Part A – Least-cost Path Analysis for a Pipeline

In this part, you will carry out various least-cost path analyses, each using slightly different settings. The purpose of the analysis is to determine the optimal path for a new pipeline based on specific criteria.

We have a particularly good example to work with at the present time. The Trans Mountain Expansion (TMX) project is intended to ship oil from Edmonton, Alberta to Trans Mountain's terminal in Burnaby, BC for export overseas (https://en.wikipedia.org/wiki/Trans_Mountain_Pipeline). Trans Mountain Pipeline ULC has applied to the National Energy Board to "twin" the existing pipeline (https://apps.neb-one.gc.ca/REGDOCS/Item/View/548311), and their application has been granted. The TMX project is quite controversial and involves many stakeholders. Both the risks and rewards are very high, so this project will likely be in the news for many years to come.

In this exercise, we will plan a section of the route for the pipeline expansion. Although the route has been decided already (largely parallel to the existing pipeline), we can explore some alternatives for the routing of the pipeline based on the terrain, rivers, roads, and railways in the area. This is exactly the sort of planning that the consultants for the TMX project would have performed to establish the preferred route.

We will perform this analysis along a 41 km section of the pipeline between the towns of McMurphy and Clearwater, BC, passing through Vavenby on the route. In terms of the pipeline planning, the route will extend from KP663 (kilometre post 663) to KP715 of the planned route. The route follows the North Thompson River, and must also be planned around the Yellowhead Highway (BC Highway 5) and the Canadian National Railway, both of which run in the river valley.

Start a new map document and add the following data from Lab3\parta\TMX.gdb to a data frame:

- Elevation – a DEM of the study area
- Rivers – a vector version of all major rivers (North Thompson, Clearwater, Adams) in the study area
- Source – the origin of the pipeline section at KP663
- Destination – the destination of the pipeline section at KP715
- Study_Area – the polygon boundaries of the 6 TRIM map sheets that make up the study area

Start by setting up your layer display and defining the proper environments, including

- The current and scratch workspaces (TMX.gdb)
- The processing extent (same as layer Study_Area)
- The cell size (same as layer Elevation), and
- The Mask (Elevation)

> **Note**: As with the last lab, having a good file naming strategy is important. Typing more descriptive file names may take a few more seconds, but can save you hours if you avoid making mistakes. Having a logbook beside your computer is a good practice to follow so that you can keep track of things. In Part A, we have 3 scenarios with similar outputs for each. A good idea might be to name your files CostRaster_Sc1, Backlink_Sc1 etc.

Scenario 1: Slope

In the first scenario, you will only consider slope as a cost factor. Lower slopes are preferred.

- Create a slope grid in degrees from the DEM
  - Both the horizontal and vertical units of the coordinate system are in meters, so the Z factor does not need to be changed.

> *Note: When you create the slope raster, some irregularities in the DEM will become apparent. These appear as slope variations that follow a pattern of large squares across the model (see screen shot below). This is a result of the source data, not anything that you have done wrong.*

- Reclassify the slope based on the following cost factors:

Slope (degrees)	Cost factor
< 2	100
2 to 5	110
5 to 10	120
10 to 15	130
15 to 20	140
20 to 25	150
25 to 30	175
> 30	200

> *Note: If you are entering the Old Values directly into the table instead of using the Classify button, there must be a space on each side of the dash, so for < 2, you would enter 0 – 2 not 0-2.*

Here is what the results looks like, after applying a stretched symbology:
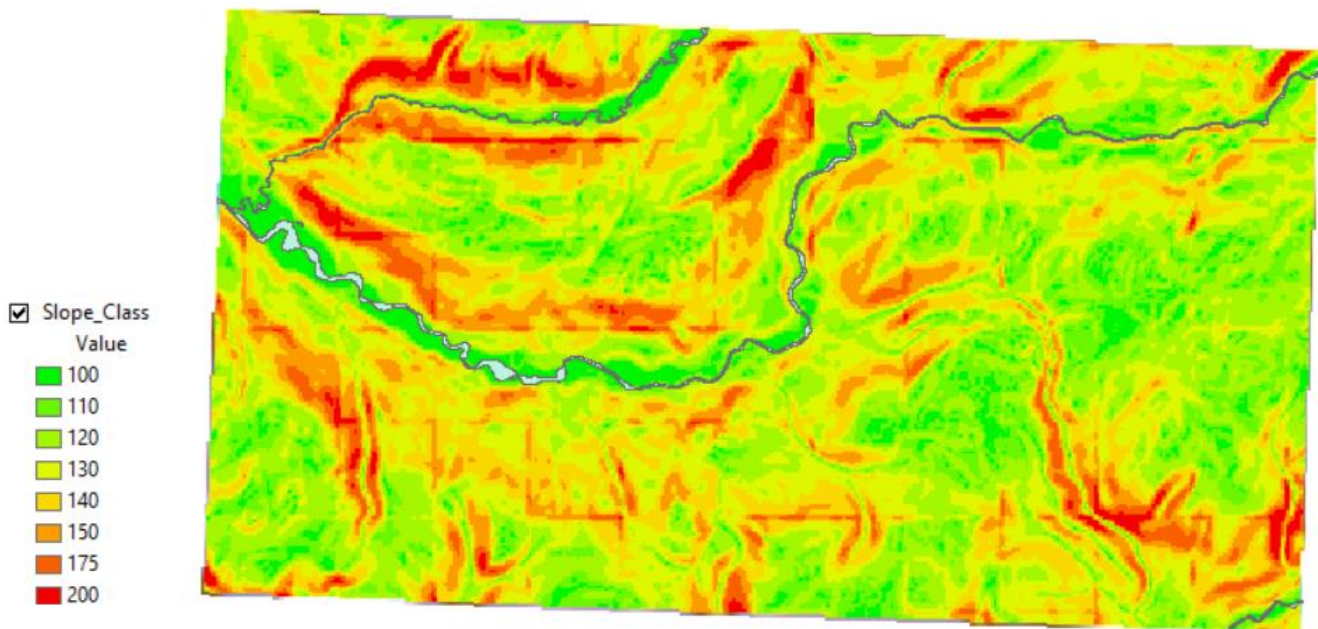
- Create a cost distance raster and associated backlink raster using the Cost Distance tool:
  - Feature source data: Source
  - Input cost raster: reclassified slope

- o Specify the output distance raster and backlink raster outputs
- o Leave the maximum distance parameter blank
- o Run the tool
- Examine the nature of your results

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Deliverable 1: What do the cell values of the cost distance raster represent? What are the units, if any? What is the purpose of the backlink raster? What do the cell values of the backlink raster represent? What are the units, if any? **(5 pts)**

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- Now perform the least-cost path analysis using the Cost Path tool:
    - o Feature destination data: Destination
    - o Use the previously created cost distance and backlink rasters as inputs
    - o Specify an output raster
    - o Leave the other parameters to their defaults
    - o Run the tool

- Convert the result from the cost path analysis to vector using Raster to Polyline
    - o Specify appropriate inputs and outputs
    - o Leave the other parameters at their default values

- Create a hillshade so that you can better see the topography. Make this layer semi-transparent and display it on top of the Elevation raster.
- Turn on the Rivers layer and shade them a medium blue color.

When you examine the result, you will notice that the least-cost path follows the North Thompson River valley in the east, then jumps to the Clearwater River valley, crossing both rivers multiple times.

- Determine how many times and where exactly the least-cost path solution crosses the river.
    - o You can use vector or raster analysis tools for this, or a combination.
    - o There will be many crossings, so it is better to get your numbers from an attribute table than by counting manually
    - o Be careful if your output generates multipart features; you will need to split these into individual features.
    - o If your final result is raster, you will still need to convert the result to vector using Raster to Point
    - o *Note: detailed steps are not provided here and you will need to determine the appropriate tools*

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Deliverable 2: Provide a brief description of your analysis steps (only for the step to determine the locations of the crossings). **(5 pts)**

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Deliverable 3: How many times does your least-cost path solution cross a river or a stream? **(5 pts)**

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- Modify the symbology:
    - o Clearly recognizable symbols for source and destination
    - o Hillshaded elevation
    - o Rivers and streams in light blue

- Least-cost path solution in a contrasting color, e.g. dark red
- Clearly recognizable symbols for the crossings

Deliverable 4: Create a screen capture of your results. **(5 pts)**

Below is an example of what your results should look like: