CASE STUDY: CLOSING FLIN FLON MINE

April 27, 2023

HUDBAY

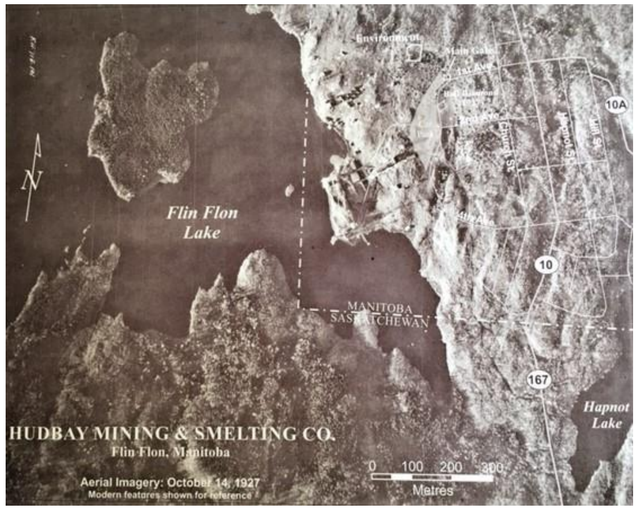
OUTLINE

- Site history
- Early planning for closure
- Refining the plan (prior to closure)
- Adjusting the plan (post closure)

SITE HISTORY

- 1915 - Tom Creighton registers a claim on land near the 55th parallel in northern Manitoba after being intrigued by “brass yellow glints” in an outcrop shared with him by local trapper David Collins. He calls his strike Flin Flon after an adventurous character in an early science fiction novel, Josiah Flintabbatey Flonatin.
- 1927 - After feasibility testing that includes the building of a pilot mill in Flin Flon, Hudson Bay Mining and Smelting (HBMS) is incorporated.
- 1930 - In June, production begins. At the time, Flin Flon was one of the largest industrial development projects in the Western Hemisphere. It has been said that it was second only to the Panama Canal in terms of scale.

1927 Aerial (with modern features for reference)



May 10, 2022 (shortly before plant closure)

SITE HISTORY

- The City of Flin Flon (Manitoba) and the Town of Creighton (Saskatchewan) quickly developed adjacent to the new mining development. As such, the residential areas are located close to the operation. Run-off from Creighton flows towards the tailing facility.

Flin Flon and Creighton	Earth view

EARLY PLANNING FOR CLOSURE 2009-2010

- At the time of this early planning work, the flows from the surface runoff from the Town of Creighton mixed with mining impacted acidic water.
- At least 8 different options for diverting Town of Creighton surface runoff were assessed to:
  - Prevent clean water from becoming impacted by the mining operation
  - Ensure that ongoing operations were not impacted
  - Ensure there was no impact on dam stability
  - Ensure that planned remediation work in the immediate area could proceed
  - Minimize the volumes of water requiring treatment for the remainder of the operating life as well as at closure
- Included in assessment:
  - Site-wide drainage and catchment areas
  - Existing closure plan
  - Current and future reclamation plans within catchment
  - Deposition history
  - Site investigations including borehole drilling and seismic refraction survey
  - Freshwater hydrology

OTHER RELATED ACTIVITY

- There were several other direct and indirect activities before and after the Creighton run-off work:
  - Regularly scheduled update to the regulated closure plan
    - Several water management, storage and treatment options evaluated
    - Various cover options also evaluated, including the impact on water management
  - Tailings dusting event
    - Resulted in closure of the south end of the tailings storage facility to move active tailings further away from residential properties
    - Applied cover material
    - The reclaimed area is adjacent to the town run-off ditches

2014-2020

- Dam failures around the world incentivized mining companies and tailings managers to re-evaluate overall risks as well as specific ones such as liquification potential
  - The investigations and resulting work to further reduce risk can impact the water balance
  - Inundation study updates led to further mitigation projects such as installation of environmental control berms between the south end of the tailing facility and the Town of Creighton
- Additional updates to the regulatory required closure plan
  - Continued investigation and refinement of options to store, treat and release water
  - Other options that directly or indirectly impact water management (e.g. cover material)
- Actual ore depletion forecast date refined
  - Initiated additional work to model
    - Water quality
    - Water volumes and flow rates
    - Storage and filling options

2020 - 2022

- Closure plans
  - 2020 update submitted to regulators, enhanced with a technical review meeting
  - 2025 plan update
    - Consultant selected and contract issued
    - Data sharing
    - Several items under analysis (e.g., geochemical, u/g mine storage capacity and fill rates, site specific water quality objectives)
    - As with any change, ongoing risk identification and assessment – new risks and/or changes to existing
- Estimated dates for post mine closure / post transition to care and maintenance for concentrator and tailings facility established
  - Key dates established (estimated) for:
    - Final deposition into tailings facility
    - Underground mine workings and open pit flood
    - Short term water treatment methods
    - Long term water treatment methods

CURRENT ACTIVITY

- Continuous monitoring of water quality, volumes and flows
- Refinement and management of key risk areas such as:
  - Resource availability – internal manpower, budget and contractors
  - Process water shutdown – reduced mixing and reduced buffer from higher pH process flows
  - Management of seepage
  - Shut down of lime plant
  - Alternative pH control
  - Quality of water entering site
  - Impact of water diverted around site
  - Adjusting discharge pH control to low flow
  - Winter water management freezing conditions with low flows
  - Freshet large inflows while facility still thawing
  - Open Pit storage volume
  - Pumping capability to move water around site

MITIGATING WATER QUALITY RISK

- Interim control of diverting water to closed mine
- pH control options under continued evaluation
  - Water Treatment Plant
  - Sodium Hydroxide (NaOH) Dosing Plant or Lime Slaking Plant
  - Small Package Plant or Tanker System or Vendor Supply System
  - Use existing Lime Plant
- All options have common challenges
  - Low flows
    - Poor circulation of reagents
    - Winter freeze up
  - Need to divert WQ upsets or large flows to open pit
    - Unknown volume / run out of capacity before permanent plant is built
  - Expensive (capital and/ or operating reagents, manpower, etc.)
  - Inputs are unknown, despite modeling prediction work and therefore, treatment needs are also uncertain

MANAGING WATER VOLUMES

- How much storage is needed vs available?
  - Despite using climate change predictions in modelling estimates, highly unknown and potentially variable
    - Estimate seepage flows
    - Estimate inflows from off site
    - Estimate level increase due to snow melt during freshet
    - Estimate level increase due to spring precipitation
  - Facility volumes
    - Bathymetry updates
    - Minimum pond levels
    - Seasonal fluctuations
  - Underground storage
    - Continual update of storage calculations based on actual measurements
    - Impact of hydraulic connectivity in the mine
  - Water movement options
    - Consider constant circulation, diversion, freeze / thaw cycle

CONCLUSIONS

- Start early
- Utilize models combined with actual monitoring data
- Update models based on ongoing observations and measurements
- Evaluate a wide array of options
- Utilize external assistance and expertise, as appropriate
- Ensure consideration for indirect impacts
- Review and adjust plans frequently