Ecohydrology applications to ecosystem reconstruction following oil-sand mining

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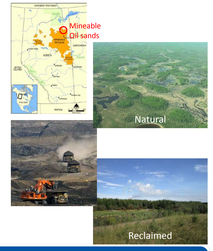
1) Problem Overview

Open-pit mining and processing of oil sands (NE Alberta, Canada) result in overburden dumps, tailings ponds and end-pit lakes. **How to reclaim?**

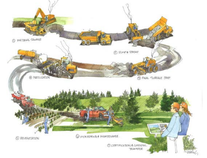
Require "equivalent landscape capability": forest and wetland ecosystems

Original Boreal Plain landscape has low relief with hummocks and 50% peatlands



2) Reclamation Approach

1) Drain tailings ponds to remove dams and contour landforms
2) Apply covers to landforms: layers of clay till, peat, forest floor



3) Plant vegetation
4) Monitor, evaluate, certify

3) Current Paradigm

Water tables loosely follow topography

- Water flows from uplands (forests) to lowlands (wetlands)

Design and contour upland structures to **shed water**

- Geotechnical stability
- Supply water to lowland wetlands (and end-pit lakes)
  - Require catchment area of 3 to 10 times wetland area

Paradigm does not mimic natural systems in the region

4) Analogues & Water Budgets

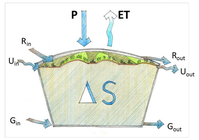
Must understand dominant processes in natural analogue systems

Full water budgets within context of climate, vegetation and geology

Buckets need not be defined by topography

Change in Storage = Input - Output

$$\Delta S = P - ET + (G_{in} - G_{out}) + (R_{in} - R_{out}) + (U_{in} - U_{out})$$



Legend:
ΔS = Change in Storage
P = Precipitation
ET = Evapotranspiration
G = Groundwater
R = Runoff
U = Uplift (by vegetation)

Subscripts represent movement of water into or out of system

5) Climate

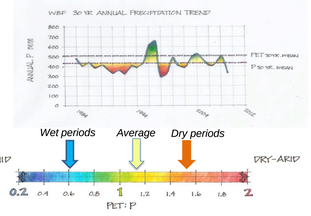
Sub-humid climate

- Dry on average, but highly variable

Actual ET varies across the landscape. Generally:

- Forestlands in deficit
- Peatlands in surplus

Average temperature near zero



6a) Forestlands

Uplands plus lowland hummocks

Depressed water tables common

- Hydrologic uplift by trees

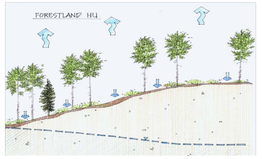
Large changes in storage

- Forest floor, soil, depressions, fine-grained layers

Water **sinks** most of the time

Forestland Hydrologic Units

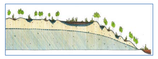
Net deficit



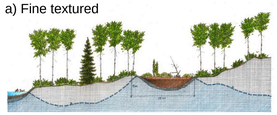
7) Geology & Connectivity

Geology (grain size, layering and heterogeneity) strongly influences storage, transmission and water table configuration

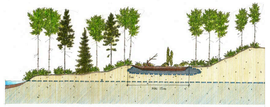
- Controls vertical fluxes vs. lateral connectivity over a range of spatial and temporal scales
- **Perched** surface and subsurface water common



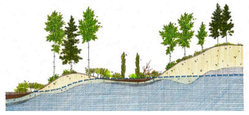
a) Fine textured

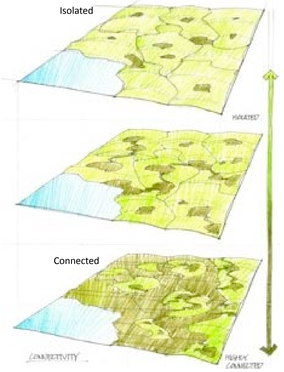


b) Coarse textured



c) Coarse over Fine





6b) Wetlands

Not just in lowlands

- Upland, perched wetlands are common and important
  - Water for forestlands

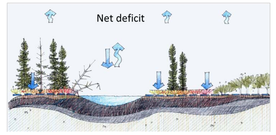
Ice and peat retain water

- Decrease evapotranspiration

Water **sources** with variable connectivity

Wetland Hydrologic Units (open water to terrestrial)

Net surplus Net surplus



8) Required Paradigm

Depressed water tables below forestlands and perched wetlands and perched water tables on uplands are common

- Water often moves vertically and from wetlands (sources) to forestlands (sinks)
- Large changes in storage reflect dry but variable climate

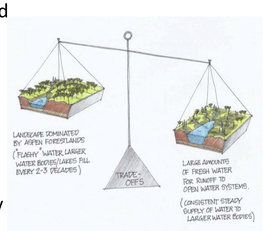
Retain water on the landscape, including uplands and hillslopes

- Require heterogeneity in geology and relief at all scales
- Extensive catchment areas only for regional systems

9) Priorities & Constraints

Competing demands require integrated planning and compromise

- Water for wetland, forestland and end-pit lake ecosystems
- Operational and geotechnical constraints
- Material limitations and excesses
- Time, space, money and uncertainty
- Performance expectations



10) Reference & Credits

Devito, K., C. Mendoza and C. Qualizza (2012). *Conceptualizing water movement in the Boreal Plains. Implications for watershed reconstruction.* Synthesis report for Canadian Oil Sands Network for Research and Development, Environmental and Reclamation Research Group. 164p.

U of Alberta Education and Research Archive: http://hdl.handle.net/10402/era.30206

Illustrations by Derrill Shuttleworth.

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A synthesis of two decades of ecohydrological research into water cycling in the Boreal Plains with applications to landform design and landscape reclamation for oil-sand mines and other disturbances.