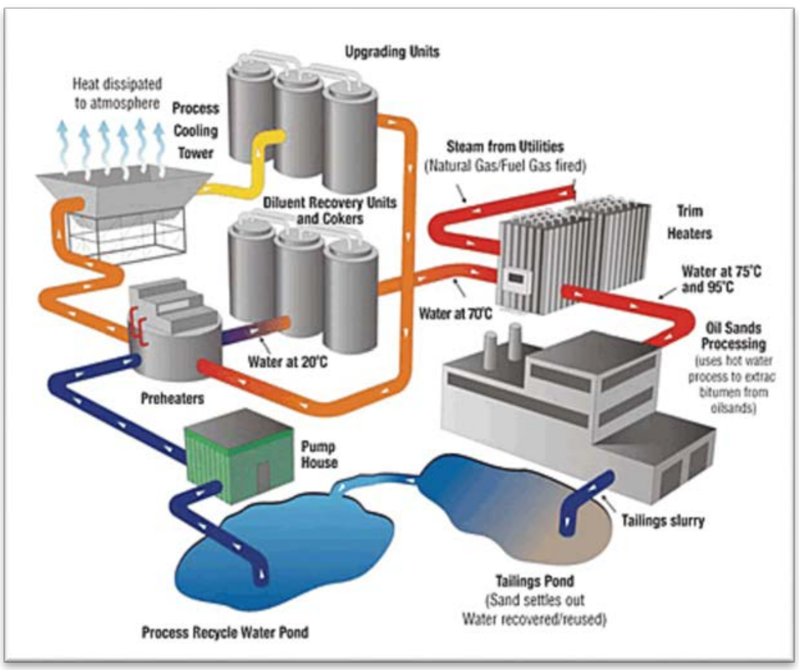
Lindsay Priest
Project Paper - Final

Theoretical Foundation

The Athabasca oil sands in Alberta, CA produce over 1.5 million barrels of crude oil per day (CAPP, 2011). The U.S. imports over 825,000 barrels of oil sands oil each day, which is approximately 21% of the U.S. imports (EPRF, 2010). To process one barrel of crude oil it takes 2 to 5 barrels of water to extract the bitumen from the sand (Woynillowicz et al., 2005). To extract the bitumen The Clark Process is used. The process uses caustic water to separate the bitumen from the sand, silt, and clay sediments (Chalaturnyk et al., 2002).



http://oee.nrcan.gc.ca/publications/industrial/cipec/14146

After the extraction process, the slurry is sent to a tailings pond. A tailings pond is a large pit that was previously mined of its oil sands and is now filled with the slurry. The slurry is made up of silt, clay, and sand particles along with the unextractable bitumen, methanogens, and naphthenic acids. The sedimentation process can take 125-150 years (Fedorak et al., 2002). During this time the tailings are suspended and able to seep into nearby tributaries thereby, polluting water resources that the local environment depends on. To emphasize, in 1979 a study was conducted to measure the effects the tailings slurry has on benthic invertebrates. A small amount of slurry was let out of a pond into the Muskeg River, located in the Athabasca oil sands region. After four weeks of the release there was a 60% drop in benthic invertebrates (Barton, 1979).

Not only are the tailings ponds going to be around for centuries but they take up 130 km^2 (32,123 acres) of land. That is over 720 million m^3 (190,203,876,893 gal.) of tailings slurry (Holroyd, 2009). According to Timoney and Lee, mercury, polycyclic aromatic hydrocarbons (PAH) have an increased amount at 9-15 times more downstream than from upstream from the tailings ponds. And, analytes, such as ammonia and arsenic have increased at a minimum 2-fold up to 4-fold downstream. These two scientists also found that walleye and whitefish over 40 cm long contain more than 0.20 mg/kg of mercury. This exceeds the U.S. EPA standards for fisher consumption (2009).

There are not only numbers to reflect the effects of tailings ponds and the oil sands. The local First Nations of Fort Chipewyan have noticed that the water tastes sour and salty and their fish are soft and have deformities like lesions and deformed fins. Timoney and Lee believe these occurrences are due to ecological degradation and food web disturbances caused by poor water quality (2009).

Planning Process

The first step in the planning process of my project was to identify a topic that could be spatially analyzed. I chose to the Athabasca tailings ponds as my topic because I am interested and concerned about the issues generated by the oil sands in general and the nearby First Nations are Cree and Chippewa. These tribes are significant to me because I belong to the same tribes here in the U.S.

To create a spatially significant project I had to consider what about the oil sands would correspond to GIS and tailings ponds site selection was the answer.

I was convinced that this was my project topic after I did my research. The majority of the research I found on tailings ponds involved information about the chemicals in the slurry and the effects it has on the environment of the region. In particular how the slurry seeps into nearby tributaries, which affects the local First Nations population and the fish they eat.

Since I committed to a topic I had to come up with a research question. What was I really asking? I wanted to know where the best locations would be to have tailings ponds in the Athabasca region. I struggled here because it would be ideal for the need for tailings ponds to be obsolete. But, since oil is one of the most consumed natural resource, it is unlikely that the oil sands mining will stop, therefore the need for tailings ponds will continue.

Based on my question “Where are the best locations for Athabasca oil sands tailings ponds?” , my intended audience became companies in the Canadian oil sands industry.

After I had my question the next step was to receive feedback from my peers to verify that my topic was appropriate considering the project guidelines. From the help of peer feedback, I was able to decide on the criteria that would be used in my analysis. The criteria were water bodies (rivers and lakes), First Nations lands, caribou habitat, and soil type.

Now that I had the basics, a project workflow was used to help with methodology. The workflow consisted of steps that I needed to make in order to develop the results I was asking for.

Methods

To accomplish my GIS spatial analysis I needed data to build my map. Due to my projects' spatial extent, Alberta, CA, data collection took up a lot of my time. Before I could start building my map I needed to organize my project data beginning with a hard drive, a project file, data folders, a geodatabase, and a feature dataset. I created a data folder for each criteria and a folder for basemaps. As I gathered my data onto ArcMap I found that I couldn't utilize the majority of the shapefiles. This led to more searching and making contacts with The University of Alberta and a GIS technical college in Alberta. Eventually I found all the data I needed and began my processes. I ended up only needing one geodatabase and one feature dataset. Then I added all my layers onto one map file.

I used the projection NAD 1983 UTM Zone12N. After a lot of searching I finally found the perfect data that I could use for my water bodies layer and I chose to use the buffer tool to exclude and land that was within 300 meters of a water body. After the buffer finished I had to re-evaluate my buffer distance because 300 meters just isn't enough distance to ensure that the slurry will not seep into the water bodies. I chose 300 meter specifically because the Standards and Guidelines for Municipal Waterworks, Wastewater and Storm Drainage Systems, that the oil sands industry follows, states that all "wastewater" must be at a minimum of 300 meters from anything. After a lot of research I decided that 4000 meters (4km) would be best.

The next step was to try and get my DEM files all on one raster. I used the Mosaic to New Raster tool to do this. I ran two NTS Grid boxes at a time first (21 of them), then I ran the first set of 10 together and then the second set of 11 together. Then I had two sets, so I ran those two together to get one complete raster for elevation. Once I had my raster I had to use the slope tool to get the slope of the land. Now that I had my slope layer I had to reclassify it. I had two classes 0 and 1. The steeper slopes were classified as 0 and the flatter slopes were classified as 1. I tried to reclassify this slope layer seven times. I tried re-running the master raster with the slope tool as well and this did not work either. I ended up not using slope as a criteria because of this as well as the fact that the slope was not very steep in the overall area.

Since I was without slope and I was also contemplating adding soil type into my project I searched for soil data. After obtaining the right soil data I then reclassified it to reflect that sand and gravel, mud, and till were the best soils to withstand a tailings pond built upon it and as well as reduce seepage.

I decided to use the boundaries of Alberta and then I digitized the boundaries of the Athabasca and Peace River oil sands regions. As I moved along in my project I ran into some issues with rasterizing my rivers and lakes layers. As I ran the tool Feature to Raster, ArcMap continued to crash after several tries. I then had to search for another basemap that would allow me to still have the oil sands boundaries within it and not crash ArcMap. I ended up finding a layer from the Land Use Framework of Alberta. They have divided Alberta into regions based on the Land Use type and area. My boundaries ended up being the regions of Lower Athabasca and Lower Peace. Both make up Northern Alberta.

Now that I had my new extent/boundary, I had to re-rasterize my other layers of caribou habitat, native lands, and soil. Since I had to re-rasterize I also had to re-reclassify each layer.

After these processes I could then start my analysis. I used the Raster Calculator to multiply the criteria by each other. Native lands, caribou habitat, and water bodies were classified as 0 if in that cell they existed. They were classified as 1 if in that cell they did not exist. Soil was classified as 0 if the soil was not suitable and 1 if it was. So, as each layer was multiplied by each other the output came up with the land that would be best suited for tailings ponds.

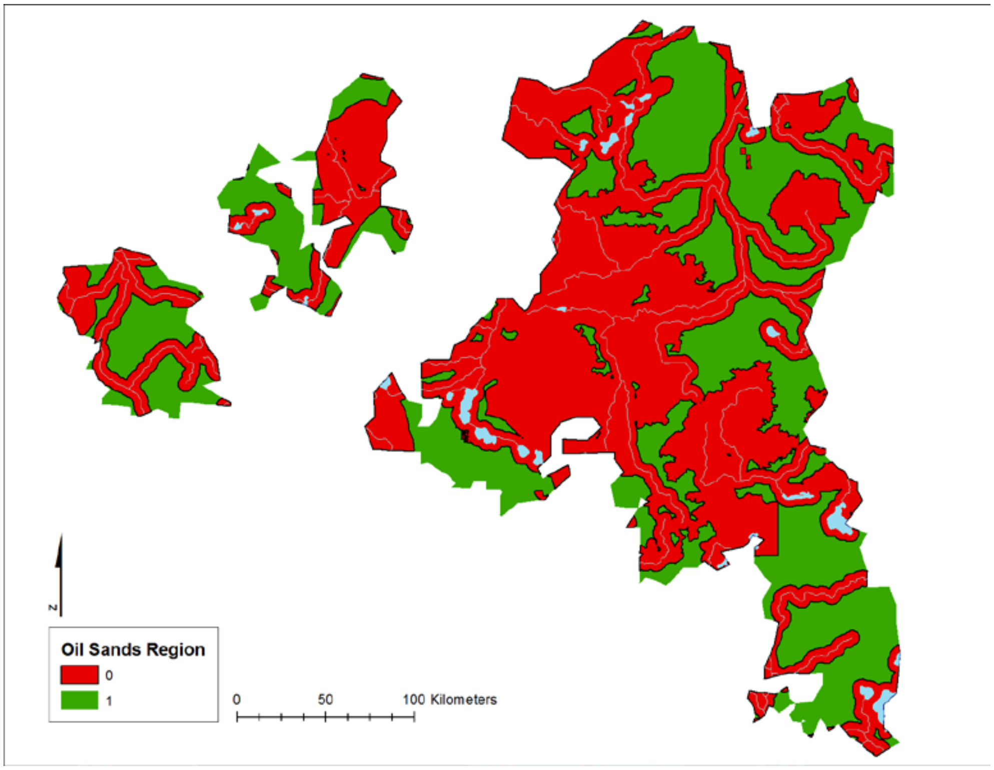
Results and Discussion

The area of the oil sands region is approximately 73,743 km^2 (18,222,431 acres). Of that area 28,409 km^2 (7,020,016 acres) is suitable land for tailings pond placement. That is 38.5 % of the land within these boundaries. I used the Select By Attributes and Select By Location tools to find the area of the suitable lands. Although the percentage reflects that most of the land within the oil sands boundaries in not suitable for tailings ponds I am surprised that the percentage is not much higher. My reaction is derived from my analysis of the two layers: caribou habitat and rivers and lakes, along with the 4000 meter buffer I applied to them. Initially these two appeared to exclude much of the land as each layer was created.

If I were to do this project over again I would do more research on the soils. I would like to know exactly what types are the absolute best. I think that this would narrow down the sites. In the beginning of this project I was focused on water alone and I really wanted the focus to be on groundwater. But, after a lot of searching and data collection I could not find any data that contained water table information in this area. I would have loved to have been able to include groundwater. Another aspect I would've liked to include would be the cities and populations within the oil sands boundaries. I am at a loss as to why this was not on my mind at the time. Although, I do believe that most of the populations in the region are within the 4 km buffer of water bodies.

I would've also liked to have completed another analysis. It was suggested to me to perform a Cost Analysis based on mining sites and the best path to take if you were to build a pipe line to a suitable tailings pond site. This would have been a great way to use my skills but it did not fit with how the mines actually work. Another option would have been to perform the Cost Analysis or something similar that could predict where the slurry would end up and the path it would take if one of the tailings ponds' dykes broke. Looking back there are obviously a lot analyses I could have done and maybe should have done, but with data collection and the Reclassify tool, I ran out of time.

Overall I am happy with my results and this project was interesting for me. I would have like to have been able to see the oil sands in person. As in our readings this quarter, a personal view would have been helpful in determining what information was more critical. I did try to get in touch with the Indigenous Environmental Network (IEN) and the Beaver Lake Cree First Nation to get their input on what they think is most important, but I never received a response. In hindsight, if I would have chosen a local topic my project might have been easier and/or I would have had a better idea of what is important to my surrounding community, but I do not regret my choice in topic because it did have a personal connection to me.



N
Oil Sands Region
0
1
0
50
100 Kilometers

Works Cited

Barton, D., Wallace, R. 1979. The effects of an experimental spillage of oil sands tailings sludge on benthic invertebrates. Environmental Pollution. 18.

CAPP. Canadian Association of Petroleum Producers. 2011. Crude Oil Forecast, Markets & Pipelines. Available from: http://www.capp.ca/getdoc.aspx?DocId=190838

Chalaturnyk, R., Scott, J., Ozum, B. 2002. Management of oil sands tailings. Petroleum Science and Technology. 20(9&10), 1025-1046.

EPRF. Energy Policy Research Foundation, Inc. 2010. An Assessment of the Keystone Proposal to Expand Oil Sands Shipments to Gulf Coast Refiners. Available from: http://eprinc.org/pdf/oilsandsvalue.pdf

Fedorak, P., Coy, D., Salloum, M., Dudas, M. 2002. Methanogenic potential of tailings samples from oil sands extraction plants. Canadian Journal of Microbiology. 48(1), 21-33.

Holroyd, P., Simieritsch, T. 2009. The Waters That Bind Us Transboundary Implications of Oil Sands Development. The Pembina Institute. Available from: http://www.pembina.org.

Timoney, K., & Lee, P. 2009. Does the Alberta Tar Sands Pollute? The Scientific Evidence. The Open Conservation Biology Journal. 3, 65-81.

Woynillowicz, D., Severson-Baker, C., Raynolds, M. 2005. Oil Sands Fever: The Environmental Implications of Canada’s Oil Sands Rush. Available from: www.pembina.org.