MACALESTER COLLEGE

Erosional Impact of Instream Aggregate Mining

With a focus on Cottage Grove, MN

Elizabeth Trevathan

STRUCTURAL GEOLOGY

INTRODUCTION

Since the 1950s, Aggregate Industries – MWR, Inc. has mined sand and gravel at their Nelson Mine Facility in Lower Grey Cloud Island.

- In early 2022, the company received approval to begin moving the facility to a new location: the backwaters of the Mississippi River in Lower Grey Cloud Island

What are the environmental and structural implications that instream gravel mining causes?

In 2001, natural aggregate accounted for the most valuable non-fuel mineral commodity in the world, at $14.5 billion in the United States

When a quarry runs out of supply, it is called sterilization.

- Nelson plant has lasted ~ 75 years and is predicted to last another 5 years

It is assumed that the proposed plant would include all three types of instream aggregate mining, as most plants do.

DEFINITIONS

Aggregate: all types of rock mineral raw materials (alluvial deposits)

Instream Aggregate Mining: removing sand and gravel from riverbeds, changing the geometry and elevation of the channel and riverbed

Quarry: an open pit mine

Sterilization: "lack or loss of the possibility of their exploitation"

Wet–pit & Dry-pit Mine: occurs within the active channel at the lowest point of the river; bulldozers vs hydraulic excavators to extract gravel from below water table level

Bar Skimming Mining: scraping off the top layer of sediment without digging deeper than the average summer water level

Water In-rush Accident: surrounding sediment can not hold back the nearby water, and water begins to pour into the mine at alarming rates

Head-cutting: the act of creating a nick point (centimeters to meters high) that locally steepens the channel slope, lowering the riverbed and increasing flow energy

Hungry Water: a river flow with an excess transport capacity; after mining deprives water of sediment, it has increased power to erode and transport new sediment from its bed and banks

Figure 1. *Aggregate Industries plans to relocate its Nelson mine to this 395-acre parcel within the Mississippi River. The company argues that its current mine will only provide resources for another five years, and the new location will help meet the region's construction needs (Cottage Grove Planning Division, n.d.).*

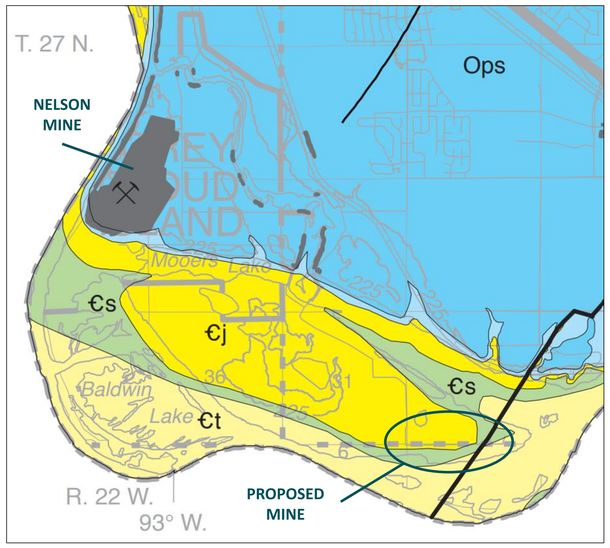

Figure 2. A zoomed-in screenshot of the proposed mining location and current mining location (marked by the gray polygon). Image taken from the Minnesota Geological Survey (Steenberg & Retzler, 2016).

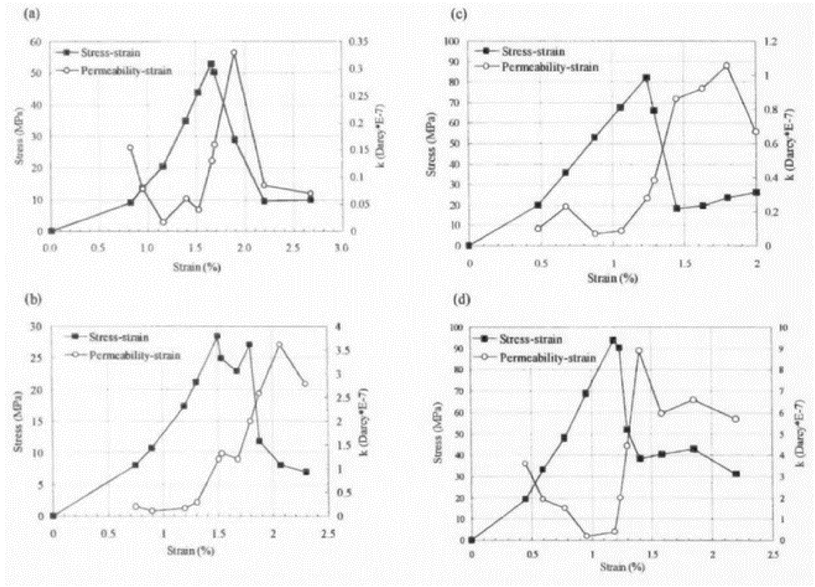

Figure 3. Stress (Mpa) vs Strain (%) plots for each rock type measured with permeability compared: (a) mudstone, (b) sandy shale, (c) fine sandstone, (d) medium sandstone (Wang & Park, 2002, 294).

RESULTS & DISCUSSION

Franconia Formation: Very fine-grained glauconitic, feldspathic sandstone and siltstone with shale partings

St. Lawrence Formation: Dolomitic, feldspathic siltstone with very fine-grained sandstone and shale interbedded

Permeability of rock types:

Mudstone < Sandy Shale < F. Sandstone < M. Sandstone

- The higher the formation's permeability, the higher the probability there will be a water in-rush accident
- Most dangerous when the pressure transitions from compression applied to the rock to shear and tension.

Rivers hold a careful balance of sediment transport, the rate of which depends on the river's power and the sediment supply from the watershed.

- Pits force rivers to adapt to steeper gradients, creating head-cutting
  - The entire riverbed can degrade to the excavation depth or until the bedrock is completely uncovered
- Sediment-depleted water creates hungry water
- Machinery, heavy equipment, increases turbidity and suspended sediment

IMPLICATIONS & CONCLUSIONS

Increased erosion caused by instream mining creates:

- Undermining of bridge piers & bridge collapses
- Lowering water tables; drying wells, reducing the amount and quality of freshwater
- Exposing pipeline crossings, increasing vulnerability of infrastructure from debris and flowing water
- Channel instability, forcing extreme bank erosion and channel migration
- Ecosystem changes; for example, removing gravel sizes used by salmonids for spawning

Final Recommendation

A comprehensive sediment budget and structural analysis should be completed before the approval.

- Determine permeability & a cut-off date or depth
  - Reduces chance of complete sterilization & water run-in accidents
- Completed routinely – every 5 to 10 years

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