, glacier retreat released the lake waters, and the South Thompson River re-established. The river cut a valley through the soft silt, leaving the old lake floor high and dry, as benchlands of silt. Over time, small streams cut gullies into the benchlands.


Earth Opening Beneath Kamloops Homes


V'VIEW POOL WORTHLESS WHOLE 'PLEX MAY BE NEXT

Figure 31. *Articles in Kamloops Sentinel, February 1976 (Left) and Victoria Colonist, July 31, 1978 (Right).*

"Red-zone" limited development area.

From the Bike Ranch viewpoint, the flat tops of the benches and the floors of the wider gullies appear to be ideal building sites for homes and buildings. The City of Kamloops built a swimming pool complex in one of the big gullies during the mid 1970s. But soon after construction, things started to go wrong. The building foundation shifted; the pool cracked and leaked. Engineers determined that the foundations had settled into small caves and tunnels within the underlying silt. Further study found numerous "sinkholes" elsewhere in the benchlands where the surface had collapsed into underground caves. Several years later, a sinkhole appeared suddenly in silt benchlands and threatened houses at Barnhartvale in easternmost Kamloops. Based on these experiences, the City of Kamloops designated the silt benchlands within the city as a special "red zone" for construction, and now strictly limits the use of these lands for development.

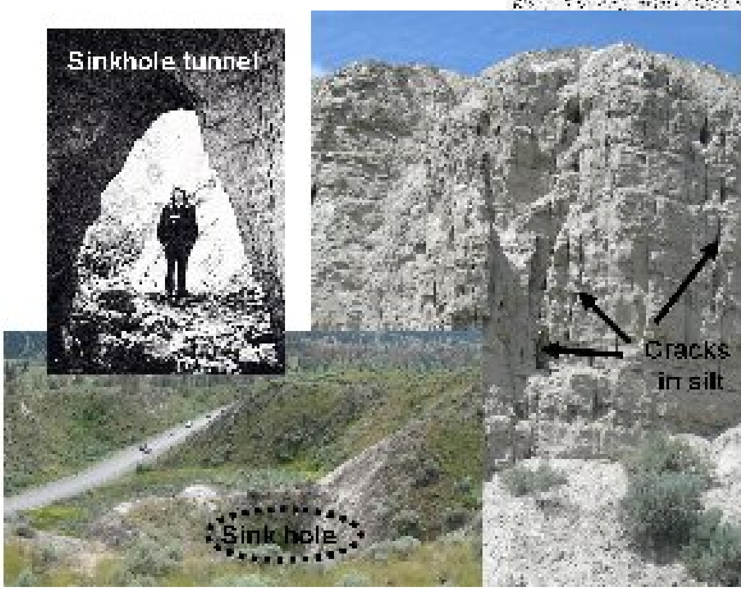
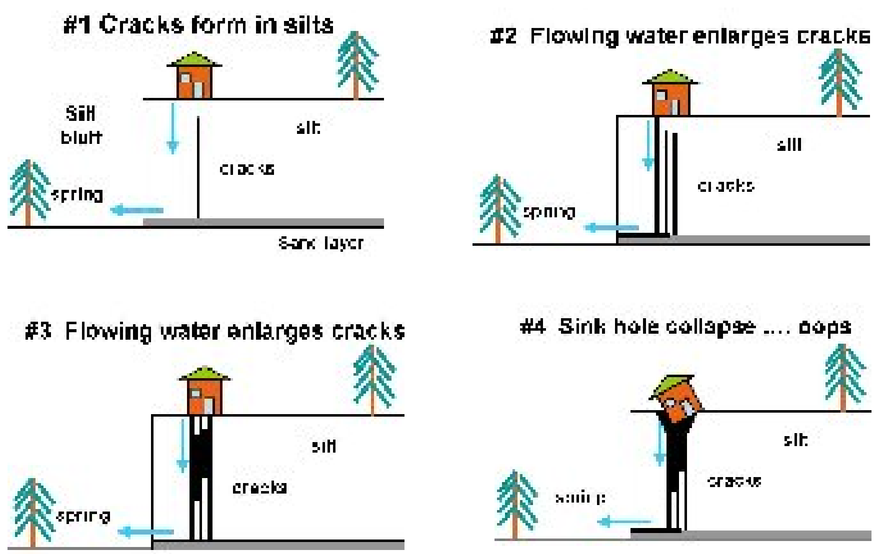


Figure 32. *(Upper left) A "sinkhole tunnel"or cave in silts that connects to a sinkhole. The photo is taken from inside the cave looking out. (Photo courtesy of R. Buchanan and B. Gerath). (Upper right) Cracks in a silt bluff are the pathways for water. (Photo by R.Turner) Over time, the flowing water will enlarge the cracks into caves, causing the surface above to collapse into a sink hole. (Middle left) A sink hole on a silt bluff along Highland Road near Valleyview. (Photo by R.Turner). (Below) How a sink hole forms.*

How a sinkhole forms



Working within nature's rules

Every community has to work with its unique local geology and geography which include natural assets and liabilities. Understanding these rules of nature and working with them, not against them, is essential to good land use planning. But learning nature's rules can be costly. For example, the river plains were some of the first lands settled in Kamloops. Then the giant flood of 1894 reminded us that floodplains will flood (see **Stop 6**). Later on, development extended onto the silt benches, only to discover that these lands are prone to sink holes that can damage a building. More recently, volcanic clay soils on some slopes in the Aberdeen area have shifted and damaged some homes. Learning how the land works is an ongoing and sometimes surprising process, and requires the expertise and advice of geologists, geotechnical engineers, environmental technicians, geographers, and others. As historian Will Durant noted "Civilization exists by geological consent, subject to change without notice."

How to get to the Kamloops Bike Ranch. Drive east on Highway 1 from the City Centre to Highland Road in Valleyview. Turn right (south). Highland Road rises through the benchlands along a gully. Pass the turnoff to the Valleyview arena (originally the Valleyview pool until the foundation settled and caused the pool leaked). Highland Road rises above the benchlands to Juniper Park at Qu'appelle Boulevard. Park at Juniper Park and walk north along the Quick Draw bike trail to a grassy bench with a panoramic view of the South Thompson River valley.

(Stop 8) Lac du Bois Grasslands Protected Area: grasslands on glacial debris

The legacy of the Ice Age is much more than ancient glacial lake sediments in the Thompson Valley. During the peak of the Ice Age, one to two kilometres of glacier ice flowed across the Kamloops area. When the glaciers melted, they left behind extensive blankets of stoney silt and sand debris that geologists call glacial till. The treeless Lac du Bois grasslands are an excellent place to view the shape and character of glacial debris landscapes. Lac du Bois Road snakes its way through a rolling landscape of small hills. Occasionally the road cuts into these hills exposing the underlying material to be a tan coloured mixture of silt, sand, and stones. This is glacial till. You will also see boulders scattered throughout the grasslands and these are part of the till deposits. The area is just a lumpy landscape of rocky debris left by the glaciers.

***Figure 33**. Lac du Bois Road winds across a rolling upland covered with small hills. These hills are piles of debris left behind by melting glaciers at the end of the last Ice Age. The view is looking south towards the valley of the Thompson River. (Photo by R.Turner)*

***Figure 34.** A small "kettle" lake surrounded by wetland lies in a hollow created thousands of years ago when an ice block from a decaying glacier was buried in glacial rock debris. When the ice melted, the rock debris collapsed to form a hollow. (Photo by R.Turner)*

Figure 35. *Hummocky landscapes along* the Lac du Bois Road. *(Photo by R.Turner)*

How to get to Lac du Bois Grasslands Protected Area. Drive north on Highway 5 from Kamloops to Halston Connector Road. Drive west across the Halston Bridge over the North Thompson River and turn north on Westsyde Road. Turn left onto Batchelor Drive and continue uphill to the end of the paved road. Follow the main gravel road which is Lac du Bois Road. Stop 8 is the entire road route from Batchelor Road to Lac du Bois. It is a great bike trip.

(Stop 9) Highland Valley copper mine: world class geological giant, billion dollar bonanza, and environmental challenge

Nearby to Kamloops is the largest copper mine in Canada, the Highland Valley mine. It is a giant among mines! In 2006 its copper production of 161,000 tonnes was 4% of the world copper production. Copper is an essential material widely used in wire, electronics, plumbing, coins and many other uses. The mine is also a major producer of molybdenum, an important alloy in steel making, aircraft parts, and motors. The mine is just west of Logan Lake, about 45 minutes from Kamloops, and is a major employer in the Kamloops region. Over 900 people from Kamloops, Logan Lake, Ashcroft, and Merritt work at the mine.

Figure 36. *The view looking south of the Highland Valley open pit copper mines from the visitor viewpoint along Highway 97C west of Logan Lake. From right to left, the following features are in the far distance of the photo: the terraced rock wall at the top of the Valley mine pit; the white line of the conveyor belt that moves crushed rock from the pit to the mill; and golden grass slopes that cover reclaimed waste rock dumps upslope of the conveyor. Active waste rock dumps are in the middle distance, to the left of the conveyor. (Photo by R. Anderson)*

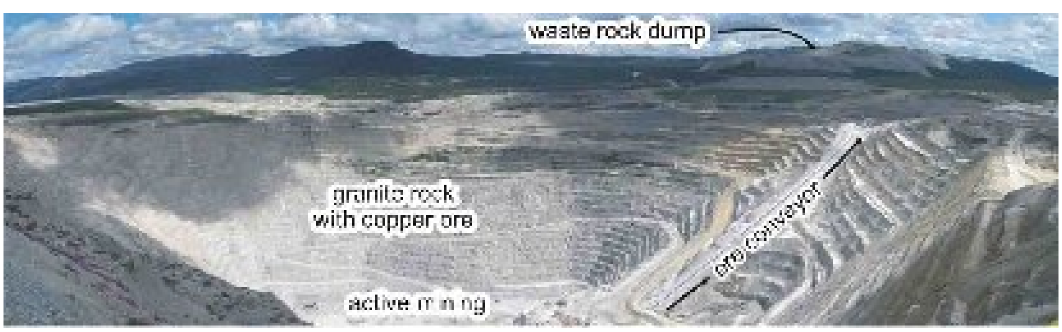


Figure 37 *(Left) The Valley pit at the Highland Valley mine is a giant hole dug to extract rock containing dispersed copper and molybdenum. Metal-bearing rock (ore) is blasted loose, dug by huge shovels, and*

transported by trucks and conveyors to the mill for processing. Waste rock with little or no copper is hauled up the steep roads to waste rock dumps.

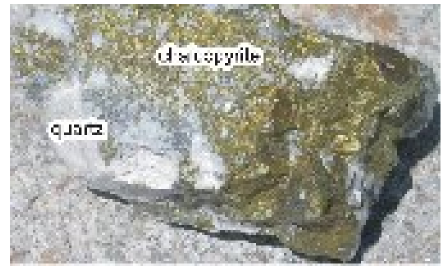
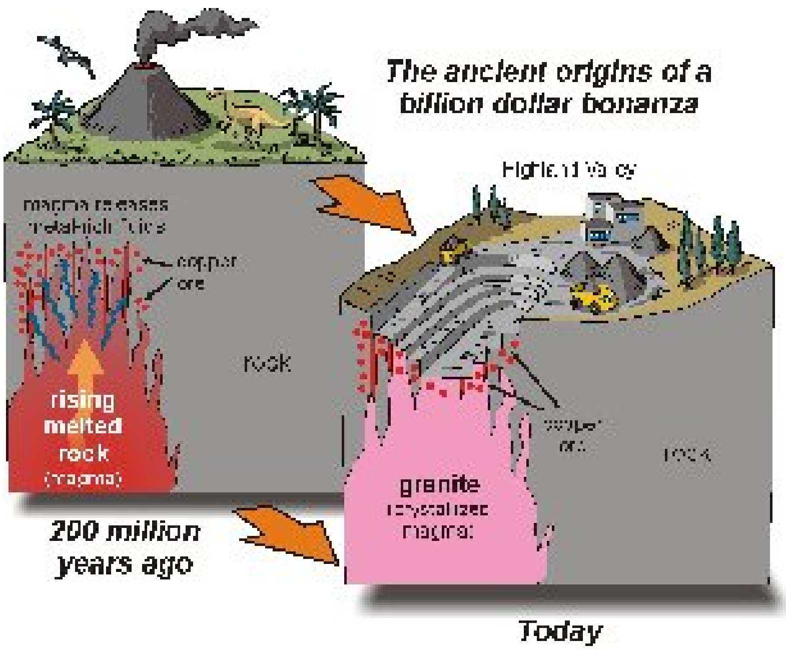


Figure 38. *(Right) A rich sample of copper ore containing the brassy mineral chalcopyrite (copper-iron-sulphur) and white quartz. (Photos by R.Turner)*

How did this giant deposit of copper form?

The Highland Valley mine extracts copper and molybdenum contained in granite. Geologically similar mines include the New Afton mine just west of Kamloops, Gibraltar mine near Williams Lake, Endako mine west of Prince George, and the former Copper Mountain mine at Princeton. The copper ores formed 200 million years ago when the mine rock was several kilometres deep in the earth. At that time, liquid rock (magma) was crystallizing into the minerals of granite. As the rock crystallized, copper and molybdenum were concentrated in a fluid that entered cracks in the cooling granite, where the metals precipitated in scattered grains or veins with quartz and other minerals.

Figure 39. *The origin of the Highland Valley mine.*



An orebody is an unusual concentration of a metal or other economic mineral. Typically an element like copper occurs in trace amounts in most rocks, perhaps 10-50 parts per million. To form a copper orebody, Nature must increase the concentration of copper hundreds to thousands of times. In the case of Highland Valley orebody, the copper contained in tens of cubic kilometres of magma was concentrated into a metal-rich liquid and deposited in a much smaller volume of rock.

Big tonnages but low grade. The Highland Valley orebodies are large tonnage but low grade copper deposits that require large scale mining to be economic. Their average copper content is only about 0.4% copper, that is, one tonne of ore contains about four kilograms of copper metal. To be successful, such mining operations have to be very large, efficient and mechanized. What is "economic" rock (ore) today may not be tomorrow, depending on the world price of copper. In 1999, the mine shut down for a short period when the price of copper dropped to $0.55 (US) per pound. Beginning in 2004, very high copper prices of $2.00 to over $3.00 per pound made the mine very profitable.

Figure 40. ***(Left)*** *Conveyor belts carry football size blocks of ore from the pit to stockpiles (centre) at the mill (lower left), ready for processing. (Photo by R. Anderson)*

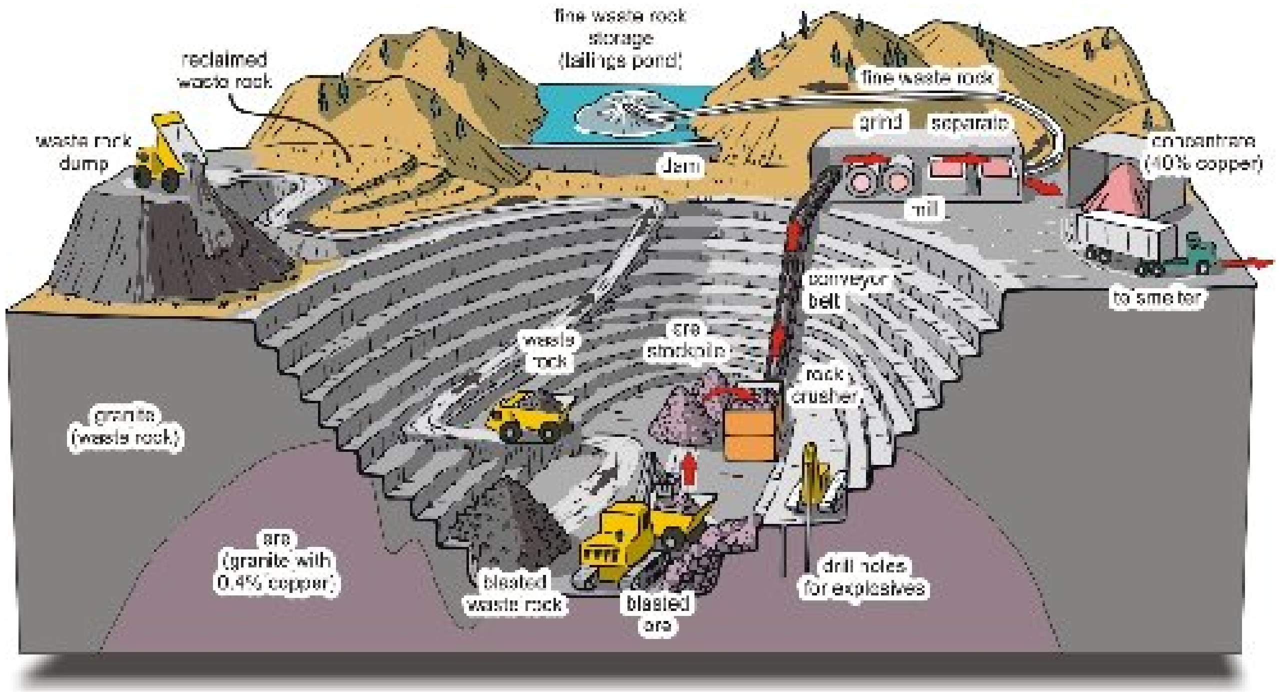


Figure 41. *The Highland Valley mine includes a series of operations that include mining from an open pit, processing the ore in the mill, storing the waste materials in tailings ponds and waste rock dumps, and reclaiming the waste rock areas and other disturbed areas with soil cover and vegetation.*

The mining process Rock is blasted from the mine pits and hauled by truck to a rock crusher in the bottom of the pit. There the rock fragments are broken to the size of a football and carried by a conveyor belt to the mill. In the mill the rock is ground to mud, freeing the individual grains of copper and molybdenum from rock. This rock mud is mixed with a soapy detergent that clings to metals. Metal-rich “suds”, one copper-rich and the other molybdenum-rich, are separated, dried, and trucked to Ashcroft and loaded on trains. The dried metal concentrate is sent to smelters in eastern Canada, Asia, and Europe where it is turned into pure copper and molybdenum metal. A slurry of waste rock mud from the mill is pumped by pipeline to a storage reservoir (tailings pond).

Figure 42. (Left) *Large cylindrical mills grind the ore from football size blocks to silt.* ***(Right)*** *Flotation tanks in the mill*

separate a detergent "suds" rich in metal particles from other fine rock particles. Sand and mud are pumped as a slurry by pipe to a storage reservoir. (Photo by R.Turner)

Figure 43. *The tailings pond for the Highland Valley mine contains white rock mud, the waste product of the milling process. The water in the pond has an aqua blue colour due to reflection of sunlight from the white lake floor (swimming pools are painted white to create this same beautiful blue colour). When mining has ended, the tailings pond will be drained of water, and its surface covered with soil and planted with grasses to transform it into pasture or meadows for cattle or deer. (Photo by R.Turner)*

Environmental management and reclamation

Highland Valley Copper is implementing a reclamation plan so that when mining is over, the site is left in a safe and productive state, as similar in appearance to the surrounding landscape as possible to support local wildlife and ranching. To date 25% of the disturbed land has been replanted. Old rock dumps and tailings ponds have been covered with a soil layer and replanted with grasses and seedlings. A replanted tailings pond is currently being tested for cattle grazing. Trout have been stocked in another former tailings pond, which even supports a fishing derby!

Figure 44. *A view of the active mining area and surrounding reclaimed mine dumps. The reclaimed mine dumps are golden brown grasslands that have been smoothed, covered with soil, and planted with grasses. The conveyor belt is the white diagonal line and transports ore from the mine pit (lower right) to the mill (centre and hidden behind active rock waste dumps). (Photo by R. Anderson)*

(Stop 10) Lafarge limestone quarry and cement plant, east Kamloops: vital earth resource and greenhouse gas challenge

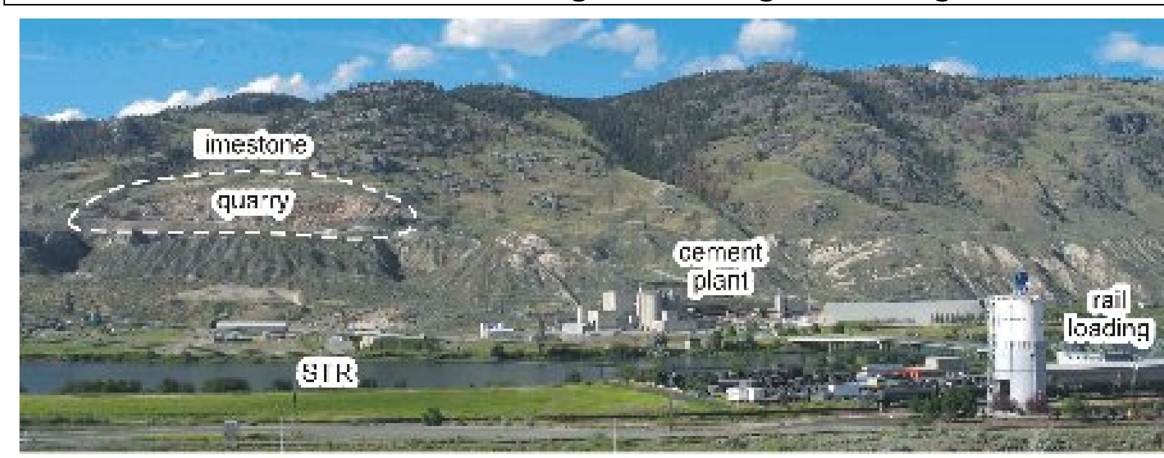


Figure 45. *Lafarge cement plant (centre background) along the South Thompson River east of Kamloops uses limestone mined from*

a nearby open pit (upper left). Cement is loaded on rail cars (lower right) for transport throughout western North America. (Photo by R. Turner)

Concrete is one of the most important building materials worldwide, essential for buildings, bridges, dams, and many roads. Cement is the mineral glue that holds concrete together. A large cement plant is visible from Highway 1 east of Kamloops on the north shore of the South Thompson River. The cement plant mines limestone, the major ingredient of cement, from an adjacent quarry. Cement is manufactured by grinding and heating the limestone, along with clay or shale, iron, and sand in a rotating kiln at temperatures of up to 1500 degrees Celsius. The calcium, aluminum, silicon, and iron combine to form a “clinker” while producing carbon dioxide, a “greenhouse gas”. The clinker is ground-up to form Portland cement, and gypsum is added to regulate the setting time of the cement.

Most of the raw materials used in the Kamloops plant, with the exception of energy, are produced locally. Limestone comes from the quarry behind the cement plant. Alumina-silica rocks are mined at the Buse Lake quarry near Barnhartvale and the Decor quarry near Hat Creek, and gypsum is quarried near Falkland.

Geologists interpret that the hill of limestone behind the cement plant formed on an ancient seafloor 270 million years ago as deposits of lime shells of microscopic marine animals and plants. These plants and animals extracted carbon dioxide dissolved in ocean water to form their shells. As the shells of dead organisms accumulated on the seafloor, the increasing pressure from continued burial slowly converted the shells to limestone rock. Today the limestone represents a vast storehouse of carbon. When limestone is heated to make cement, carbon dioxide, a major greenhouse gas, is released back into the atmosphere. Research continues to look for ways to reduce the carbon dioxide in the exhaust gases of cement production so that it does not return to the atmosphere.

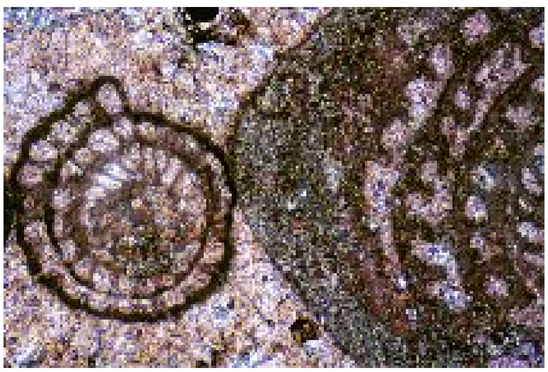


Figure 46. *A tiny fusilinid fossil about the size of a rice grain, as seen through a microscope. Geologists have determined that marine fossils found in the limestone are about 270 million years old and that they lived below a tropical sea. Things sure have changed! (Photo courtesy of C. Kendall)*

Go take a look: Drive east from Kamloops on Highway 1 about 15 km to Campbell Creek. Exit onto Dallas Drive, turn north and cross the highway overpass, rail lines, and bridge over the South Thompson River to the Lafarge cement plant. Tours of the cement plant may be arranged in advance.

(Stop 11) Making concrete and asphalt: mostly local earth materials

Figure 47. *(**Above**) A redi-mix concrete and asphalt plant, and gravel pit along Yellowhead Highway 5 at Paul Lake Road. Sand and gravel deposits are sorted by screening into separate piles of gravel and sand, and used in the production of concrete. (**Below**) Sand,*

gravel, cement, additives, and water stored in the tower are carefully measured and mixed at the concrete redi-mix plant. (Photo by R.Turner)

Try to imagine Kamloops without concrete. There would be no highway overpasses, home basements, building foundations, or roadside curbs. Many tall buildings in the city centre, river bridges, and important parts of Highway 1 through Kamloops would be missing. Now let's imagine Kamloops without asphalt. There would be no sealed or paved roads, highways, or parking lots. Roads would be dusty in summer and muddy in winter.

Hundreds of thousands of tons of concrete and asphalt are made and used each year in the Kamloops area. What might surprise you is that the major ingredient of our asphalt and concrete is sand and gravel from the Kamloops area.

Figure 48. *Sand, gravel, cement, additives, and water stored in the tower are carefully measured and mixed at the concrete redi-mix plant. (Photo by R.Turner)*

Concrete is the most widely used construction material globally. Twice as much concrete is used in construction than all other building materials combined, including wood, steel, plastic and aluminum. Concrete is made by combining water with nine parts sand and gravel and one part cement. Sand and gravel make up the bulk of concrete; cement is the glue that holds it together. To make the cement "glue", limestone, shale, and sand are mixed and ground to a fine powder, and then roasted at high heat. Sand and gravel for Kamloops' concrete is quarried from local gravel pits, while some cement is from local limestone, silica, and gypsum (**Stop 10**).

Asphalt is similar to concrete in that it is made primarily of local rock materials. The Paul Lake Road plant uses crushed rock from a quarry near the Kamloops airport. However, its "glue" is liquid bitumen, a tar-like hydrocarbon related to petroleum and natural gas. The liquid asphalt is brought to Kamloops by truck or rail car from a petroleum refinery in Vancouver.

Where does sand and gravel come from? The answer is ancient rivers. Extensive sand and gravel deposits occur below flat benches within the valleys of the Thompson rivers. Benches are flat because they are former river beds. Gravels also occur below gently sloping "alluvial fans" where side valleys enter the main river valleys, such as at Paul Lake Road. The sand and gravel bars of the North Thompson and Thompson rivers, visible when river levels are low, remind us that rivers form clean gravel and sand deposits by flushing the finer mud downstream to where it settles in the quiet waters of lakes or ocean.

How to get to the concrete and asphalt plant: Drive north from downtown along Highway 5 and turn right on Paul Lake Road. A large sand and gravel pit and concrete and asphalt plant operation is on the north side of the road at the intersection with Chief Louis Road. Pull off on the road shoulder and take a look. There are also several large sand and gravel pits on Barnhartvale Road east of Kamloops.

(Stop 12) Petro-Canada petroleum storage depot: Gasoline and diesel fuels. Where do they come from?

Figure 49. *(Left) Bulk petroleum storage depot on Tranquille Road near the airport. Tanker trucks transport gasoline from the depot to gas stations from Merritt to Williams Lake in the BC Interior. The depot is adjacent to the Trans Mountain Pipeline. (Photo by R.Turner)*

Gasoline, diesel, and natural gas provide vital energy for vehicles, industry, and homes in

Kamloops. These fuels reach Kamloops by pipeline from oil refineries in Alberta and gas plants in northeastern BC, and are part of a broader range of petroleum-based products such as asphalt and plastics. Gasoline and diesel are carried by pipeline from Edmonton to Kamloops and are stored at a petroleum depot near the airport. Various fuel retailers such as Shell, Husky, and Esso mix additives to the gasoline or diesel fuel and then transport thefuel by truck to gas stations throughout the Interior. The route of the natural gas pipeline that connects northeastern BC gas fields to markets in Vancouver passes to the west of Kamloops at Savona. A branch pipeline brings natural gas from Savona to Kamloops.

Figure 50. *(Below) The smoothed and revegetated scar marks the buried route of the Trans Mountain Pipeline up the valley slope north of the petroleum depot and airport. The pipeline transports gasoline and diesel, each in separate batches, over 1000 kilometres from refineries in Edmonton via Kamloops to Vancouver and Washington State. The 60 cm diameter pipeline is owned by Kinder Morgan Ltd. and can transport over to 250,000 barrels of oil per day. (Photo by R.Turner)*

Oil and natural gas come from the Earth. Most natural gas used in British Columbia comes from deep reservoirs beneath northeastern BC. Most oil used in BC comes from rock reservoirs deep buried below Alberta or from the giant deposits of tar sands in northeastern Alberta. Oil and natural gas and coal are referred to as “fossil fuels” because they are derived from ancient (or “fossil”) animals and plants that were buried in the sediments of ancient seafloors and swamps. Deep burial at high temperatures and pressures caused organic matter to release hydrocarbon liquids and gases that flowed through the underground and some of which became trapped in rock reservoirs. Oil and natural gas are extracted from these reservoirs by drilling wells, often to depths of 1000 to 3000 metres below the surface. Oil and natural gas occur in the spaces, millimetres to centimetres in size, within sandstone or limestone layers.

How to get to the Petro-Canada bulk storage depot

The Petro-Canada terminal or petroleum bulk storage depot is on Tranquille Road next to the airport and adjacent to the route of the Trans Mountain Pipeline.

What about climate change?

In spite of the tremendous benefits and convenience of fossil fuels, a clear consensus has developed among climate and atmospheric scientists that the greenhouse gases produced from the use of oil and natural gas and coal are dramatically changing the composition of our atmosphere and contributing to global climate change.

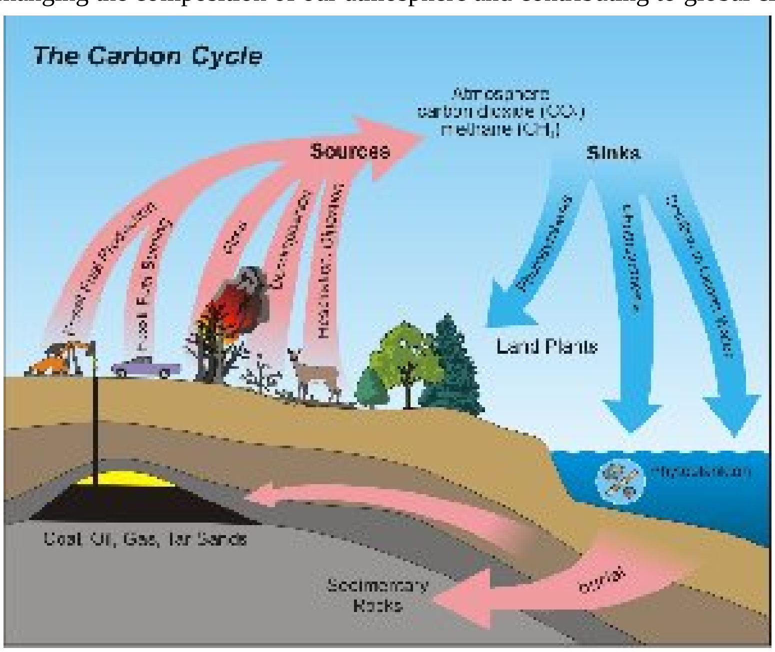


Figure 51. *The production and burning of fossil fuels is rapidly adding carbon to the atmosphere. Fossil fuels represent carbon that once was part of the natural carbon cycle but long ago became stored in the Earth. Releasing this carbon into the Earth’s atmosphere is upsetting the natural balance developed by nature, and allowing the levels of carbon to increase in the atmosphere. Carbon gases such as carbon dioxide and methane are referred to as “greenhouse” gases because of their natural ability to trap heat in the atmosphere. The build-up of these greenhouse gases in the atmosphere is causing surface warming of the planet Earth. Such global warming and climate change has a myriad of consequences, including melting of glaciers and ice caps, sea level rise, and changes in rainfall and storm patterns.*

British Columbia has warmed significantly in the last 100 years and direct evidence of this is seen in the widespread and rapid recession of glaciers in the Columbia and Rocky Mountains to the east and

Coast Mountains to the west. One of the most dramatic impacts of climate change in BC is the spread of the mountain pine beetle infestation. Forests throughout central BC are infected, and the infestation is spreading east into Alberta. Formerly, periods of very cold winter weather held the beetles in check. However, warming winter temperatures have allowed the beetle to thrive. The rapid death of our extensive interior forests is a huge challenge for the forestry industry and the communities that depend on that industry. The financial costs will be very high, likely billions of dollars.

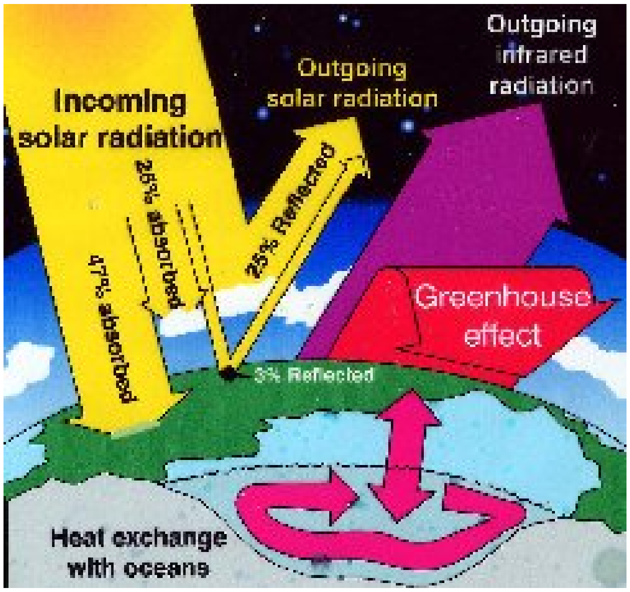


Figure 52. *Nearly one third of incoming sunlight is reflected back into space by clouds and the Earth's surface. The remainder is absorbed by the Earth and its atmosphere. The heat-trapping quality of the atmosphere, the so-called "greenhouse effect", is caused by gases that absorb long-wave radiation emitted by the Earth. We are rapidly increasing this heat-trapping by release of greenhouse gases into the atmosphere.*

Become informed. What are the likely impacts of climate change to British Columbia and the rest of Canada? Visit the Natural Resources Canada website **www.adaptation.nrcan.gc.ca/posters**

Calculate your own green house gas emissions. Do you know how many green house gas emissions you produce each year? Use this Government of Canada calculator to find out and learn how to reduce them. Visit **www.ecoaction.gc.ca/**

What can we do? Lots! Need some ideas? Visit **www.davidsuzuki.org/Climate_Change/What_You_Can_Do/**

(Stop 13) Where does our water come from? The South Thompson River

Water supply is a vital resource to any community. The City of Kamloops draws its water from the clear-flowing South Thompson River. The South Thompson River water is filtered in a state-of-the-art filtration plant just east of city centre. Water use in Kamloops averages 10 to 11 million litres per day, but doubles in the summer to over 20 million litres due to outdoor water uses such as lawn care.

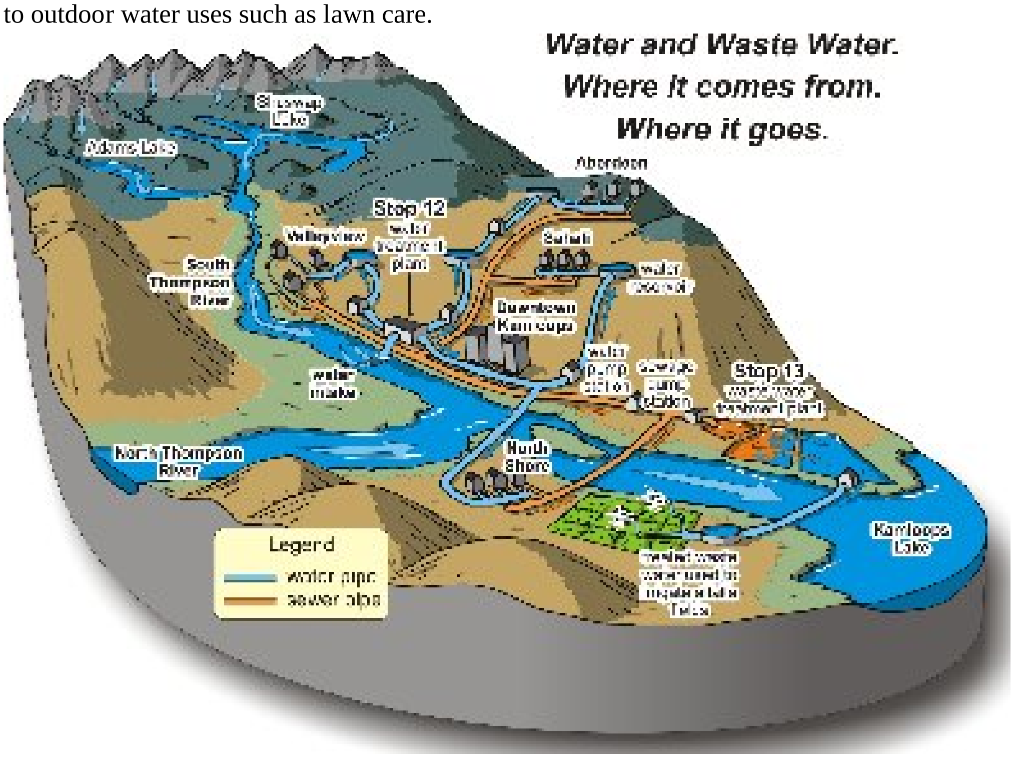


Figure 53. *Kamloops water supply is drawn from the South Thompson River through an intake pipe just upstream of the downtown area. The river is fed by snowmelt and rainfall within its watershed. The water is filtered and pumped by pipe (blue) throughout the city, including areas as much as 500 metres above the river. Waste water from homes and businesses is collected in a network of sewer pipes (orange) that carry waste water to a treatment plant west of the city. Treated water is either returned to the river or used to irrigate hay crops.*

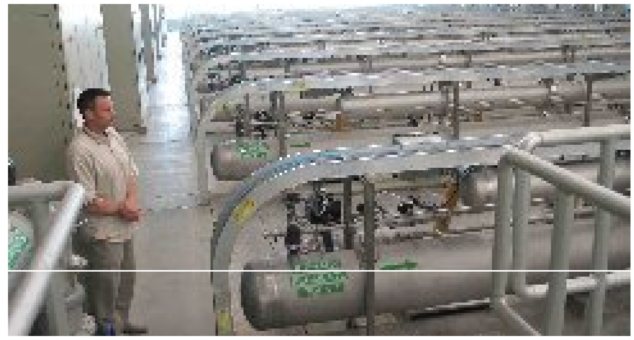


Figure 54. (Left) City of Kamloops Centre for Water Quality, water treatment plant.
***(Right)** Pipes within the treatment plant contain the membrane filtration units. (Photo by R. Turner)*

Why filter the water?

The water treatment plant was built to filter all particles in the South Thompson River water bigger than 4 one hundred millionths of a millimeter, including water-borne disease-causing pathogens such as cryptosporidium and giardia. The source of these pathogens may be the abundant cattle and other livestock in the watershed upstream from Kamloops. Prior to the construction of the filtration plant, the City used only chlorine to remove pathogens. Chlorine is effective at killing pathogens, except when the river waters are muddy, a condition that can occur during spring high water. Prior to construction of the filtration plant, the BC Ministry of Health often needed to issue a Boil Water Order during the spring, alerting residents to boil their drinking water to ensure adequate water safety.

The BC Ministry of Health noted a reduction in gastrointestinal problems such as diarrhea during these Boil Water Orders. This suggested that during normal periods, chlorine was not adequately treating the Kamloops drinking water. To deal with this problem the City had several choices: bring water by pipeline from a cleaner river source that didn't need filtration, (e.g. Clearwater River in Wells Gray Park), draw naturally filtered groundwater from nearby wells, or build a filtration plant. The filtration plant option was selected, and since the plant began service in 2005, the incidence of gastrointestinal diseases in Kamloops residents has dropped.

There is energy in that water

When you turn your hose on next time to water the garden, remember use are using expensive water. It has been filtered, chlorinated, and pumped to where you live. Summer water use in Kamloops jumps as much as 4 times in the summer because of additional outside water use, largely due to watering gardens. And the City pumps water uphill as much as 500 metres to reach the highest homes. This pumping takes a lot of energy. So every time you turn on the tap, you aren't just using water, you are using energy too!

The new way to build: a green building

The filtration plant is an example of a new breed of "green building" that uses less energy and water to operate. Heat from the river water that passes through the plant is used to warm the building during the winter. A garden on the roof cools the building naturally in summer. Gardens of native drought resistant shrubs around the plant need less water during summer drought, and rainwater that falls on the parking lot and roof flows to a wetland that naturally filters pollutants.

How to get to water treatment plant.

City of Kamloops Centre for Water Quality, the water treatment plant, is on River Street east of the downtown near the Charles Anderson stadium. From Victoria Street, turn north on 10th Avenue and right on River Street. Tours must be arranged in advance with the City of Kamloops.

(Stop 14) Where does our waste water go? After treatment, back to the Thompson River

Waste water treatment is a vital part of the municipal "water cycle". When you flush the toilet, where does it go? The answer is the Thompson River. So how does the City manage the waste of 85,000 people and protect the environmental quality of the Thompson River? It's a big challenge!

Figure 55. *View of sewage lagoons at the City of Kamloops waste water treatment plant west of Kamloops along the Thompson River. (Photo by R..Turner)*

How waste water treatment works

Kamloops' waste water treatment relies on an extensive series of ponds or "lagoons" excavated into the river plain of the Thompson River. This lagoon complex is the largest municipal lagoon complex in British Columbia. Waste water takes three to four months to flow through the treatment facility.

As waste water enters the treatment facility, screens remove the large solid objects (it's amazing what people flush down toilets!). In primary lagoons, solids settle and bacteria eat the organic wastes. These lagoons lack oxygen and bacteria here are less efficient. In secondary lagoons, air is bubbled through the water to ensure sufficient oxygen for "efficient" bacteria to live. Most break down of wastes occurs here. Alum (aluminum sulphate) is added to cause fine particles to clump and settle, removing the nutrient phosphorous from the water. The BC Ministry of the Environment closely regulates the amount of phosphorous that the waste water treatment plant releases into the Thompson River. Phosphorous is a plant nutrient, and phosphorous in the river can cause excessive algae growth. This is a widespread problem in agricultural areas across North America, where agricultural fertilizers that contain phosphorous leach into waterways. On the Thompson River, this does not appear to be a problem, mainly because of the limited agriculture within the river's large watershed.

Figure 56. *Bubblers within the secondary treatment lagoon mix oxygen into the wastewater. This oxygen is essential to sustain bacteria that feed on and digest the organic matter, converting organic compounds to non-harmful products. Abundant green algae on the surface and shoreline plants reflect the nutrient-rich nature of the waste water. (Photo by R..Turner)*

Organic solids that accumulate are removed, centrifuged, and sent to the green waste compost facility across the river (**Stop 14**). After composting, they are used on farm fields for growing alfalfa for livestock and municipal parks. The remaining liquids are disinfected with chlorine and then stored. From April to October treated waste water is pumped through pipes under the Thompson River, to farm fields where waste water is sprayed on hay and alfalfa fields. In winter, the waste water is discharged into the Thompson River.

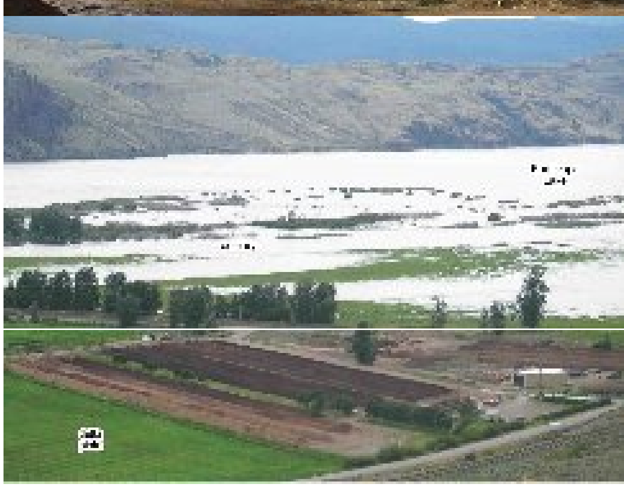
How to get there: The City of Kamloops waste water treatment plant is on Mission Flats Road west of downtown along the Thompson River. The entrance road to the treatment plant is on the right, just before the entrance to the city landfill. Tours must be arranged in advance with the City of Kamloops.

(Stop 15) Where does our yard green waste go?
Cinnamon Ridge composting facility

Figure 57. *Long piles of green waste are composted at the Cinnamon Ridge Compost Facility west of the airport. Cinnamon Ridge, from which the facility takes its name, rises in the background on the north side of the Thompson River valley (**see Stop 2**). (Photo by R..Turner)*

The City of Kamloops operates the Cinnamon Ridge Compost Facility west of the airport on Tranquille Road. Residents can drop off yard wastes such as lawn clippings, leaves and garden wastes, shrub and tree branches up to 15 cm diameter, and even sod and turf. The facility grinds and mixes the greenwaste and piles it in long piles where it composts through natural bacterial activity. To maintain optimal conditions for the bacterial growth and ensure all material composts, machinery is used to add water and turn and mix the wastes. Heat produced by the bacteria as they digest the organic matter raises the temperature inside the piles to about 50 degrees Celsius – almost too hot to touch! Such high temperatures kill pathogens such as viruses. After seven or eight months of composting, the composted material is available for purchase. It is excellent addition to garden soils by providing organic matter, water retention, and nutrients. The City estimates that more than 11,000 tonnes of yard waste was diverted from the City landfill in 2005. Information on the compost facility and home composting can be found on the City of Kamloops website at www.kamloops.ca.

Figure 58. *Green waste is loaded into a grinder at the compost facility. Grinding is essential to the composting process as it increases the surface area that bacteria can colonize and digest. (Photo by R..Turner)*



.

Figure 59. *A view of the Cinnamon Ridge Compost Facility from the trail on Cinnamon Ridge (**Stop 2**). The brown rows are composting organic yard wastes. The facility sits at the growing edge of the Thompson River delta, where the river meets Kamloops Lake (see **Stop 4**). A separate part of the compost facility mixes green yard waste with biosolids from the waste water treatment plant to produce a composted soil for use in City parks. This material is not currently available to the public. The compost facility is part of a larger farm area where treated waste water from the treatment plant across the river is used to irrigate hay and alfalfa crops. (Photo by R..Turner)*

<u>How to get there</u>: The City of Kamloops Cinnamon Ridge composting facility is on Tranquille Road west of the airport.

(Stop 16) Where does our garbage go? To the city landfill (but much gets recycled)

Figure 60. *Garbage is weighed in at the City of Kamloops Mission Flats landfill, and charged accordingly. Prior to drop off, City staff inspect for items that can be reused or recycled. (Photo by R..Turner)*

How well do we manage our solid waste? How effectively do we reuse materials or recycle what we do not reuse? Dealing with garbage is a major task for local governments. Landfills sites are difficult to find, and expensive to operate. The City of Kamloops is trying to divert recyclable material from its landfill as much as possible. It operates a landfill at Mission Flats west of downtown along the Thompson River, and to the east at Barnhartvale. The Mission Flats landfill also handles recycling for glass, paper, cardboard, plastics, and other scrap materials (see the City of Kamloops website for more information; www.kamloops.ca).

Let's follow your load of garbage into the Mission Flats landfill.

The Mission Flats landfill lies on the southern slopes of the Thompson River valley west of the downtown. As you drive in, attendants help you identify things that you can leave at the "Drop and Shop" reuse store, as well as recyclables such as scrap metal, ovens and refrigerators. There is no charge for bringing reuse articles or recycling – but there is a fee for any garbage dropped off. Freon is removed (there is a small fee) from old refrigerators before they are compacted and trucked to the Vancouver area for scrap metal, ultimately to be smelted into new products. If you still have garbage in your vehicles, you weigh in on drive-through scales and then dump your garbage into bins. Vehicles are reweighed on departure, the dumping charge is calculated, and you pay the fee. This garbage is hauled by truck uphill to the landfill where it is dumped, compacted with other garbage and covered with soil. The soil cover material is glacial till (see **Stop 8**) that is dug from the slopes above the landfill. More garbage is piled on top of the soil cover, and covered by additional soil. In this way, the landfill buries garbage in pods encased in layers of soil. Leachate created by rain and snowmelt that percolates through the landfill is captured in pipes below the landfill and piped to the nearby City waste water plant for treatment.

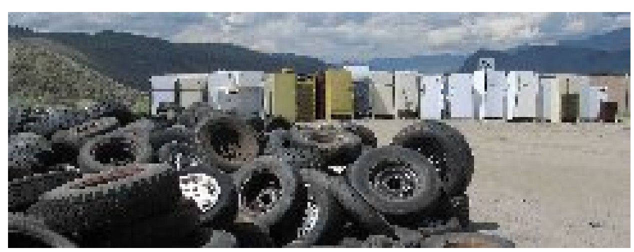


***Figure 61**. (**Above, left**) Items that can be reused are identified at the "Drop and Shop" reuse store as vehicles enter the landfill site. (**Above, right**) Recycled materials such as refrigerators and tires are also removed from loads entering the landfill. (**Left**) Garbage is dumped in the landfill and then compacted by tractor and covered with soil. (Photos by R.Turner)*

Did you know? Mastodon tusks were discovered in 2001 during road construction at the landfill.

Credits

The authors

Bob Turner, Natural Resources Canada, Vancouver
Bob Anderson, Natural Resources Canada, Vancouver
Richard Franklin, Sidney
Mike Cathro, Geological Consultant, Kamloops
Bruce Madu, Ministry of Energy, Mines, and Petroleum Resources, Kamloops
Crystal Huscroft, Department of Geography, Thompson Rivers University, Kamloops
Ken Favrholdt, Department of Geography, Thompson Rivers University, Kamloops
Ed Frey, Department of Physical Sciences-Geology, Thompson Rivers University, Kamloops
Ken Klein, Department of Physical Sciences-Geology, Thompson Rivers University, Kamloops

Thank you to the resource people that provided help
David Teasdale, Mark Bregoliss, Mike Cain, Public Works and Utilities, City of Kamloops
George Piva, City of Kamloops Cinnamon Ridge Compost Facility, Kamloops
Craig Beeson, Ted Fuller BC Ministry of Environment, Kamloops
Katie Burles, Thompson Rivers University, Kamloops
Royanna Wild, Kamloops Exploration Group, Kamloops
Marianne Ceh, Natural Resources Canada, Vancouver
Sheila Stenzel, Mineral Resources Education Program of BC, Vancouver
Dave Langevin, McAbee Fossil Beds, Kamloops
Bruce Magee, Lafarge Canada Ltd., Kamloops
Stephen Demianiuk, Petro-Canada Ltd., Kamloops
Mark Ottem, Kinder Morgan Canada Inc., Kamloops

Thank you to local teachers that provided help
Beth Dye, Logan Lake Secondary, Logan Lake
Aura Carriere, South Kamloops Secondary, Kamloops
Jim Pedersson, Brock Secondary, Kamloops
Brandi Rusk, South Kamloops Secondary, Kamloops
Carla Salituro, Westsyde Secondary, Kamloops
Gerry Bond, South Kamloops Secondary, Kamloops
Dan Trepanier, Kamloops

This guide is available as a free download at City of Kamloops (www.kamloops.ca) and Kamloops Exploration Group (www.keg.bc.ca).